Methodological Document
AFOLU SECTOR

BCR0005 Quantification of GHG Emissions Reduction

ACTIVITIES THAT PREVENT LAND USE CHANGE IN NATURAL SAVANNAS

BIOCARBON REGISTRY®

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Credits

BIOCARBON REGISTRY® recognizes the role and technical support of the Fundación Cataruben in the construction of this methodology, as a tool for the conservation, restoration and sustainable management of natural savannas.

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Table of contents

Listo of tables

Acronyms and abbreviations

AFOLU	Agriculture, Silviculture and Other Land Uses
AB	Aboveground biomass
BB	Belowground biomass
CH_4	Methane
CNVC	Change in the area with natural vegetation cover
CO_2	Carbon dioxide
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse Gases
GIS	Geographical Information System
HCV	High Conservation Value
IPCC	Intergovernmental Panel on Climate Change
N_2O	Nitrous oxide
SOC	Soil Organic Carbon
TB	Total biomass
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VCC	Verified Carbon Credits

1 Introduction

Natural savannas are one of the most characteristic biomes of the terrestrial intertropical zone, dominating large regions of South America, Africa, Southeast Asia and Australia. It is one of the great structural and functional units in which the biota of the earth's land surface has been differentiated, at the same level as forests, montane forests, moorlands or deserts. They are characterized by associations of herbaceous vegetation with or without the presence of scattered trees and shrubs and with seasonal patterns of water availability determined by a marked dry climatic season.

In savannas and other grasslands the belowground carbon is predominant, accumulated mainly in roots and soil organic matter. Savannas in general have developed adaptations to cope with grazing and the common perturbation of fire and consequently both the vegetation and soil carbon are relatively resistant to moderate disturbances from grazing and fire regimes IPCC (2006) [1].

Although natural savannas are known to play a key role in carbon storage, provide habitat for wildlife and play an important role in water regulation, they have rarely been considered in conservation strategies to avoid land use change. At the same time, according to WWF (2021) [2], "*natural savannas currently face one of the highest and fastest rates of conversion and degradation, which means a significant loss of biodiversity and increased greenhouse gas emissions. Consequently, actions to reduce conversion are necessary and depend on finding a balance between production and conservation*".

This methodology document focuses on activities that avoid land use change and, consequently, the loss of natural vegetation cover in natural savannas. Holders of GHG projects located in savanna biomes shall apply the provisions of this methodology document.

The methodology include aspects related to activities that avoid land use change in natural savannas, comprising GHG removals by ecosystem restoration, and the use of landscape management tools, identification of GHG reservoirs and sources, spatial and temporal boundaries, drivers of land use change, baseline scenario, additionality, uncertainty and risk management, leakage management and monitoring activities.

[1] https://www.ipcc-nggip.iges.or.jp/public/2006gl/spanish/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf

[2] https://www.wwf.org.co/?367073/Los-pastizales-naturales-son-esenciales-para-enfrentar-el-cambio-climatico-y-revertir-la-perdida-de-biodiversidad

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 prevent land use change in natural savannas;

(b) present methodological requirements for baseline identification of projects that prevent land use change in natural savannas;

(c) set out requirements for the quantification of GHG reductions resulting from activities that avoid land use change in natural savannas;

(d) render requirements for the quantification of GHG removals resulting from restoration activities and landscape management tools in natural savannas;

(e) ; provide methodological requirements for baseline identification of projects that avoid land use change in natural savannas;

(f) establish methodological requirements for demonstrating additionality of projects that avoid land use change in natural savannas;

(g) ; describe the requirements for monitoring and follow-up of project activities that prevent land use change in natural savannas;

(h) Establish requirements related to permanence and leakage;

(i) Facilitate the articulation of the project accounting with national accounting, if applicable.

2 Version and validity

This document constitutes the version 1.0. October 21, 2022.

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 of baseline, quantification of GHG emission reductions/removals and monitoring of projects that prevent the land use change in natural savannas.

This Methodology is limited to project activities that generate reduction or removals of GHG emissions, by activities that prevent the land use change, and those that consider activities of restauration and landscape management tools in natural savannas.

This methodology shall be used by the GHG projects holders, only to be certified and registered with the Voluntary Carbon Market Standard. BCR STANDARD.

4 Applicability conditions

This Methodology is applicable under the following conditions:

a) the areas within the geographic boundaries of the project correspond to natural savannas;

b) project activities prevent land use change in natural savannas;

c) project activities include biodiversity conservation actions that integrate preservation, restoration and/or management efforts and sustainable use of the savannas;

d) the causes of land use changes identified may include, among others: expansion of the agricultural frontier, mining, extraction or loss of natural vegetation cover;

e) carbon stocks in soil organic matter, litter and dead wood may decrease or remain stable in the areas within the project boundaries;

f) soil disturbance due to project activities, if any, is carried out in accordance with appropriate soil conservation practices and does not recur for less than 20 years;

g) the quantity of nitrogen-fixing species used in the project activities is not significant, so GHG emissions from denitrification can be considered insignificant.

This methodology allows the inclusion of areas in the project that correspond to the category of wetlands and/or contain organic soils.

Projects holders shall at all times use the latest version of current methodologies and/or methodological documents. If the project holder proposes activities involving the use of different methodologies, it may do so as long as the applicability conditions and requirements contained in the methodologies applied jointly are met.

5 Normative references

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

(a) The Voluntary Carbon Market Standard. BCR STANDARD, in the most recent version;

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

(c) current legislation related to GHG projects, or that which modifies or updates it;

(d) the guidelines, other orientations, and guides defined by BIOCARBON REGISTRY, within the scope of the AFOLU sector.

Similarly, compliance with the provisions of the following ISO Standards is obligatory:

a) ISO 14064-2: 2019 standard (en). Greenhouse gases - Specification with guidance, at the project level, for the quantification, monitoring, and reporting of the reduction of emissions or the increase in removals of greenhouse gases, or that which updates it;

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

6 Terms y definitions

Additionality

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

Those GHG emission reductions project holder demonstrates that would not occur in the absence of the project are considered additional, as described in section 8 of this document.

