Blue Carbon Methodology

BCR0012

Methodology for Quantifying GHG Emission Reductions and Removals from the Conservation, Restoration and Sustainable Management of Blue Carbon Ecosystems

Applicable to mangroves, tidal marshes, and seagrass meadows

BioCarbon Cert®

Version Public Consultation | September 3, 2025

BioCarbon Cert

www.biocarbonstandard.com

BIOCARBON CERT. 2025. Blue Carbon Methodology. Methodology for Quantifying GHG Emission Reductions and Removals from the Conservation, Restoration and Sustainable Management of Blue Carbon Ecosystems. Applicable to mangroves, tidal marshes, and seagrass meadows. Public Consultation Version. September 3, 2025. 68 p. http://www.biocarbonstandard.com

Table of contents

List of tables

Acronyms and abbreviations

AFOLU	Agriculture, Forestry and Other Land Uses
AGB	Aboveground biomass
BGB	Belowground biomass
CDM	Clean Development Mechanism
CF	Carbon fraction of the dry matter
CH_4	Methane
CO_2	Carbon dioxide
CO_{2e}	Carbon dioxide equivalent
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse Gases
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
N_2O	Nitrous oxide
QA/QC	Quality Assurance/Quality Control
SOC	Soil organic carbon
UNFCCC	United Nations Framework Convention on Climate Change
VCC	Verified Carbon Credit

1 Introduction

This methodology provides project holders with the normative requirements, procedures, models, parameters, and data necessary to quantify and monitor greenhouse gas (GHG) emission reductions and removals attributable to activities that conserve, restore, or sustainably manage Blue Carbon ecosystems. These ecosystems include mangroves, tidal marshes, seagrass meadows, and other intertidal wetlands that are characterized by high rates of carbon sequestration and long-term storage of carbon in biomass and soils.

The methodology covers aspects related to the definition of eligible Blue Carbon activities, spatial and temporal boundaries, agents and drivers of ecosystem degradation or conversion, identification of the baseline scenario and demonstration of additionality, quantification of emission reductions and removals, uncertainty management, risk and leakage management, non-permanence provisions, and compliance with social and environmental safeguards.

This methodology is globally applicable and has no geographical limitation, provided that the project area meets the applicability conditions defined in this document.

Project holders applying this methodology shall follow the requirements of the BioCarbon Standard and its associated tools. Methodological deviations may be proposed, provided that they comply with the principles set forth in ISO 14064-2, applicable national legislation, and are approved by BIOCARBON prior to validation.

This methodology shall be used by Blue Carbon project holders to seek certification and registration under the BIOCARBON STANDARD.

2 Objectives

The objective of this methodology is to provide project holders with the requirements, procedures, and tools to:

(a) Quantify greenhouse gas (GHG) emission reductions and removals generated by project activities in Blue Carbon ecosystems, including mangroves, tidal marshes, and seagrass meadows;

(b) Establish a credible and conservative baseline scenario representing expected emissions and removals in the absence of the project;

(c) Demonstrate additionality by proving that project activities go beyond legal obligations, common practice, and business-as-usual scenarios;

(d) Ensure environmental integrity through the comprehensive accounting of relevant carbon pools (aboveground biomass, belowground biomass, and soil organic carbon), and where significant, non-CO_2 gases such as CH_4 and N_2O;

(e) Address permanence risks by requiring risk assessment and the establishment of a buffer reserve to compensate for potential reversals caused by natural or anthropogenic disturbances (e.g., sea-level rise, storms, or coastal erosion);

(f) Identify and account for leakage that may result from the displacement of activities affecting other coastal ecosystems;

(g) Provide monitoring, reporting, and verification (MRV) requirements that allow transparent, replicable, and conservative quantification of net GHG benefits;

(h) Safeguard social and environmental co-benefits, including biodiversity conservation, coastal protection, and sustainable livelihoods for local communities;

(i) Ensure consistency with the BioCarbon Standard, the IPCC 2006 Guidelines and 2013 Wetlands Supplement, and national requirements;

(j) Facilitate the articulation of the Project accounting with national accounting, if applicable;

3 Scope

This methodology applies to project activities that reduce greenhouse gas (GHG) emissions or enhance carbon removals by conserving, restoring, or sustainably managing Blue Carbon ecosystems, including mangroves, tidal marshes, and seagrass meadows. The scope of this methodology covers the following.

3.1 Ecosystem types

Mangrove forests (including both aboveground and belowground biomass and soils), coastal tidal marshes, seagrass meadows.

3.2 Project activities

(a) Conservation of existing Blue Carbon ecosystems under threat of degradation or conversion;

(b) Restoration of degraded ecosystems, including hydrological restoration, revegetation, and replanting; and,

(c) Sustainable management practices that enhance long-term carbon storage and ecosystem resilience.

3.3 Carbon pools considered

(a) Aboveground biomass, belowground biomass (roots), and soil organic carbon (SOC) (Mandatory);

(b) Dead wood and litter, when significant and measurable (Optional).

3.4 GHG gases included

(a) Mandatory: CO_2;

(b) Optional (where significant): CH_4 and N_2O, particularly in waterlogged soils and managed wetlands.

This methodology is applicable worldwide, with no geographical restriction, provided that the ecosystems meet the eligibility conditions and the project complies with the BIOCARBON STANDARD and applicable national regulations.

4 Version and validity

This document constitutes the Public Consultation Version. September 3, 2025.

This document is published for public consultation. Comments received during the consultation period will be considered to prepare the final Version 1.0 of this methodology. Only the official Version 1.0, once approved and published, shall be applicable for validation, verification, and credit issuance under the BIOCARBON STANDARD.

5 Applicability conditions

This methodology is applicable to project activities that meet all of the following conditions:

5.1 Ecosystem type

(a) The project area shall consist of Blue Carbon ecosystems, specifically mangroves, tidal marshes, or seagrass meadows;

(b) The area shall be clearly mapped and georeferenced, with stratification by ecosystem type where applicable;

5.2 Project activities

Eligible activities include:

(a) Conservation of existing ecosystems under threat of degradation or conversion;

(b) Restoration of degraded ecosystems, including hydrological restoration, revegetation, and replanting;

(c) Sustainable management practices that maintain or increase carbon stocks.

Activities shall not include large-scale conversion of ecosystems to other land uses, or the introduction of invasive or non-native species.

5.3 Baseline scenario

The project area shall be subject to an identifiable risk of degradation or loss (e.g., conversion to aquaculture, agriculture, urban infrastructure, or other non-wetland uses; hydrological alteration; unsustainable harvesting; erosion; pollution).

Areas where there is no plausible threat or risk of degradation are not eligible.

5.4 Legal and regulatory compliance

(a) Project activities shall not be mandated by law or regulation;

(b) The project shall demonstrate secure rights to implement the activities and to claim the associated GHG benefits, including tenure, access, or formal agreements.

5.5 Projects in legally protected areas

The mere existence of a protected-area designation shall neither preclude project eligibility nor suffice to demonstrate additionality. Eligibility shall be established only where project activities materially exceed applicable legal requirements, where the competent authority participates in the project governance structure and provides explicit written consent, and where the resulting climate benefits are measurable, reportable, and verifiable.

In consequence, projects located within legally protected areas may be eligible provided that: (i) the project actions are not legally required or materially exceed any applicable legal obligations (regulatory surplus); (ii) the baseline scenario demonstrates ongoing or likely degradation or loss in the absence of the project; (iii) the competent authority confirms that the actions are not mandated and/or not funded as part of its statutory duties; and (iv) all other eligibility, additionality and MRV requirements of this Methodology and the BioCarbon Standard are met. Credits intended for CORSIA or Article 6 use shall comply with program-specific rules (e.g., Host Party authorization, "*inside/outside NDC*", and corresponding adjustments where applicable).

In this context, projects located within legally protected areas may be eligible provided that all of the following conditions are met:

(a) Regulatory surplus: Project actions are not legally required or materially exceed any applicable legal obligations. The legal framework and the specific obligations applicable to the project area shall be identified and demonstrated in the Project Document;

(b) Baseline credibility: The baseline scenario shows ongoing or likely degradation or loss in the absence of the project, supported by verifiable evidence (e.g., remote sensing, field reports, enforcement records, or peer-reviewed/lawful sources);

(c) Authority participation and consent: The competent management authority of the legally protected area shall (i) participate in the project governance structure, contributing to decision-making during project formulation and implementation (without the obligation to provide financial resources), and (ii) provide an explicit written statement confirming its agreement with the implementation of the project;

(d) Competent authority confirmation: A written statement (or equivalent official documentation) from the competent management authority confirms that the proposed actions are not mandated and/or not funded as part of its statutory duties, and that the project does not substitute existing committed public expenditure;

(e) Additionality and MRV: All other eligibility, additionality, quantification, monitoring, and verification requirements of this Methodology and the BioCarbon Standard are met, including leakage, permanence, and safeguards.

5.6 Environmental and social safeguards

(a) The project shall not cause significant negative impacts o biodiversity, ecosystem services, or local livelihoods:

(b) Activities shall comply with the BioCarbon Sustainable Development Safeguards (SDS) and national environmental and social regulations.

5.7 Carbon pools and GHGs

The methodology is applicable only where project activities maintain or enhance at least the following carbon pools: aboveground biomass, belowground biomass, and soil organic carbon.

Non-CO_2 gases (CH_4, N_2O) shall be included if significant, as determined by IPCC guidelines.

5.8 Exclusions

(a) Projects that rely on draining wetlands, large-scale dredging, or other practices inconsistent with ecosystem integrity are excluded;

(b) Projects that use non-renewable biomass or that generate significant leakage outside the project boundary are not eligible.

6 Normative references

The following documents are integral to the application of this Methodology. All references shall be applied in their latest version in force at the time of project validation, unless otherwise approved by BioCarbon. In case of future updates to these tools and standards, project holders shall adopt the revised versions as instructed by BioCarbon, including during baseline reassessment and revalidation stages.

6.1 Applicable Standards and Guidelines

The following external and internal references shall be used for the implementation of this methodology:

(a) The BCR STANDARD;

(b) IPCC Guidelines for National Greenhouse Gas Inventories (2006, 2019), Vol. 4 – AFOLU;

(c) Applicable national GHG legislation and land-use regulations;

(d) Relevant decisions from the UNFCCC, ICAO-CORSIA (ICAO, 2024)[1], and the Paris Agreement Article 6 mechanisms (UNFCCC, 2015)[2];

(e) ISO 14064-2 (ISO, 2019a) and ISO 14064-3 (ISO, 2019b), for project-level GHG quantification and verification.

[1] For use in the Carbon Offsetting and Reduction Scheme for International aviation (CORSIA), emission units shall comply with CORSIA program eligibility and vintage requirements as set by the BioCarbon Rules.

[2] Where mitigation outcomes are intended for international transfer under Article 6, the Project Document and Monitoring Reports shall include (i) Host Party authorization, (ii) indication of 'inside/outside NDC' scope, and (iii) evidence that corresponding adjustments will be applied by the Host Party, consistent with the BioCarbon ADC Tool and registry procedures.

6.2 BioCarbon Tools

Project holders shall apply, as applicable, the following tools and procedures developed under the BioCarbon Standard. These are normative and binding for the quantification, monitoring, and registration of emission reductions under Blue Carbon activities:

(a) Baseline and Additionality Tool;

(b) Permanence and Risk Management Tool;

(c) Monitoring, Reporting and Verification (MRV) Tool;

(d) Uncertainty Assessment Tool;

(e) Avoidance of Double Counting (ADC) Tool;

(f) Sustainable Development Safeguards Tool (SDSs);

(g) Sustainable Development Goals Tool (SDGs).

BioCarbon may issue additional tools, technical guidance, or procedures that become mandatory upon publication. These shall be listed on the official BioCarbon website and communicated to project holders.

7 Terms and definitions

The following terms are used throughout this Methodology. Unless otherwise specified, definitions are aligned with the BioCarbon Standard, the IPCC Guidelines for National Greenhouse Gas Inventories (2006, 2019), and ISO 14064-2 (ISO, 2019a) and 14064-3 (ISO, 2019b). In case of conflict, definitions provided in the BioCarbon Standard and its associated tools shall prevail.

Activity data

Data representing the extent of human or natural activities that cause GHG emissions or removals. In Blue Carbon projects, activity data refers to measurable changes in the condition or extent of coastal ecosystems (e.g., mangroves, tidal marshes, or seagrass meadows), such as area gained or lost, restoration progress, or degradation levels. These data may be derived from satellite imagery, aerial photography, hydrological monitoring, soil and biomass sampling, or other verifiable sources.

Source: Adapted from IPCC Guidelines and BioCarbon (2025d) MRV Tool.

Additionality

The characteristic of a GHG mitigation activity by which it generates emission reductions or removals that would not have occurred in the absence of the project. Additionality shall be demonstrated in accordance with the BioCarbon Baseline and Additionality Tool.

Source: Adapted from ISO 14064-2 and CDM Glossary.

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

A reference scenario that reasonably represents the expected changes in carbon stocks (emissions or removals) within the project area in the absence of the Blue Carbon project activity. The baseline shall reflect the most plausible trajectory of ecosystem loss, degradation, or non-restoration, based on historical evidence, identified drivers, and projected land- and seascape dynamics.

In Blue Carbon projects, the baseline scenario may include:

(a) Conversion of mangroves, tidal marshes, or seagrass meadows to aquaculture, agriculture, or urban infrastructure;

(b) Drainage or hydrological alteration leading to soil organic carbon (SOC) losses;

(c) Progressive coastal erosion or land subsidence;

(d) Continued unsustainable harvesting of mangrove wood or other resources;

(e) Non-intervention in degraded wetlands, resulting in limited natural recovery.

The baseline shall be established using the BioCarbon Baseline and Additionality Tool (BioCarbon Cert , 2025c) and in alignment with IPCC 2006 Guidelines, the 2013 Wetlands Supplement (IPCC, 2014), and the 2019 Refinement.

Blue Carbon

For the purpose of this methodology, Blue Carbon shall be defined as the carbon captured by living organisms in coastal ecosystems (e.g., mangroves, tidal marshes, and seagrass meadows) and marine ecosystems, and stored in biomass and sediments (IPCC, 2018; IPCC, 2022).

Carbon fraction

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

Carbon pools

The components of a coastal or marine ecosystem where carbon is stored. Relevant pools in this methodology include:

(a) Aboveground biomass: carbon stored in living vegetation above the soil or sediment surface (e.g., mangrove trees, marsh grasses).

(b) Belowground biomass: carbon stored in roots and rhizomes of mangroves, marsh plants, and seagrasses.

(c) Soil organic carbon (SOC): carbon stored in soils and sediments, often the largest pool in Blue Carbon ecosystems.

(d) Deadwood and litter: necromass and organic detritus, which may be significant in mangrove systems.

Carbon pools may be excluded only if their exclusion is technically justified and results in more conservative estimates of net GHG emission reductions and removals.