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

Agents causing land use change

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

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 or reference scenario

The baseline scenario is the scenario that reasonably represents the sum of the variations in carbon stocks, included in the project boundaries, that would occur in the absence of the project's activities.

Source: Adapted from the Glossary CDM terms. Version 10.0

Bioindicators

Organisms or communities of organisms whose study or observation generates information about the ecosystem in general.

Carbon fraction

Tons of carbon per ton of dry biomass, in the case of AFOLU projects. According to IPCC (2006) the carbon fraction is 0,47.

Direct causes of land use change

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

Drainage

Elimination of excess water either from the surface of the soil or under it, caused by rains, too much irrigation, seepage of channels, floods, among other causes, to control the water table of agricultural soils[3].

[3] Brouwer, C., Goffeau, A., & Heibloem, M. (1985). Irrigation water management: training manual no. 1-introduction to irrigation. Food and Agriculture Organization of the United Nations, Rome, Italy, 102-103.

Ecological Restoration

According to the Society for Ecological Restoration (SER), ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed.[4]

Eligible areas

Areas within the geographical limits of the project that corresponds to the category of natural savannas, in the periods of reference, that is mean at the beginning of the project activities, and at least five years before the start date of the project[5].

Herbaceous vegetation

Cover constituted by a plant community dominated by typically herbaceous elements developed naturally in different densities and strata, which form a dense cover (>70% occupancy) or an open cover (30% - 70% occupancy). An herbaceous plant is a non-lignified or barely lignified plant, so that it has a soft consistency in all its organs, both subway and epigeous (Font Queur, 1982) [6]..

GHG Project (Greenhouse gas project)

activity or activities that alter the conditions of a GHG baseline and cause GHG emissions reductions or GHG removals.

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

GHG Project holder (greenhouse gas project proponent)

individual or organization that has overall control and responsibility for a GHG project.

Note 1 to entry: The term "project proponent" is also used synonymously in the text.

[SOURCE: ISO 14064-2:2019(en), 3.3.2]

Greenhouse gas reservoir (GHG reservoir)

component, other than the atmosphere, that has the capability to accumulate GHGs, and to store and release them.

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[4] https://www.ser.org/

5Natural grasslands are currently showing an accelerated rate of loss, with an average value of 50% globally (Van der Valk AG (2006) The biology of freshwater wetlands. Oxford University Press, Oxford, UK). In response to the accelerated loss, a reference date of at least five (5) years is evaluated, in order to also be able to choose natural grasslands whose degradation is recent.

[6] FON QUER, P. (1982). En: Leyenda CORINE LAND COVER

Note 1 to entry: The total mass of carbon contained in a GHG reservoir at a specified point in time could be referred to as the carbon stock of the reservoir.

Note 2 to entry: A GHG reservoir can 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 storage of the collected GHG in a GHG reservoir could be referred to as GHG capture and GHG storage.

[SOURCE: ISO 14064-3:2019(en), 3.3.5]

Ecological integrity

Combination of ecosystem processes (functions) and biodiversity that characterize an area in a specific period. Maintaining the ecological integrity of an area implies the continuous provision of ecosystem goods and services[7].

High conservation value - HCV

Exceptionally significant or critical Biological, ecological, social, or cultural value.

Land use change

Land use changes in natural savannas, that constitute loss of natural cover. That is, changes generated by anthropic activities, which result in the conversion of natural vegetation covers to other land uses.

Leakages

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

Leakage Area

Natural vegetation cover areas, to which activities that generate land use change can be displaced and that are beyond the control of the project holder. That is the areas to which the agents that generate land use change can move, because of the project activities.

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[7] Bridgewater, P., Kim, R. & Bosselmann, K. (2015). Ecological Integrity: A Relevant Concept for International Environmental Law in the Anthropocene? Yearbook of International Environmental Law. 25. 61-78. 10.1093/yiel/yvv059.

Mineral soils[8]

Any soil that does not meet the definition of organic soil (see Annex 3A.5, Chapter 3, Volume 4 of the 2006 IPCC Guidelines).

Natural Forest (Forest)

"Forest" is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 meters at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest[9].

The GHG project holder must demonstrate the consistency of the eligibility analysis, in accordance with national forest definitions, following the criteria defined by the UNFCCC in its decision 11/COP.7.

Organic soils

According to FAO (definition adopted by IPCC)[10], they are soils with organic carbon content equal to or greater than 12%. Organic soils (e.g., peat and manure) have at least 12 to 20 percent organic matter by mass and thrive under poorly drained wetlands conditions.

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

1. Organic horizon thickness is greater than or equal to 10 cm. A horizon of less than 20 cm has 12 percent or more organic carbon when mixed to a depth of 20 cm.
2. Soils that are never saturated with water for more than a few days shall contain more than 20 percent organic carbon by weight (i.e., about 35 percent organic matter).
3. Soils are subject to water saturation episodes and have either:
    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

[8] https://www.ipcc-nggip.iges.or.jp/public/wetlands/pdf/Wetlands_separate_files/WS_Glossary.pdf
[9] UNFCCC. The Marrakesh Accords. Available in https://unfccc.int/sites/default/files/resource/docs/cop7/13a01.pdf
[10] Hiraishi, Takahiko, et al. "2013 supplement to the 2006 IPCC guidelines for national greenhouse gas inventories: Wetlands." *IPCC, Switzerland* (2014).

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

Permanence

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

Project Area

The area on which project activities that demonstrate net climate benefits are implemented. If a programmatic approach is used, the project area also includes all potential areas, that is, all new areas where project activities can be implemented after initial validation.

Project Start date

Date on which activities that will result in emission reductions or effective GHG removals begin. For GHG projects that apply this methodology, the start date corresponds to the date on which the implementation of the project activities begins to generate the reduction of emissions by avoiding land use changes in the eligible areas, within the limits of the project. These may be, for example, agreements with the actors who have the right to use the land and/or the initiation of management actions of the areas within the limits of the project.