Source: IPCC 2006 Guidelines; IPCC 2013 Wetlands Supplement; BioCarbon MRV Tool (2025d).

Eligible areas

Areas within the project boundary that consist of mangroves, tidal marshes, or seagrass meadows eligible under this methodology. Eligible areas shall be clearly georeferenced, demonstrate the presence or potential for restoration of Blue Carbon ecosystems at the start of project activities, and comply with all legal, ecological, and methodological requirements of the BioCarbon Standard.

Emission factor

A coefficient that quantifies GHG emissions or removals per unit of activity data, typically expressed in tCO_2e per hectare. Emission factors shall be derived from credible sources such as peer-reviewed literature, national GHG inventories, or direct field measurements, and selected conservatively.

Emission factors are combined with activity data to calculate emissions and removals, consistent with IPCC guidance.

Source: IPCC 2019, ISO 14064-2 2019.

GHG Project (Greenhouse gas project)

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

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

GHG emission reductions

The quantified decrease in anthropogenic greenhouse gas emissions attributable to the implementation of project activities, measured against a conservative and credible baseline scenario. Emission reductions shall be real, additional, measurable, permanent, and verified in accordance with the BioCarbon Standard.

Leakages

A measurable and attributable increase in GHG emissions that occurs outside the project boundary as a result of the implementation of Blue Carbon project activities. Leakage may occur when human pressures or resource uses are displaced to other coastal or marine areas due to restrictions or interventions within the project area.

In Blue Carbon projects, potential sources of leakage include:

(a) Displacement of aquaculture or agriculture to adjacent coastal zones or wetlands;

(b) Increased harvesting of mangrove wood or non-timber resources in neighboring areas;

(c) Shifts in fishing or resource extraction pressure to ecosystems outside the project boundary;

(d) Relocation of coastal infrastructure or drainage works that negatively affect nearby ecosystems.

Leakage shall be identified, monitored, and quantified in accordance with the BioCarbon MRV Tool. Where quantification is not feasible, conservative deduction factors shall be applied to ensure environmental integrity.

Source: Adapted from IPCC Guidelines and BioCarbon 2025d MRV Tool.

Legally protected area

A geographically defined space formally designated under national or subnational law for the conservation of biodiversity, ecosystems, or natural resources, where legally binding restrictions on land use, resource extraction, or management practices are established and enforceable by a competent authority.

The mere designation of a legally protected area does not in itself ensure effective conservation outcomes, and projects shall demonstrate compliance with all applicable requirements of this Methodology.

Mangroves

Mangroves are intertidal forests dominated by salt-tolerant tree and shrub species adapted to brackish and saline waters. They occur along sheltered tropical and subtropical coastlines, estuaries, lagoons, and river deltas, and are characterized by high productivity and substantial carbon storage in aboveground and belowground biomass and in waterlogged soils.

Source: IPCC, 2013 Wetlands Supplement; Ramsar Convention 1987.

Monitoring period

The monitoring period is the defined time interval during which data are collected and verified to quantify GHG emission reductions or removals from Blue Carbon activities, in accordance with the Project Document and the BioCarbon Standard.

Organic soils

Organic soils are soils with high organic carbon content, typically ≥12% by weight, formed under conditions of poor drainage and water saturation such as peatlands, mangroves, and tidal marshes. These soils store large amounts of carbon in anaerobic conditions and are highly vulnerable to GHG emissions when drained, degraded, or converted. For the purpose of this methodology, organic soils shall be identified and accounted for following the IPCC 2006 Guidelines and the 2013 Wetlands Supplement.

Permanence

Permanence refers to the long-term maintenance of GHG emission reductions and removals generated by Blue Carbon activities, ensuring that credited carbon stored in biomass and soils is not released back into the atmosphere due to natural or human-induced disturbances.

Project area

The geographic area under the legal authority or control of the project holder, within which Blue Carbon activities are implemented and GHG emission reductions or removals are quantified and monitored.

The project area shall:

(a) Consist of one or more eligible coastal ecosystems, including mangroves, tidal marshes, or seagrass meadows;

(b) Be clearly delineated and georeferenced using GIS, satellite imagery, or equivalent spatial data;

(c) Include restoration, conservation, or sustainable management activities that directly generate climate benefits;

(d) Exclude areas where conservation is already legally mandated and where no additional mitigation outcomes can be demonstrated.

The project area may include multiple polygons, provided that each meets all eligibility criteria and is justified as part of the project scope.

Source: Adapted from BioCarbon Standard and IPCC 2013 Wetlands Supplement.

Project boundary

The project boundary defines the geographic area, quantification period, and carbon pools and GHGs included in the assessment of Blue Carbon activities. It encompasses the mangroves, tidal marshes, or seagrass meadows under the project, documented with georeferenced maps; the temporal scope of monitoring and quantification; and the accounting of aboveground biomass, belowground biomass, soil organic carbon, and, where significant, CH_4 and N_2O, in accordance with BioCarbon Standard requirements and IPCC guidelines.

Project holder

The project holder is the legal entity or individual with operational control over the project area and the right to claim, register, and transfer GHG emission reductions or removals, demonstrating compliance with all applicable legal, technical, and programmatic requirements under the BioCarbon Standard.

Project Start date

The project start date is the moment when the first physical activity aimed at generating GHG emission reductions or removals in Blue Carbon ecosystems is implemented, such as hydrological restoration, replanting, or conservation interventions.

Quantification period

The quantification period is the timeframe over which GHG emission reductions or removals from Blue Carbon activities are calculated for credit issuance, aligned with the project start date and the validity of the baseline scenario, and may include multiple monitoring periods.

Renewable Biomass

For the purpose of this methodology, Renewable Biomass shall be defined in accordance with the CDM Executive Board (EB23, Annex 18) as biomass that meets one of the following conditions:

(a) Biomass originating from forest land where the land remains a forest, managed sustainably, and in compliance with national or regional forestry regulations.
(b) Woody biomass from croplands and/or grasslands, where the land remains cropland or grassland (or reverts to forest), managed sustainably, and in compliance with applicable regulations.
(c) Non-woody biomass from croplands and/or grasslands, where the land remains cropland or grassland (or reverts to forest), managed sustainably, and in compliance with applicable regulations.
(d) Biomass residues, by-products, or waste streams from agriculture, forestry, and related industries, provided that their use does not decrease carbon pools (e.g., dead wood, litter, soil organic carbon) in the land areas where they originate.
(e) The non-fossil fraction of industrial or municipal waste.

Note: This definition is included to ensure consistency in the treatment of biomass within BioCarbon methodologies. It clarifies that only renewable biomass may be used in project activities, thereby preventing negative impacts on existing carbon pools (e.g., soil organic carbon, dead wood, litter) and avoiding leakage or non-permanence risks. For Blue Carbon projects, the requirement applies to any biomass used in restoration, conservation, or associated project activities.

Safeguards

Safeguards are the social, environmental, and governance measures established to prevent adverse impacts and ensure that Blue Carbon project activities respect human rights, biodiversity, cultural values, and equitable benefit-sharing, in accordance with the BioCarbon Standard Sustainable Development Safeguards (SDS) Tool.

Seagrass meadows

Seagrass meadows are submerged marine ecosystems formed by rooted, flowering plants (angiosperms) that develop dense underwater meadows in shallow coastal waters. They stabilize sediments, improve water quality, provide habitat for marine biodiversity, and store carbon mainly in their root and rhizome systems and associated sediments.

Source: IPCC, 2013 Wetlands Supplement; Ramsar Convention 1987.

Soil Organic Carbon (SOC)

Soil Organic Carbon (SOC) is the carbon component of soil organic matter, including carbon stored in decomposing plant and animal residues, soil organisms, and substances synthesized by soil biota. In Blue Carbon ecosystems, SOC represents the dominant carbon pool, stored in anaerobic and waterlogged sediments, and shall be quantified following the IPCC 2006 Guidelines, the 2013 Wetlands Supplement, and the 2019 Refinement.

Source, sink, or carbon pool-related

A source is any process or activity that releases GHGs into the atmosphere; a sink is any process, activity, or mechanism that removes GHGs from the atmosphere; and a carbon pool is a reservoir that stores carbon. In Blue Carbon projects, relevant pools include aboveground and belowground biomass, soil organic carbon in sediments, and, where applicable, dead organic matter.

Tidal marshes

Tidal marshes are coastal wetlands located in the intertidal zone, periodically inundated by tidal waters, and dominated by herbaceous vegetation such as grasses, sedges, and rushes. They are highly productive ecosystems that accumulate organic matter and store large amounts of soil organic carbon under anaerobic conditions.

Source: IPCC, 2013 Wetlands Supplement; Ramsar Convention 1987.

Uncertainty

Uncertainty is the degree of imprecision associated with the quantification of GHG emissions or removals in Blue Carbon projects, arising from limitations in data, models, sampling methods, or measurement techniques, and shall be assessed and conservatively addressed in accordance with IPCC guidance and the BioCarbon Uncertainty Assessment Tool.

Verified Carbon Credit (VCC)

A Verified Carbon Credit (VCC) is a serialized unit equivalent to one metric tonne of CO_2-equivalent emission reductions or removals that has been verified and issued under the BioCarbon Standard, ensuring uniqueness, traceability, and environmental integrity.

Wetlands

Wetlands are ecosystems permanently or seasonally saturated with water, including mangroves, tidal marshes, and seagrass meadows, where waterlogging creates anaerobic conditions that favor long-term carbon storage in soils and sediments. For the purposes of this methodology, wetlands shall be defined in accordance with the Ramsar Convention (1987) and the IPCC Guidelines (2006, 2013 Wetlands Supplement, 2019 Refinement).

8 Carbon pools and sources of emissions

This section describes the carbon pools and GHG emission sources that shall be considered for quantifying emission reductions and removals under this Methodology. The selection of carbon pools shall follow IPCC principles and be justified based on conservativeness and project-specific conditions.

8.1 Carbon pools

The selection of carbon pools shall be consistent between baseline and project scenarios. Any pool excluded from the baseline shall also be excluded from the project scenario, unless justified by risk of overestimation. The carbon pools to be quantified within the project boundary are presented in *Table 1*.

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

Carbon pool	Baseline Scenario	Project Scenario	Justification/Explanation
Aboveground biomass	Included	Included	Significant in mangroves and tidal marshes; mandatory in both scenarios.
Belowground biomass	Included	Included	Roots of mangroves, marshes, and seagrasses represent a substantial carbon pool; mandatory in both scenarios.
Soil Organic Carbon (SOC)	Included	Included	Dominant carbon pool in Blue Carbon ecosystems; required in both scenarios, measured following IPCC Wetlands Supplement (2013).

Carbon pool	Baseline Scenario	Project Scenario	Justification/Explanation
Deadwood and litter	Optional	Optional	Relevant mainly in mangroves; may be excluded if conservatively justified and demonstrated to be insignificant.

8.2 Source of emissions

The sources of GHG emissions considered under this Methodology are those resulting from the loss, degradation, or conversion of Blue Carbon ecosystems, as well as project-related activities that may generate GHG emissions. These sources shall be consistently accounted for in both the baseline and project scenarios.

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

Table 2. Emission sources and GHGs selected for accounting

Source	GHG	Whether selected (Yes/No)	Justification/Explanation
Drainage or hydrological alteration	CO_2	Yes	Drained wetlands and altered tidal flows release SOC as CO_2.
Decomposition of disturbed soils/sediments	CO_2, CH_4, N_2O	Yes	Disturbance, erosion, or conversion mobilizes SOC and may generate CH_4 and N_2O.
Biomass burning (if fire is present)	CH_4, N_2O	Yes	Although rare, fires in mangroves can emit CH_4 and N_2O; shall be included when documented. CO_2 is covered by carbon stock change.
Fuel use for project activities	CO_2	Yes (if significant)	Restoration, planting, monitoring, or transport may generate fossil CO_2 emissions; shall be included where not de minimis.
Leakage-related displacement	CO_2, CH_4, N_2O	Yes (if applicable)	Activity displacement (e.g., aquaculture, fuelwood harvest, fishing pressure) outside the project boundary

GHG emissions from each source shall be quantified using methods consistent with IPCC (2006 Guidelines, 2013 Wetlands Supplement, and 2019 Refinement) and the BioCarbon MRV Tool (2025d). The most accurate available data shall be used, applying Tier 2 or Tier 3 methods when feasible, or applying conservative default values with proper justification when higher-tier data are not available.

Emission sources shall be included consistently in both the baseline and project scenarios. Any exclusion shall be conservative and justified in the Project Document.

Default values for SOC, CH_4, and N_2O may be taken from Annex 1 where project-specific data are not available

9 Spatial and temporal limits

This section defines the spatial and temporal boundaries within which GHG emission reductions shall be quantified under this Methodology. The boundaries shall be clearly documented and justified in the Project Document, following the definitions provided in Section 7.

9.1 Geographic boundaries

The geographic boundary shall include the full extent of the Blue Carbon ecosystem under the project, documented with georeferenced maps and coordinates. Project holders shall account for potential dynamic changes in the boundary caused by natural processes such as sea-level rise, erosion, accretion, or hydrological shifts, and describe how these are addressed in monitoring.

9.2 Temporal boundaries

The project start date shall be the date on which the first physical activity related to the conservation, restoration, or management of the Blue Carbon ecosystem is implemented. The quantification period shall be a maximum of twenty (20) years, renewable once for a total maximum project length of forty (40) years.

9.3 Carbon pools and GHGs

The following carbon pools and GHGs shall be considered within the project boundary:

(a) Mandatory pools: aboveground biomass, belowground biomass, and soil organic carbon (SOC).

(b) Optional pools: dead wood and litter, where significant.

(c) Mandatory gas: CO_2.

(d) Non-CO_2 gases: CH_4 and N_2O shall be included where they are significant, as determined in accordance with the 2006 IPCC Guidelines and the 2013 Wetlands Supplement.

10 Project activities

10.1 Description of activities

Project activities shall consist of interventions designed to conserve, restore, or sustainably manage Blue Carbon ecosystems, including mangroves, tidal marshes, and seagrass meadows.

For the purpose of this methodology, the term Blue Carbon ecosystems refers to coastal and marine ecosystems that are highly effective at sequestering and storing carbon in both biomass and soils. These ecosystems include mangroves, tidal marshes, and seagrass meadows, each defined below. Together, they represent the primary scope of this methodology and are recognized by the IPCC Wetlands Supplement (2013) and the Ramsar Convention (1987) as critical ecosystems for climate change mitigation, adaptation, and biodiversity conservation.

The Project Document shall describe in detail the type, location, and implementation plan of the activities, including the stakeholders involved and the expected impacts on greenhouse gas (GHG) emissions and removals.