Reference region

They are the geographical boundaries on which the historical patterns of land use changes are analyzed, which will be projected in the project area to obtain the land use change values, for the baseline scenario, in the project area.

Sandy soils[11]

It includes all soils (regardless of their taxonomic classification) that have >70% sand and <8% clay, based on standard texture analysis (in the FAO classification includes: Arenosoles, Sandy Regosols).

[11] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_03_Ch3_Representation.pdf

Savannas

Savannas are tropical or subtropical climate ecosystems, in which grasses abound and there are few trees and shrubs. They form part of the so-called grasslands together with prairies, differing from the latter in climate and species composition.

Shrubland

It includes the areas covered by shrub vegetation naturally developed in different densities and substrates. A shrub is a perennial plant, with a woody stem structure, with a height between 0.5 and 5 m, strongly branched at the base and without a defined crown FAO (2001) [12].

Soil carbon[13]

Organic carbon contained in mineral and organic soils (including peat) to a given depth chosen by the country and applied consistently throughout the time series. Live fine roots of less than 2 mm (or another diameter chosen by the country for underground biomass) are included with soil organic matter when they cannot be distinguished from the latter empirically.

Soil organic matter[14]

Soil organic matter comprises all organic materials of plant or animal origin, decomposed, partially decomposed and undecomposed. It is generally synonymous with humus, although the latter is more commonly used to refer to well-decomposed organic matter, referred to as humic substances. Soil organic matter is a primary indicator of soil quality.

Spodic soils (Spodosols)[15]

Spodosols are mineral soils that do not have a plaggen epipedon or an argillic or kandic horizon above a spodic horizon and have one or more of the following:

1. A spodic horizon, an albic horizon in 50 percent or more of each pedon, and a cryic soil temperature regime; or;

2. An Ap horizon containing 85 percent or more spodic materials; or;

[12] ORGANIZACIÓN DE LAS NACIONES UNIDAS PARA LA AGRICULTURA Y LA ALIMENTACION. 2001. Situación de los bosques del mundo 2001. FAO, Roma, 131 p. En: Leyenda CORINE LAND COVER
[13] IPCC Guidelines for national greenhouse gas inventories (2006)
[14] https://www.fao.org/3/ca7471es/ca7471es.pdf
[15] https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051232.pdf

3. A spodic horizon that has all of the following properties:

a. One or more of the following: (1) A thickness of 10 cm or more; or (2) An overlying Ap horizon; or (3) Cementation in 50 percent or more of each pedon; or (4) A coarse-loamy, loamy-skeletal, or finer particlesize class and a frigid temperature regime; or (5) A cryic temperature regime; and,

b. An upper boundary within the following depths from the mineral soil surface: either (1) Less than 50 cm; or (2) Less than 200 cm if the soil has a sandy or sandy skeletal particle-size class between the mineral soil surface and the spodic horizon; and

c. A lower boundary as follows:

(1) Either at a depth of 25 cm or more below the mineral soil surface, at the top of a duripan or fragipan, or at a densic, lithic, paralithic, or petroferric contact, whichever is shallowest; or

(2) At any depth,

(a) If the spodic horizon has a coarse-loamy, loamyskeletal, or finer particle-size class and the soil has a frigid temperature regime; or

(b) If the soil has a cryic temperature regime; and

d. Either:

(1) A directly overlying albic horizon in 50 percent or more of each pedon; or

(2) No andic soil properties in 60 percent or more of the thickness either:

(a) Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; or

(b) Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Underlying causes of land use change

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

Tropical zone

Tropical or Equatorial Climate Zone according to the Köppen climate classification and distribution. It is characterized by being humid and rainy.

Vegetation cover, different from natural forest

This coverage includes a vegetation group of a natural type and a natural succession's result, whose growth habit is shrubby and herbaceous, developed on different substrates and elevational floors, with little or no anthropic intervention. According to CORINE Land Cover legend, this class includes other cover types such as areas covered by mainly shrubby vegetation with an irregular canopy, shrubs, palms, vines, and low growing vegetation.

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 are restricted to wetlands where the water table is artificially changed (e.g., drained or raised) or those created through human activity"[16].

According the Ramsar Convention on Wetlands (Article 1)"wetlands are *areas of marsh, fen, peat, and or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters*." (Ramsar, 1971)[17].

7 Project boundaries

7.1 Temporal and spatial limits

7.1.1 Eligible areas

The GHG project holder shall demonstrate that the areas in the geographical boundaries of the Project are in the natural savanna's biome, in the category of herbaceous vegetation and shrublands, at the beginning of the project activities, and five years before the start date of the project. In this sense, the project holder shall:

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

(a) Ensure that the project boundaries are within the savanna biome and identify the ecoregion according to WWF classification (2012)[18].

(b) Identify, delimit and classify the savannas present in the project area, based on a cartographic analysis of land cover, using the Corine Land Cover methodology (or similar) at level 3, corresponding to the categories of herbaceous vegetation and Shrublands.

The project holder shall account with adequate geographic data and mapping information to assess land cover and land use during the historical reference period, based on digital processing of remotely sensed imagery. The minimum spatial resolution required is 30 m (as currently available with Landsat 8 products). The recommended resolution is 10 m or higher (as currently available with Sentinel-2A and 2B). For all satellite imagery used, established approaches to satellite data preprocessing should be applied.

7.1.2 Adding areas to the project after validation

Areas may be added to the project, after validation, 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 shall meet to be added to the project are:

   i) Comply with the guidelines of the BCR STANDARD, in the most recent version;

   ii) Include GHG emission reductions and removals, only for validated project activities[19];

   iii) Implement the activities to prevent land use change, described in the validated project document;

   iv) Causes and agents of land use changes, the baseline scenario and the Additionality conditions of the new areas shall be consistent with the characteristics validated for the initial areas;

   v) Have a start date after the start date of the areas included in the validation.

[18] WWF, 2012. Terrestrial Ecoregions of the World. Available at: https://www.worldwildlife.org/publications/terrestrial-ecoregions-of-the-world

[19] An activity excluded in the validation Cannot be contemplated as a new area.

7.1.3 **Reference region for baseline estimation**

The GHG project holder shall delineate a reference for estimating changes in natural vegetation cover (herbaceous and shrublands) in savanna areas, which could occur in the project area in the baseline scenario. The reference region should be similar to the project area in terms of access, land-use change drivers, land-use categories and/or land-use change, landscape configurations, environmental and socioeconomic conditions, and local/regional context.

The geographic boundaries of the reference area shall meet the following criteria:

a) the reference region and the project area are part of the same ecoregion[20];

b) drivers that generate land use changes identified in the reference region can access the project area;

c) the project area is of interest to the agents identified in paragraph b, above;

d) land tenure and land use rights in the region of reference are similar to the project area.

7.1.4 **Leakage area**

Areas corresponding to the categories of herbaceous and shrublands, in the savanna biome, to which activities that generate land use changes may be displaced to, beyond the project holder's control. That is, the areas to which the agents that generate land-use change may be displaced as a consequence of project activities.

The leakage area is delimited on the basis of the following criteria:

a) all areas of herbaceous and shrubland that are within the mobility range of the agents identified in section 9 (below) should be included.

b) exclude areas of restricted access to agents that generate changes in land use.

7.1.5 **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:

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[20] Región geográfica con determinadas características en cuanto a clima, geología, hidrología, flora y fauna. https://www.worldwildlife.org/biomes

(a) the project start date,

(b) the period of quantification of reductions, and

(c) the monitoring periods.

7.1.6 Historical period of land use change

The analysis of historical average land use changes for the reference region and for the leakage area should be performed between at least two dates (project start date and ten years prior to the project start date).

It is recommended to use official sources of land cover according to classification methodologies such as Corine Land Cover or similar to reduce inconsistencies with official data and uncertainty. As far as possible, use the base cartography of the country and adapt it to the temporal needs of the historical period.

7.1.7 Estimation of GHG emissions reduction/removal

The estimation of the project's emission reductions/removals corresponds to the project's quantification period, i.e., the period during which the GHG project holder will quantify the GHG emission reductions or removals, measured against the baseline, to request the issuance of Verified Carbon Credits (VCC).

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

7.2 Greenhouse gas reservoirs and sources

7.2.1 Greenhouse gas reservoirs

The Intergovernmental Panel of Experts on Climate Change (IPCC) foresees the estimation of changes in carbon stocks in the following reservoirs: aboveground biomass, belowground biomass, deadwood, litter, and soil organic carbon.

Project holders can choose one or more carbon reservoirs, as long as they provide transparent and verifiable information and demonstrate that such a choice will not lead to an increase in GHG emission reductions, quantified by the project.

The choice of carbon pools to quantify carbon stock changes at the project boundaries is shown in Table 1.

Table 1. Greenhouse gas reservoirs

Carbon pool	Selected (Yes/No/Optional)	Justification
Aboveground biomass	Yes	The change in carbon content in this pool is significant, according to the IPCC.
Belowground biomass	Yes	The change in carbon content in this pool is significant, according to the IPCC.
Deadwood	Optional	The change in carbon stocks in this reservoir may increase due to project activities.
Litter	Optional	The change in carbon stocks in this reservoir may increase due to project activities.
Soil organic carbon	Optional	The change in carbon stocks in this reservoir may increase due to project activities.

7.2.2 GHG sources

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

Table 2. Emission sources and GHG

Source	GHG	Selected (Yes/No)	Justification
Burning of woody biomass [21]	CO_2	No	CO_2 emissions due to woody biomass combustion are not quantified as changes in carbon stocks.
	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.

8 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[22] sector, the project holder

[21] 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

[22] In the Executive Board Decisions, it is noted: Afforestation and Reforestation, however, the scope of this methodology also applies to REDD+ Projects.

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[23]:

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:

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

[23] Adapted of "Combined tool to identify the baseline scenario and demonstrate additionality" (Report EB35, Annex 19).

(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 GHG 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 Drivers of land use change

The project shall identify, describe and analyze the drivers that generate changes in land use, in the project area as an input to:

(a) design activities to reduce land use change;

(b) define strategies, measures and actions to improve management practices for savanna ecosystems; and,

(c) delimit the reference area.

This methodological document suggests the application of the conceptual guidelines for the characterization of drivers of deforestation and forest degradation proposed by the UN-REDD Programme[24]. The change of natural vegetation from savanna ecosystem to other land uses would be the equivalent to the mention of deforestation and forest degradation.

The key elements for developing a characterization of causes and agents of land use change are described below.

[24] United Nations Environment Programme, 2018. Drivers of deforestation and forest degradation. Available in https://www.un-redd.org/sites/default/files/2021-10/UN-REDD%20ACADEMY%203_ES_Low%20res.pdf

9.1 Spatial and temporal dimensions

The land use change has spatial and temporary dimensions that shall be characterized. In the spatial terms is necessary to know and analyze the phenomenon's location and extent (project area and proposed reference region). Understanding its temporal dimension allows understanding the land use change 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 contexts 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.

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 cover.

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 coverage.

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 have 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 should be designed based on the results of the analysis of the identified drivers as described in section 9 (above). In addition, it should consider what has been established by the communities (if applicable), based on the participatory construction. The design of each project activity should include, at a minimum, 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[25], goal[26], unit of measurement, and responsible for measurement.

11 GHG emission reduction from project activities

11.1 Estratificación

In order to improve accuracy with respect to the estimation of carbon stock changes, if the distribution of biomass in the project areas is not homogeneous, a stratification process should be carried out in order to improve accuracy with respect to biomass estimates.

The project holder shall determine different strata for the baseline scenario and for the with-project scenario. This optimizes the accuracy in estimating GHG emission reductions and removals (where applicable).

The present methodology recommends stratification using levels 4 or higher of official land classification methodologies or use satellite remote sensing methodologies

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

supported with field data such as that developed by Lopez et al (2020)[27] or Dixon et al (2014)[28].