10.2 Eligible activities

The following activities are eligible under this methodology:

(a) Conservation of existing ecosystems under threat of degradation or conversion (e.g., preventing drainage of tidal marshes, restricting unsustainable logging in mangroves, or avoiding conversion of seagrass meadows to aquaculture);

(b) Restoration, including:

  i) Hydrological restoration, such as breaching dikes, removing barriers, or re-establishing tidal exchange to degraded wetlands,

  ii) Revegetation and replanting of mangroves, marsh grasses, or seagrass meadows with appropriate native species,

  iii) Sediment management where necessary to promote natural recolonization and stability.

(c) Sustainable management, including practices that maintain or enhance long-term carbon storage, ecosystem health, and resilience, such as community-based harvesting of mangrove wood under sustainable limits, rotational closures of fishing grounds, or regulated grazing in salt marshes.

10.3 Excluded activities

The following activities are not eligible:

(a) Conversion of wetlands or coastal areas to aquaculture, agriculture, or infrastructure;

(b) Introduction of non-native or invasive species;

(c) Large-scale dredging, drainage, or activities that permanently reduce the capacity of the ecosystem to sequester carbon.

(d) Activities required by law or regulation, which do not demonstrate additionality.

11 Analysis of drivers and agents

11.1 Requirement to identify drivers and agents

Project holders shall identify and analyze the direct and underlying drivers of degradation or loss in Blue Carbon ecosystems, as well as the agents responsible. This analysis shall provide the technical basis for the baseline scenario, additionality demonstration, and the assessment of leakage risks.

11.2 Direct drivers of degradation and loss

The following are common direct drivers affecting mangroves, tidal marshes, and seagrass meadows:

(a) Conversion to aquaculture (e.g., shrimp or fishponds);

(b) Agricultural expansion in coastal lowlands and drained wetlands;

(c) Urbanization and infrastructure development, including ports, roads, tourism facilities, and industrial sites;

(d) Hydrological alterations, such as diking, canalization, or drainage that restricts tidal flow and sediment deposition;

(e) Overharvesting of wood and other resources from mangroves and marshes for fuel, charcoal, or construction;

(f) Coastal erosion and sediment extraction (e.g., sand mining) leading to loss of soil organic carbon (SOC);

(g) Pollution and eutrophication, especially nutrient loading from upstream agriculture and untreated wastewater;

(h) Boat propeller scarring and dredging that damage seagrass meadows.

11.3 Underlying drivers

Underlying drivers that intensify pressures include:

(a) Population growth in coastal areas;

(b) Economic demand for aquaculture products and coastal land;

(c) Weak enforcement of environmental regulations;

(d) Lack of alternative livelihoods for coastal communities;

(e) Climate change impacts, including sea-level rise and extreme weather events;

11.4 Agents responsible

The main agents associated with these drivers include:

(a) Aquaculture operators (industrial and small-scale);

(b) Agricultural producers expanding into coastal wetlands;

(c) Developers and infrastructure companies (ports, tourism, urban expansion);

(d) Local communities engaging in subsistence or commercial harvesting of mangrove wood, fish, and other resources;

(e) Government or municipal authorities promoting drainage, land reclamation, or development in coastal areas.

11.5 Documentation

The Project Document shall:

(a) Provide evidence (maps, satellite imagery, field surveys, literature, or government data) of the presence and impacts of drivers and agents;

(b) Describe how these drivers and agents influence the baseline scenario and may contribute to leakage outside the project boundary;

(c) Explain the extent to which project activities address or mitigate each driver.

12 Quantification of GHG emission reduction from Blue Carbon activities

Quantification shall be conservative, transparent, and based on recognized scientific methods. All relevant carbon pools and GHGs identified in Section 9.3 shall be included, and the same pools and gases shall be accounted for in both baseline and project scenarios to ensure consistency and prevent overestimation.

12.1 Activity data

Activity data represent the quantitative extent of human or natural activities that cause GHG emissions or removals. In Blue Carbon projects, activity data shall include measurable changes in the extent, condition, or management of mangroves, tidal marshes, and seagrass meadows.

Acceptable forms of activity data include, but are not limited to:

(a) Ecosystem area changes: hectares of ecosystem lost, conserved, or restored;

(b) Restoration and management interventions: hectares replanted, hydrological barriers removed, tidal flows restored;

(c) Condition indicators: canopy cover, vegetation density, seagrass shoot density;

(d) Hydrological parameters: water level, salinity, inundation frequency;

(e) Disturbance records: area affected by aquaculture conversion, erosion, storm damage, or unsustainable harvesting.

Activity data shall be derived from verifiable sources, including:

(a) Remote sensing (satellite imagery such as Landsat, Sentinel, or Planet; aerial photography; drones, etc.);

(b) GIS-based land cover and land use change analysis;

(c) Field surveys (vegetation plots, soil sampling, hydrological monitoring);

(d) Official records (permits, land tenure, management agreements);

(e) Participatory and community monitoring systems.

All activity data shall be:

(a) Georeferenced and documented in the Project Document;

(b) Monitored consistently during each monitoring period;

(c) Cross-checked with emission factors to calculate baseline and project emissions in accordance with IPCC 2006 Guidelines, the 2013 Wetlands Supplement, and the 2019 Refinement.

12.2 Stratification of the project area

The project area shall be stratified into relatively homogeneous units prior to quantification of greenhouse gas (GHG) emission reductions and removals. Stratification is a mandatory step to reduce sampling error, improve precision, and ensure representativeness of sampling efforts in accordance with IPCC Good Practice Guidance (IPCC, 2006; IPCC, 2013 Wetlands Supplement; IPCC, 2019 Refinement).

Each stratum shall be defined based on measurable and verifiable characteristics, which may include but are not limited to:

(a) Ecosystem type: mangroves, tidal marshes, or seagrass meadows;

(b) Biophysical characteristics: soil type (mineral or organic), salinity regime, hydrological conditions, geomorphological setting (deltaic, estuarine, lagoonal);

(c) Vegetation condition: intact, degraded, or restored;

(d) Management and disturbance history: conservation status, restoration activities, aquaculture conversion, harvesting intensity, or pollution levels.

12.2.1 Mapping and documentation

Strata shall be delineated using georeferenced maps, GIS analysis, and remote sensing data (satellite imagery, aerial photography, or other). Each stratum shall be clearly documented in the Project Document, including:

(a) Boundary coordinates (latitude/longitude);
(b) Area (hectares);
(c) Stratification criteria applied;
(d) Supporting spatial data sources and resolution.

12.3 Sampling design

Sampling for biomass, soil organic carbon (SOC), and non-CO_2 gases shall be allocated by stratum, following stratified random or systematic designs. Sampling intensity shall be proportional to the variability and the area of each stratum.

Higher variability strata (e.g., heterogeneous mangrove stands or areas with recent disturbance) require greater sampling effort to achieve the same confidence level as more homogeneous strata.

Minimum requirements include:

(a) Stratification documented prior to field sampling;

(b) At least 3 permanent sampling plots per stratum for biomass and vegetation parameters;

(c) At least 3 soil cores per stratum for SOC estimates to 1 m depth, unless local regulations or IPCC guidance require deeper sampling;

(d) Justification for sample size, with reference to statistical power and uncertainty assessment (Section 15).

The minimum requirement of three (3) permanent sampling plots per stratum for biomass and vegetation parameters, and three (3) soil cores per stratum for SOC estimates, is established to ensure long-term traceability and the ability to detect temporal changes in carbon stocks. These permanent plots and cores are additional to the temporary or rotating sampling plots that may be required to capture spatial variability within each stratum. Project holders shall design their sampling plans in accordance with statistical best practices and IPCC guidance, ensuring that both spatial representativeness (via temporary plots) and temporal consistency (via permanent plots) are adequately addressed.