11.2 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 7.1.3.

These activity data include changes in vegetation cover associated with areas identified as herbaceous and shrubs in the project area.

11.2.1 Estimation of the land use change

The project holder shall carry out the land use analysis[29] between at least two dates (project start date and ten years before that start date).

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 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[30] 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.

This process should be supported by cartographic inputs for the period of analysis, based on the following recommendations:

(a) Collect data that will be used to analyze land use changes on natural savanna vegetation cover, during the historical reference period within the project boundaries. It is a good practice to perform this for at least three time points, (3) to (5) years apart.

[27] Lopes, M., Frison, P.-L., Durant, S.M., Schulte to Bühne, H., Ipavec, A., Lapeyre, V. and Pettorelli, N. (2020), Combining optical and radar satellite image time series to map natural vegetation: savannas as an example. Remote Sens Ecol Conserv, 6: 316-326. https://doi.org/10.1002/rse2.139

[28] Dixon A.P., Faber-Langendoen, D., Josse, C., Morrison, J., Loucks, C.J. (2014) Distribution mapping of world grassland types. Journal of Biogeography. Disponible en: https://www.worldwildlife.org/publications/world-grassland-types

[29] The GHG project holder shall present the methodology used in the delimitation of natural covers and changes to other land uses change.

[30] 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.

(b) Select spatial data of medium resolution (from 10 meters to a maximum of 30 meters spatial resolution) from optical and radar sensor systems, such as (but not limited to) Landsat, SPOT, ALOS, AVNIR2, ASTER, Sentinel 1 and 2, among others, covering the last 5 -10 years.

(c) Collect high-resolution remotely sensed data (< 5 x 5 meters per pixel) and/or direct field observations for validation of maps on the terrain. Describe the type of data, coordinates and sampling design used to collect them.

(d) In tabular format (**¡Error! No se encuentra el origen de la referencia.**), provide information on the data collected.

Table 3. Characterization of the cartographic inputs

Vector (Satellite o airplane)	Sensor	Resolution		Covering	Date of acquisition	Scene or identification point	
		Spatial	Spectral	(Km²)	(DD/MM/YYYY)	Path/Latitude	Row/Longitude

When interpreted data with adequate spatial and temporal resolution are available, they can also be considered for further analysis[31]. To complete the land cover analysis, it is recommended to classify the natural land cover with the strata defined in numeral 11.1.

Validation processes for the treatment of satellite images and geographic data should be supported by international standards such as ISO, OGC or the American Society for Photogrammetry and Remote Sensing.

The detailed methodological procedures used in the pre-treatment, classification, post-classification processing and accuracy assessment of the remote sensing data should be carefully documented in a technical annex. In particular, the following information should be documented:

[31]Existing maps should be used by performing a full quality validation of these. As they often do not report on documentation, error estimates, whether they were obtained by change detection techniques rather than by comparison of static maps, etc. If historical land cover and land use change data are already available, information on the minimum mapping unit, the methods used to produce these data, and descriptions of cover and use classes, category changes should be compiled, including how these classes can be matched to cover classes and categories.

i. Data sources and pre-processing[32]

ii. Data classification and further processing[33]

The assessment of classification accuracy that ensures the quality of land cover and land use maps should be above 90%.

As a result of this analysis, a matrix of land cover change is obtained, which combines all defined land cover classes in which land use changes are evident. A table should list the resulting categories of change between the initial and final period. Additionally, it should contain the area data for each of the periods and their totals.

Table 4. Matrix of land cover change and use [34]

IDcl		Initial Classes Coverage/Use			
		I1	I2	I3	I4
Final Classes Coverage	F1				
	F2				
	F3				
	F4				

11.2.2 Historical land use change in the reference area

This equation estimates the annual historical land use change without project scenario[35]:

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

Where:

$SCNC_{yr}$ = Change in the area under natural vegetation cover in the without project scenario; ha yr^{-1}

[32] Specify type, resolution, source and date of acquisition of remote sensing data (and other data) used; geometric, radiometric and other corrections made; spectral bands and indices used (such as NDVI); projection and parameters used to geo reference images; error estimate of geometric correction; software version and software used to perform pre-processing tasks; etc.

[33] Definition of land cover and land use classes and categories of change; classification approach and classification algorithms; coordinates and description of ground-truthing data collected for training purposes; ancillary data used in classification, if any; software and software version used to perform the classification; additional spatial data and analysis used for post-classification analysis, including class subdivisions using spectral criteria, if any; etc.

[34] Each class will have a unique identifier (IDcl). The methodology sometimes uses the notation icl (= 1, 2, 3, ... Icl) to indicate the initial coverage classes; and fcl (= 1, 2, 3, Fcl) to indicate the final classes. All initial and final classes are listed in this table.

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

$t_2 =$ 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.

11.2.3 Projection of annual changes in land use in the project scenario

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

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

Where:

$SCNC_p$[36] = 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.

In the project area, different rates of change in the area with natural vegetation cover are estimated for each stratum. The land covers should be presented using the following table:

Table 5. Land use/coverage units in the project area

Coverage		Description	Area per year			
			1	2	...	t
ID_i	Name		ha	ha	ha	ha
1						
2						
...						
n						

11.2.4 Historical land use changes in the leakage area

The annual historical land use change 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

This evaluation results in a matrix of cover change that combines all the defined classes. The following table should show the resulting categories of change.

Table 6. Matrix of changes in vegetation cover in the leakage area

IDcl		Initial Classes Coverage/Use			
		I1	I2	I3	I4
Final Classes Coverage	F1				
	F2				
	F3				
	F4				

11.2.5 Projected 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.

In the leakage area, different rate of change in the area with natural vegetation cover can be estimated, if a stratification process has been carried out[37]. The resulting land cover units should be summarized in a table as follows.

Table 7. Land use/coverage units in the leakage area

Coverage		Description	Area per year			
			1	2	…	t
ID_i	Name		ha	ha	ha	ha
1						
2						
…						
n						

11.3 Emissions factor

The emission factors correspond to the carbon stocks in the reservoirs considered. The project holder shall submit a detailed description of the estimate of changes in carbon stocks in these reservoirs, in accordance with IPCC guidelines, and demonstrate that their use does not lead to overestimation of emissions at baseline.

Emission factors are determined based on IPCC good practices, under the following assumptions:

- Belowground biomass is included differentially to soil organic carbon content.
- 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.

[37] Coverages or strata can be static (with fixed boundaries) or dynamic (with boundaries that change over time)

- A gross emission is assumed in which the soil carbon content (SOC) at 30 cm[38] is emitted in equal proportions for 20 years after the land use change event occurs.

11.3.1 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; $t\ ha^{-1}$
CF	=	Carbon fraction of the dry matter (0,47)
$\frac{44}{12}$	=	The molecular ratio constant between carbon (C) and carbon dioxide (CO_2)

11.3.2 Emission factor of soil organic carbon (SOC)

Annual rates of soil organic carbon emissions can be determined by the following options: (a) using default values, (b) project own estimates. These are described below.

(a) Using default values

The IPCC acknowledges that "*it is good practice to use the default reference value for carbon stocks (SOC_{REF}) indicated in Table 3.3.3*" of the IPCC Good Practice Guidance for LULUCF (Tier 1).

Mineral soils

The default values for SOC (in mineral soils) are found in *Table 8*.

[38] The project holder may include the estimation of SOC at a depth greater than 30 cm. In this case, the SOC estimation shall be performed in areas with and without natural cover and the difference in SOC between both covers shall be used in the equation presented in section 11.3.2.

Table 8. Default reference (under native vegetation) soil organic C stocks (SOCREF) in tonnes C per ha for 0 - 30 cm depth

Region	HAC soils[1]	LAC soils[2]	Sandy soils [3]	Spodic soils[4]	Volcanic soils [5]	Wetland soils [6]
Boreal	68	NA	10#	117	20#	146
Cold temperate, dry	50	33	34	NA	20#	87
Cold temperate, moist	95	85	71	115	130	
Warm temperate, dry	38	24	19	NA	70#	88
Warm temperate, moist	88	63	34	NA	80	
Tropical, dry	38	35	31	NA	50#	86
Tropical, moist	65	47	39	NA	70#	
Tropical, wet	44	60	66	NA	130#	

Note: Data are derived from soil databases described by Jobbagy and Jackson (2000) and Bernoux et al. (2002). Mean stocks are shown. A default error estimate of 95% (expressed as 2X standard deviations as percent of the mean are assumed for soil-climate types. NA denotes 'not applicable' because these soils do not normally occur in some climate zones.

# indicates where no data were available and default values from IPCC Guidelines were retained.

[1] Soils with high activity clay (HAC) minerals are lightly to moderately weathered soils, which are dominated by 2:1 silicate clay minerals (in the World Reference Base for Soil Resources (WRB) classification these include Leptosols, Vertisols, Kastanozems, Chernozems, Phaeozems, Luvisols, Alisols, Albeluvisols, Solonetz, Calcisols, Gypsisols, Umbrisols, Cambisols, Regosols; in USDA classification includes Mollisols, Vertisols, high-base status Alfisols, Aridisols, Inceptisols).

[2] Soils with low activity clay (LAC) minerals are highly weathered soils, dominated by 1:1 clay minerals and amorphous iron and aluminium oxides (in WRB classification includes Acrisols, Lixisols, Nitisols, Ferralsols, Durisols; in USDA classification includes Ultisols, Oxisols, acidic Alfisols).

[3] Includes all soils (regardless of taxonomic classification) having > 70% sand and < 8% clay, based on standard textural analyses (in WRB classification includes Arenosols,; in USDA classification includes Psamments).

[4] Soils exhibiting strong podzolization (in WRB classification includes Podzols; in USDA classification Spodosols)

[5] Soils derived from volcanic ash with allophanic mineralogy (in WRB classification Andosols; in USDA classification Andisols)

[6] Soils with restricted drainage leading to periodic flooding and anaerobic conditions (in WRB classification Gleysols; in USDA classification Aquic suborders)

Source: Good Practice Guidance for Land Use, Land-Use Change and Forestry [39]

<u>*Organic soils*</u>

According to the IPCC, "*When estimating emissions from organic soils that have been modified through artificial drainage and other practices for use as managed grassland, an emission factor (EF) is required for different climatic regimes. Default emission factors, unchanged from the IPCC Guidelines, are provided in Table 3.4.6. Natural, 'wetland'*

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

grasslands that may be used for seasonal grazing but have not been artificially drained are excluded." The annual emission factors (EF) for managed grassland organic soils are shown int Table 9.

Table 9. Annual emission factors (EF) for managed grassland organic soils

Climatic temperature regime	IPCC Guidelines default (tonnes C $ha^{-1}yr^{-1}$)	Error(1)
Cold Temperate	0.25	±90%
Warm temperate	2.5	±90%
Tropical/sub-tropical	5.0	±90%
(1)Represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean		

Source: Good Practice Guidance for Land Use, Land-Use Change and Forestry[40]

It will be assumed that the emissions continue as long as aerobic organic layer subsists and the soils is considered organic soil.

(b) project-specific data

Project holders which develop their own emission factors should provide scientifically based evidence of their reliability and representativeness, document the experimental procedures used to derive them, and provide uncertainty estimates.

Soil carbon stocks shall be determined from measurements. These should be carried out separately for each soil mapping unit identified within the project boundaries. For estimating SOC from project data, a methodology that meets the technical and statistical rigor appropriate for this type of estimation should be used. It is suggested to use the method described in **Annex 1** of this document.

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 according to the following equation.