To ensure the accuracy and reliability of the estimated emission factors, the sampling precision shall meet the following minimum requirement:

- A relative precision of ±10% at a 90% confidence level, calculated across the full population or stratum.

If this level of precision is not achievable due to practical limitations (e.g., access, cost, terrain), the project holder shall apply conservative emission factors and transparently document the reasons and implications.

12.4 Emission factors

The project holder may determine emission factors using data derived from field sampling plots or adopt regionally appropriate values from national or international sources, provided they are conservative and scientifically robust.

12.4.1 Field-Based estimation of emission factors

When emission factors are derived from sampling plots, the project holder shall follow the sampling requirements described by the Intergovernmental Panel on Climate Change (IPCC, 2006) Guidelines and subsequent refinements), including:

(a) Sampling principles (e.g., random, stratified, or systematic sampling);

(b) Sampling design (e.g., plot size, shape, number, and distribution);

(c) Sampling methods for area estimation;

(d) Sampling methods for estimating emissions and removals of greenhouse gases;

(e) Quantification and management of uncertainties in sample-based surveys.

Field data shall be collected in a manner that is statistically representative, independently verifiable, and spatially consistent with the strata or land classes used in the emission reduction estimates.

12.4.2 Use of published or default values

Where direct sampling is not feasible or data gaps exist, the project holder may use:

(a) National emission factors published by the host country (e.g., in GHG inventories, NDCs, REDD+ FRELs), if consistent with IPCC Tiers 2 or 3 (2019);

(b) Regionally relevant peer-reviewed literature or forest inventory databases;

(c) IPCC 2019 default values (Tier 1) only if justified as conservative and no higher-tier data are available.

The selected emission factors shall:

(a) Be consistent with the forest strata or land cover classes defined in the project;

(b) Reflect the appropriate biomass components (e.g., aboveground, belowground, deadwood);

(c) Be expressed in tCO_2e per hectare using applicable conversion factors and root-to-shoot ratios, as per IPCC 2019 guidance.

12.4.3 Documentation and validation

All emission factor sources, methodologies, assumptions, and calculations shall be:

(a) Clearly described in the Project Document,

(b) Supported by traceable datasets (field forms, calibration methods, equations, etc.), and

(c) Subject to validation by an independent third party.

The uncertainty associated with emission factors shall be incorporated into the overall project uncertainty assessment as required under Section 15.

12.5 Baseline emissions

Baseline emissions shall represent the expected loss of carbon stocks and associated GHG emissions in the absence of the project. Sources include:

(a) Conversion of ecosystems to aquaculture, agriculture, or infrastructure;

(b) Drainage or hydrological alteration of wetlands;

(c) Ongoing unsustainable extraction of biomass;

(d) Coastal erosion or sediment removal.

The baseline emissions shall be calculated according to the Equation 1.

$$BE_y = \sum_{m=1}^{M}\sum_{i=1}^{I}\left(\Delta C_{i,m,BE,y} \times \frac{44}{12}\right) + \sum_{m=1}^{M}\left(E_{CH_4,m,BE,y} \times GWP_{CH_4}\right) + \sum_{m=1}^{M}\left(E_{N_2O,m,BE,y} \times GWP_{N_2O}\right) \qquad \text{Equation 1}$$

Where:

BE_y	=	Baseline emissions in year y; tCO_2e
$\Delta C_{i,m,BE,y}$	=	Change in carbon stock in pool i, for stratum m, under baseline; tC
$\frac{44}{12}$	=	Molecular weight ratio ($C:CO_2$)

$E_{CH_4,BE,y}$	=	Baseline methane emissions; tCO_2e
GWP_{CH_4}	=	Global warming potential for CH_4; dimensionless
$E_{N_2O,BE,y}$	=	Baseline nitrous oxide emissions; tCO_2e
GWP_{N_2O}	=	Global warming potential for N_2O; dimensionless
$i, \dots, I$	=	Carbon pool; dimensionless
$m, \dots, M$	=	Stratum; dimensionless

Where default emission factors are used, project holders shall apply those provided in Annex 1.

12.6 Project emissions

Project emissions include GHG releases resulting from project implementation, such as:

(a) Biomass burning during site preparation;

(b) Emissions from fuel use (transport, restoration);

(c) Residual CH_4 and N_2O from restored wetlands (where significant).

The baseline emissions shall be calculated according to the Equation 2.

Equation 2

$$PE_y = \sum_{m=1}^{M}\sum_{i=1}^{I}\left(\Delta C_{i,m,PE,y} \times \frac{44}{12}\right) + \sum_{m=1}^{M}\left(E_{CH_4,m,PE,y} \times GWP_{CH_4}\right) + \sum_{m=1}^{M}\left(E_{N_2O,m,PE,y} \times GWP_{N_2O}\right) + \sum_{m=1}^{M}\left(E_{FF,m,PE,y}\right)$$

Where:

PE_y	=	Project emissions in year y; tCO_2e
$\Delta C_{i,m,PE,y}$	=	Change in carbon stock in pool i, for stratum m, under project scenario in year y; tC
$\frac{44}{12}$		Molecular weight ratio ($C:CO_2$); dimensionless
$E_{CH_4,m,PE,y}$		Project emissions of methane, in stratum m, in year y; tCH_4
GWP_{CH_4}	=	Global warming potential for CH_4; dimensionless

$E_{N_2O,m,PE,y}$	=	Project emissions of nitrous oxide, in stratum m, in year y; tN_2O
GWP_{N_2O}	=	Global warming potential for N_2O; dimensionless
$E_{FF,m,PE,y}$		Fossil fuel emissions, in stratum m, in year y; tCO_2e
$i, \dots, I$	=	Carbon pool; dimensionless
$m, \dots, M$	=	Stratum; dimensionless

12.7 Carbon stock changes

Carbon stock changes represent the difference in carbon stored in selected pools between the baseline and project scenarios. In Blue Carbon ecosystems, the most relevant pools are aboveground biomass (AGB), belowground biomass (BGB), and soil organic carbon (SOC). Dead wood and litter may also be included where significant and measurable.

For the purposes of this methodology, all carbon pools shall be estimated on a stratum basis, following the stratification requirements set out in Section 12.2. Within each stratum, carbon stock values shall be expressed as mean values per unit area (tC/ha), derived from statistically representative field sampling and laboratory analysis in accordance with IPCC 2006 Guidelines, the 2013 Wetlands Supplement, and the 2019 Refinement.

Changes in carbon stocks (ΔC) shall be calculated as the difference between mean carbon stocks at monitoring time t and at baseline (t_0), multiplied by the area of the stratum and, where relevant, by the sampling depth (e.g., SOC). Total project-level carbon stock changes shall then be obtained as the area-weighted sum of all strata.

12.7.1 Aboveground and belowground biomass (mangroves and marshes)

Changes in biomass shall be calculated according to the Equation 4:

Equation 3

$$\Delta C_{B,y} = \left(\sum_{m=1}^{M} A_m \times \left(C_{B,m,t} - C_{B,m,0} \right) \right) \times \frac{44}{12}$$

Where:

$\Delta C_{B,y}$	=	Total carbon stock change in aboveground and belowground biomass, for stratum m, in year y; tCO2e
A_m	=	Stratum area; ha

$C_{B,m,t}$	=	Mean value of aboveground (AGB) and belowground (BGB) biomass carbon stock in stratum m at time t; tC/ha
$C_{B,m,0}$	=	Mean value of aboveground (AGB) and belowground (BGB) biomass carbon stock in stratum m at time 0; tC/ha
$\frac{44}{12}$	=	Molecular weight ratio (C:CO_2); dimensionless
$m, \ldots, M$	=	Stratum; dimensionless

For the purpose of this methodology, $C_{B,m,t}$ shall represent the mean carbon stock per unit area (tC/ha) in stratum m at time t. The mean value shall be derived from field sampling (permanent or temporary plots) or equivalent verified data sources, and shall be statistically representative of the stratum. Using mean values, rather than individual plot measurements, ensures consistency with IPCC Good Practice Guidance (IPCC 2006, Vol. 4; IPCC 2013 Wetlands Supplement; IPCC 2019 Refinement), improves representativeness, and prevents bias from atypical or extreme measurements.