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

Where:

[40] Ibid, p. 3.42

$SOCeq$ = 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)

11.4 GHG emissions 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; $tCO_2\ ha^{-1}$

$SCNC_{project}$ = Land use change in the project scenario; $ha\ yr^{-1}$

CBF_{eq} = Carbon dioxide equivalent in total biomass; $tCO_2e\ ha^{-1}$

SOC_{eq} = Carbon dioxide equivalent in soil; $tCO_2e\ ha^{-1}$

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}

11.4.1 Emissions of other GHG

If the project holder identifies the presence of fires in the tree component during the monitoring period, the project holder shall quantify the CH_4 and N_2O emissions caused by the combustion of woody biomass, considering the guidelines presented in the IPCC (2006) guidelines for national GHG inventories.

Biomass burning is the major natural (or semi-natural) source of non-CO2 gas production, the amount released can be estimated using emission factors based on the amount of carbon released[41].

The quantification of CH_4 and N_2O emissions caused by woody biomass combustion shall take into consideration the guidelines presented in the IPCC (2006) guidelines for national GHG inventories. CH_4 and N_2O emissions are calculated using the following equations:

$$Emissions\ of\ CH_4 = Carbon\ released\ x\ 0{,}016\ x\ CO_2EFM$$

Where:

CO2EFM= Carbon dioxide equivalent factor of 21

$$Emissions\ of\ N_2O = Carbon\ \text{released} * 0{,}00011 * CO_2EFN$$

Where:

CO2EFN= Carbon dioxide equivalent factor of 310

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

11.5 Expected GHG emissions reduction due to project activities

Emission reductions from avoided land use changes in natural savanna's 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; $tCO_2e\ yr^{-1}$

12 Uncertainty management

According to GOFC-GOLD (2016)[42], "*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 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%*".

Under the BCR STANDARD, uncertainty management is determined by the accuracy of the maps used to estimate activity data values and the application of discounts in emission factors.

For activity data, accuracy should be greater than 90%. The accuracy assessment should be made from the use of field observations or analysis of high-resolution imagery.

[42] 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.

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[43].

Regarding carbon stocks in soils, according to the IPCC (2006)[44] "*There are three major sources of uncertainty in soil C inventories:*

> *(1) uncertainties in data on land use and management activity and the environment;*
>
> *(2) uncertainties with reference to stocks of C in the soil if Tier 1 or 2 methods are used (mineral soils only); and*
>
> *3) uncertainties in stock change and emission factors for Tier 1 or 2 methods, error in model structure/parameters for Tier 3 model-based methods, or measurement/variability errors in sampling related to inventories based on Tier 3 measurements.*

In general, the accuracy of an inventory is increased (e.g., lower confidence intervals) with greater sampling to estimate values for the three general categories. In addition, it is more feasible to reduce bias (i.e., improve accuracy) by developing a higher-level inventory that includes country-specific information."

12.1 Conservative selection of default values

According to the CDM Executive Board guidelines[45], GHG project holders should ensure that the application of default data for the estimation of removals results in conservative (but not overly conservative).

When using default data to estimate the net anthropogenic GHG removals by sinks, the following guidance should be applied when selecting sources of data:

- If an approved A/R CDM methodology requires application of a default value and provides its numerical value, then the value shall be considered as the conservative one;
- Values should if possible be species-specific, with selection from the following data sources (given in order of priority; highest first):
    - Local peer-reviewed studies under similar climate/soil conditions provided the smaller datasets typical of local studies are considered sufficiently reliable; or

[43] The project holder may use data from scientific studies that have less than data uncertainty than 10%.
[44] https://www.ipcc-nggip.iges.or.jp/public/2006gl/spanish/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf
[45] https://cdm.unfccc.int/Reference/Guidclarif/ar/methAR_guid26.pdf

- Regional or national forest or GHG inventory for the same ecological zone (that is, the same broad climate zone, and similar soil fertility and depth); or
- International or global forest or GHG inventory, including IPCC literature, for the same ecological zone.

- If species-specific default data are not available, data may be selected from studies in the same ecological zone for the same genus 1 and regarded as conservative. Default data may also be selected from studies in the same ecological zone for the same family, provided the applicability of the data is checked (see Section 3.c. (i), in the AR Guideline). The priority for selection of default data sources should be that given in the bullet point above.

13 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.

13.1.1 Monitoring of the project boundary

The Project's geographic limits, constituted by the eligible areas[46] 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.

[46] Eligible areas refer to areas that meet the condition of presence of natural cover, on the reference dates established by the BCR STANDARD.

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 described in section 11.2.

13.1.2 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 10. Monitoring of the project activities implementation

Activity ID	
Indicator ID	
Indicator name	
Type[47]	
Goal[48]	
Measurement unit	
Monitoring methodology	
Monitoring frequency	
Responsible for measurement	
Result indicator in the reporting period	
Documents to support the information	
Observations	

13.1.3 Monitoring of the permanence of the 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. 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.

[47] Result, product or impact.
[48] Expected value and time for compliance.

13.1.4 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 11.2.

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:

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

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:

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

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, 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

13.2 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[49]. 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.

13.2.1 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

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

(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.

13.2.2 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), 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.

ANNEX A. Direct estimation of carbon stock in natural savannas

Based on the identification of land covers and the analysis of geographic and ecological information for the delimitation and classification of savannas ecosystem, field sampling is defined. Direct carbon estimation from field measurements allows emission factors in the project boundary. This estimate consists of three stages:

Measuring plan

For the quantification of carbon stocks, a measuring plan shall be developed, based on the following steps:[50]

a) Define project boundaries (Section 7).

b) Stratify project area (Section 11.1).

c) Select the greenhouse gas reservoirs to measure (Section 7.2)

Sampling plots

The delimitation and stratification of the project area give rise to the strata polygons. On these, the type of sampling to be carried out is defined: systematic (Figure 1.a), random (Figure 1.b) or in transect (Figure 1.c), it is defined considering the different types of land cover, in general, systematic sampling is recommended. In the event of steep slopes, transect sampling is recommended. The spacing of the points is given by the spatial scale.

Sampling precision is required to be within (10%) of the true value of the mean, with a 95% confidence level[51.] Field data and samples shall be representative of the different systems and taken independently.