12.7.2 Soil organic carbon (SOC) in sediments

SOC is the dominant pool in Blue Carbon ecosystems. Stock changes shall be calculated as:

$$\Delta C_{SOC,m,y} = \sum_{m=1}^{M} \left(SOC_{m,t} - SOC_{m,0}\right) \times A_m \times D \times \frac{44}{12} \quad \text{Equation 4}$$

Where:

$\Delta C_{SOC,m,y}$	=	Change in soil organic carbon stock in stratum m, year y; tC
$SOC_{m,t}$	=	Mean value of SOC stock in stratum m at time t; tC/ha
$SOC_{m,0}$	=	Mean value of SOC stock in stratum m at baseline (t=0); tC/ha
A_m	=	Area of stratum m
D	=	Depth of sampling (m), minimum 1 m (IPCC Wetlands Supplement, 2013).
$\frac{44}{12}$	=	Molecular weight ratio (C:CO_2); dimensionless
$m, \ldots, M$	=	Stratum; dimensionless

For the purpose of this methodology, soil organic carbon (SOC) shall be quantified separately for each stratum. $SOC_{m,t}$ and $SOC_{m,0}$ shall represent the mean value of SOC per unit area (tC/ha) in stratum m at time t and at baseline respectively, derived from soil core sampling, bulk density, and carbon fraction analysis, in accordance with IPCC (2006 Guidelines; 2013 Wetlands Supplement; 2019 Refinement).

The sampling depth (D) shall be at least 1 m unless otherwise justified by local soil conditions or regulations. Total project SOC change ($\Delta C_{SOC,y}$) shall be calculated as the area-weighted sum of changes across all strata.

SOC shall be monitored using stratified random sampling, with bulk density and carbon fraction measured in laboratory following standardized protocols.

12.7.3 Dead wood and litter

Dead wood and litter pools are considered optional in this methodology. Where included, they shall be quantified separately for each stratum, consistent with IPCC (2006 Guidelines, Vol. 4, Ch. 2; 2019 Refinement). $DW_{m,t}$, $DW_{m,0}$, $L_{m,t}$, and $L_{m,0}$ shall represent the mean carbon stock per unit area (tC/ha) for dead wood and litter in stratum m at time t and at baseline, respectively. Total project-level changes in dead wood and litter ($\Delta C_{DW+L,y}$) shall be calculated as the area-weighted sum of stratum-level changes. Where project holders exclude these pools, exclusion shall be justified and shown to be conservative in accordance with Section 8.1.

$$\Delta C_{DW+L,y} = \left(\sum_{m=1}^{M} A_m \times \left(DW_{m,t} + L_{m,t}\right) - \left(DW_{m,0} + L_{m,0}\right) \right) \times \frac{44}{12} \qquad \text{Equation 5}$$

Where:

$\Delta C_{DW+L,y}$	=	Total carbon stock change in dead wood and litter, for stratum m, in year y; tCO2e
A_m	=	Stratum area; ha
$C_{DW,m,t}$	=	Mean value of dead wood carbon stock in stratum m at time t; tC/ha
$C_{DW,m,0}$	=	Mean value of dead wood carbon stock in stratum m in baseline; tC/ha
$L_{m,t}$	=	Mean value of litter carbon stock in stratum m at time t; tC/ha
$L_{m,0}$	=	Mean value of litter carbon stock in stratum m in baseline; tC/ha

$\frac{44}{12}$	=	Molecular weight ratio ($C:CO_2$); dimensionless
$m, \ldots, M$	=	Stratum; dimensionless

12.8 Non-CO2 gases

Emissions of methane (CH_4) and nitrous oxide (N_2O) shall be quantified at the stratum level, since emission factors depend on ecosystem conditions such as salinity, hydrological regime, and nutrient inputs. Project holders shall use emission factors consistent with IPCC 2006 Guidelines, the 2013 Wetlands Supplement, and the 2019 Refinement, or more specific peer-reviewed or nationally approved data where available.

12.8.1 Methane (CH_4)

For drained or flooded soils, CH_4 fluxes shall be estimated as:

$$E_{CH_{4},y} = \sum_{m=1}^{M} EF_{CH_4,m} \times A_m \times GWP_{CH_4} \qquad \text{Equation 6}$$

Where:

$E_{CH_{4},y}$	=	CH_4 emissions in the stratum m, in the year y; tCO2e
EF_{CH_4}	=	Emission factor for methane (kg CH_4/ha/yr) from IPCC Wetlands Supplement (2013)
A_m	=	Stratum area; ha
GWP_{CH_4}	=	Global warming potential of methane (28, AR5 or updated value).

12.8.2 Nitrous oxide (N_2O)

Nitrous oxide (N_2O) emissions shall be estimated at the stratum level. Project holders shall apply one of the following approaches, depending on ecosystem conditions and data availability.

12.8.2.1 General default factor approach (Tier 1)

The N_2O emissions shall be estimated as:

$$E_{N_2O,m,y} = \sum_{m=1}^{M} EF_{N_2O,m} \times A_m \times GWP_{N_2O}$$ Equation 7

Where:

$E_{N_2O,m,y}$	=	N2O emissions in the stratum m, in the year y; tCO2e
EF_{N_2O}	=	Default emission factor for nitrous oxide (kgN2O/ha/yr) from IPCC Wetlands Supplement (2013)
A_m	=	Stratum area; ha
GWP_{CH_4}	=	Global warming potential of nitrous oxide

12.8.2.2 Fertilization (managed input) approach

For fertilized or managed wetlands:

$$E_{N_2O,y} = \sum_{m=1}^{M} \left(EF_{N_2O} \times N_{input,m} \times 44/28\right) \times GWP_{N_2O}$$ Equation 8

Where:

$E_{N_2O,y}$	=	N2O emissions in the stratum m, in the year y; tCO2e
EF_{N_2O}	=	Emission factor for N_2O; kg N_2O-N/kg N input
$N_{input,m}$	=	Nitrogen input per stratum; kg N/ha
$44/28$	=	Molecular weight conversion from N-to-N_2O
GWP_{N_2O}	=	Global warming potential of N_2O

12.9 Net GHG emission reductions and removals

Net GHG emission reductions and removals shall be calculated as:

$$ER_y = \left(BE_y - PE_y\right) - Lk_y \pm U_y$$ Equation 9

Where:

ER_y	=	Net emission reductions and removals in year y; tCO_2e
BE_y	=	Baseline emissions in year y; tCO_2e
PE_y	=	Project emissions in year y: tCO_2e
Lk_y	=	Leakage emissions in year y; tCO_2e
U_y	=	Uncertainty deduction (tCO_2e), as per the BioCarbon Uncertainty Tool

Note: If you report results by stratum, compute BE_y and PE_y using the stratified forms (area-weighted sums), then plug the aggregated values into the equation above.

12.10 Data, parameters, and quality assurance

All data and parameters shall be documented in the Project Document and default values may be used only when site-specific data are not available and shall follow IPCC 2006/2013/2019.