The new number of plots is calculated as follows[52]:

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[50] Pearson, T., Walker, S. & Brown, S. (2005). Sourcebook for Land use, Land use change and forestry projects. Winrock International. 11-33 pp. Additionally, the project must take into account the IPCC Good Practices Guide for land use, land use change and forestry.

[51] Cisneros-de la Cruz D.J., J. A Herrera-Silveira, C. Teutli-Hernández, S.A Ramírez-García, A. Moreno-Martínez, J. Mendoza-Martínez, J. Montero-Muñoz, F. Paz-Pellat, R. M. Roman-Cuesta. 2021. Manual for the Measurement, Monitoring and Reporting of Carbon and Greenhouse Gases in Mangroves under Restoration. Project, Mainstreaming Wetlands into the Climate Agenda: A multi-level approach (SWAMP). CIFOR/CINVESTAVIPN/UNAM-Sisal/PMC, 90pp.

[52] A useful tool for calculating the number of plots is available at http://www.winrock.org/Ecosystems/tools.asp (Winrock International 2011). To use the tool, enter the desired precision and the number, area, mean carbon density, and coefficient of variation for each stratum.

$$(n) = ((t * s)/E)^2$$

Where:

n: number of plots

t: statistic of the t distribution for the 95% confidence interval, t is generally 2, because the sample size is unknown.

s: expected or known standard deviation of previous or initial data.

E: admissible error in the first half of the confidence interval, obtained by multiplying the average of the carbon stock by the desired precision, i.e. * 0.1 (10% accuracy).

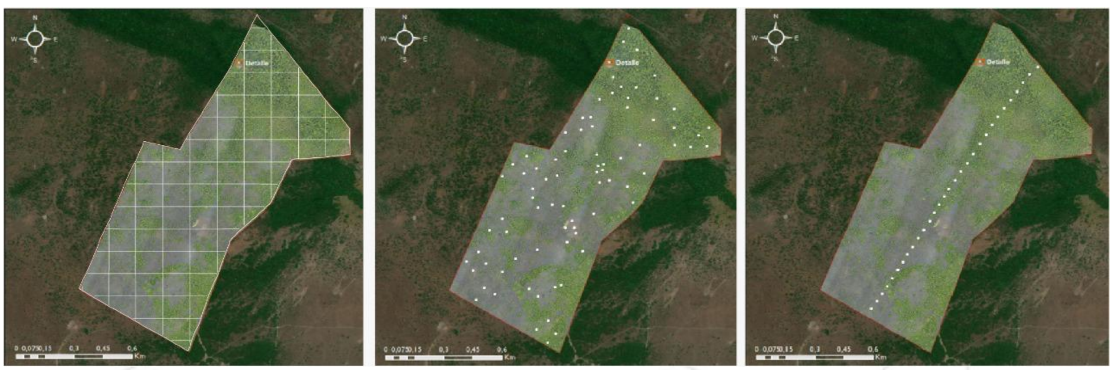

Figure 1. Sampling a) systemic, b) random, c) in transect

Schedule the field work period according to the climatic conditions in the project area, it is suggested to take data and samples at least once a year, at the end of the dry season. In case of two or more dry seasons per year, it should be done at the end of the dry period of the year. At that time the net value of carbon stock, especially in the soil, after the potential increase in the wet months and loss in the dry season, remains.

On-site measurements

Locate in the site the pre-established sampling points, according to the delimitation and stratification of the project area, following the guidelines below.

a) Soil

Take the soil samples using a sediment sampler. It is suitable to collect the samples at 1 m deep or more, segmented as follows: 0-30, 30-50, 50-100 cm, to ensure that the entire organic layer is measured. However, at least the 0-30 cm deep segment must be sampled.

b) Herbaceous biomass and litter

Delimit the sample of herbaceous biomass and litter using a quadrant with a defined area (0.25 m^2, 0.50 m^2 o 1.00 m^2).

Collect manually or with the help of a cutting tool, all the biomasses found inside the quadrat. In the case of using the smallest quadrat, a composite sample, meaning one sample integrated by at least three different samples, should be taken.

In wetland areas with water-rooted aquatic plants, it is recommended to use quadrats with high edges in order to delimit the biomass within the water column. In deep vegetated areas, a quadrat of floating material is recommended.

Samples shall be individually packaged, duly labeled with a pre-established code system, which identifies the sampling point. They should be stored and transported in a cool or refrigerated place.

c) Shrub woody biomass

Regarding the deposits of woody, shrub, and dead wood biomass, it is preferable the use of the methodology proposed by Kauffman et al. (2016), for both on site measurements and laboratory analysis and calculations. Estimated carbon contents for these pools should be added to the sum of the Total Biomass (TB).

Laboratory analysis

a) Soil

Soil samples should be dried at 60ºC until they are free of moisture to ensure their preservation. Subsequently, they should be sieved with a 2 mm sieve to remove the remains of belowground biomass (>2 mm). Samples have to be sent to the laboratory for final preparation and subsequent CNH[53] elemental analysis by combustion. The quantity of sample to be sent and other details of sample preparation for analysis (grinding and sieving) must be coordinated with the laboratory performing the analysis. A portion of the sample should be reserved as a contra sample to be used in case of sample loss or in case a repeat analysis is required.

The density in the different soil segments of the soil section sampled must be calculated. This datum is important to be enable the carbon content to be quantified. Density is measured by taking a soil sample of defined volume, taking care not to alter the soil volume, for example, by compacting the sample. Once the sample is completely dry, it is weighed, and the density is calculated as follows:

[53] CNH (Carbon, Nitrogen and Hydrogen)

DAs = Dry weight (g) / Wet sample volume (cm^3)

$$DAs = \frac{dry\ weight\ (g)}{Wet\ sample\ volume\ (cm^3)}$$

Where:

DAs= Soil bulk density (gr/cm^3) (*Bulk density)*

History of document

Type of document

Methodological document Project activities that prevent land use change in natural savannas

Version	Date	Nature of the document
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