Quality assurance and control (QA/QC) procedures shall follow ISO 14064-2 (2019) and BioCarbon MRV Tool.

Examples of parameter documentation tables are provided in Annex 3.

13 Leakage management

13.1 General requirements

Project holders shall identify and quantify, where significant, greenhouse gas (GHG) emissions that occur outside the project boundary as a result of project activities. Such emissions, referred to as leakage, shall be accounted for to ensure the environmental integrity of the Verified Carbon Credits (VCCs) issued under the BioCarbon Standard.

13.2 Sources of leakage in Blue Carbon ecosystems

Potential sources of leakage include, but are not limited to:

(a) Displacement of aquaculture or agriculture: establishment or expansion of ponds, crops, or grazing areas in nearby coastal or wetland ecosystems as a result of project restrictions;

(b) Fuelwood and timber extraction: increased harvesting in adjacent mangrove or coastal forests when access to project areas is restricted;

(c) Fishing and resource use: increased pressure on neighboring areas due to restrictions on fishing, crab harvesting, or other extractive practices within the project boundary;

(d) Infrastructure development: relocation of roads, drainage canals, or coastal works to nearby zones outside the project boundary.

13.3 Identification and monitoring of leakage areas

The project holder shall identify zones outside the project boundary where leakage risk is likely to occur, based on the mobility and behavior of the agents identified in the baseline scenario.

Such zones shall be georeferenced and described in the Project Document.

Monitoring shall include activity data and emissions from these areas using consistent methods applied to the project area, in line with IPCC 2006 Guidelines and the 2013 Wetlands Supplement.

13.4 Quantification of leakage emissions

Where leakage is significant, emissions shall be quantified using activity data, emission factors, and methodologies consistent with the treatment of the project area.

In cases where direct quantification is not feasible, the project holder shall apply a conservative deduction factor from the project's net GHG benefits.

Default deduction factors or conservative assumptions may be used if approved under the BioCarbon Standard.

13.5 Mitigation of leakage

Project holders shall describe and implement measures to minimize leakage, which may include:

(a) Supporting alternative livelihoods for communities previously dependent on mangrove fuelwood or aquaculture;

(b) Establishing agreements with local stakeholders to prevent displacement of unsustainable practices;

(c) Promoting sustainable use of coastal resources in adjacent areas.

13.6 Deduction from net emission reductions

All identified and quantified leakage emissions shall be deducted from the gross project benefits to determine the net GHG emission reductions and removals eligible for credit issuance.

14 Permanence and reversal risk management

Ensuring the long-term permanence of GHG emission reductions and removals is critical in Blue Carbon projects, where carbon stored in biomass and soils remains vulnerable to reversal due to human and natural risks. Project holders shall identify and assess all potential reversal risks, including coastal erosion, sea-level rise, extreme storms, hydrological alteration, illegal conversion to aquaculture or agriculture, land tenure insecurity, and institutional instability, throughout the quantification period and beyond.

14.1 Definition and scope of reversal

Project holders shall assess, mitigate, and manage the risk of reversal of GHG benefits generated through Blue Carbon activities. They shall ensure that all credited climate benefits are real, long-term, and durable.

A reversal refers to any intentional or unintentional event that results in the release of previously credited greenhouse gas (GHG) emission reductions or removals. This may include:

(a) Natural disturbances (e.g., hurricanes, cyclones, tsunamis, storm surges, coastal erosion, pest or disease outbreaks);

(b) Anthropogenic disturbances (e.g., drainage of wetlands, conversion to aquaculture or agriculture, sand mining, unsustainable harvesting of mangroves, coastal infrastructure development);

(c) Policy or legal changes that compromise the protection of coastal ecosystems or carbon stock integrity;

(d) Management failure, governance breakdown, or project abandonment.

Due to their nature, Blue Carbon ecosystems are inherently exposed to both climatic and anthropogenic permanence risks that shall be systematically addressed throughout the quantification period and beyond.

14.2 Measures to enhance permanence

Project design and implementation shall include elements that strengthen the permanence of emission reductions and removals, such as:

(a) Legal protection of the area (e.g., conservation easements, customary tenure recognition, community agreements);

(b) Integration into jurisdictional or long-term coastal ecosystem governance frameworks;

(c) Participatory forest monitoring and adaptive management practices;

(d) Transparent benefit-sharing and full engagement of local and Indigenous communities;

(e) Coastal defense, erosion control, and hydrological restoration to maintain ecosystem resilience;

(f) Risk reduction strategies against extreme weather events and sea-level rise.

These measures shall be documented in the Project Document and assessed during validation and verification.

14.3 Permanence and risk management tool

Project holders shall apply the BioCarbon Permanence and Risk Management Tool to:

(a) Evaluate the risk of reversal;

(b) Assign a risk score using a structured methodology; and

(c) Determine the required contribution to the BioCarbon Reserve.

The tool includes a risk-weighted scoring system based on five categories:

The tool includes a risk-weighted scoring system based on five categories: ecological, natural disturbance, socio-economic, legal/policy, and management risks. Each category is scored on a 1 to 5 scale based on predefined criteria and guiding questions. The final score corresponds to a reserve contribution of 10%, 20%, or 30% of the total verified emission reductions and removals. This amount is deducted prior to credit issuance.

14.4 Risk assessment and monitoring requirements

Project holders shall:

(a) Complete the full risk assessment as defined in Annex 1 of the BioCarbon Tool;

(b) Provide clear and auditable justification for each assigned score;

(c) Update the risk assessment at each verification cycle;

(d) Report any reversal events and classify them as avoidable or unavoidable in accordance with Section 4.1 of the tool.

In the event of a reversal:

(a) The corresponding volume of credits shall be retired from the BioCarbon Reserve;

(b) For avoidable reversals, corrective actions and/or additional reserve contributions may be required.

15 Uncertainty assessment and conservative adjustment

Project holders shall assess and manage uncertainty in the quantification of GHG emission reductions and removals from Blue Carbon activities in accordance with the BioCarbon Tool: Conservative Approach and Uncertainty Management. The application of this tool is mandatory for all Blue Carbon projects.

This requirement ensures that all Verified Carbon Credits (VCCs) issued under this methodology are based on transparent, conservative, and verifiable assumptions, in full alignment with IPCC good practice guidance and the integrity safeguards of the BioCarbon Standard.

The tool applies to all relevant parameters that significantly influence the quantification of both baseline and project emissions or removals, including:

(a) Activity data (e.g., area of mangrove, tidal marsh, or seagrass loss or restoration measured through remote sensing or field mapping);

(b) Emission or removal factors (e.g., biomass carbon density, soil organic carbon stocks, CH_4 and N_2O emission factors under different salinity or hydrological conditions);

(c) Sampling and measurement systems, including remote sensing, soil coring, and biomass plots;

(d) Modeling assumptions, proxies, or expert judgment, where applied.

Project holders shall calculate combined uncertainty using one of the following approaches:

- Tier 1: Error propagation method (deterministic);

- Tier 2: Probabilistic method (e.g., Monte Carlo simulation), where applicable and supported by the data.

15.1 Required confidence level and adjustment rule

Uncertainty shall be expressed as a two-sided 90% confidence interval. The relative half-width of this interval shall determine the need for a conservative adjustment to the net emission reductions and removals:

(a) If the relative half-width is ≤ 30%, no deduction is applied;

(b) If the relative half-width exceeds 30%, the excess percentage shall be deducted from the net GHG benefits prior to credit issuance.

15.2 Data quality and discount factors

Where data sources are classified as lower quality (e.g., IPCC Tier 1 defaults, coarse-resolution land cover, global-average SOC values, 2019), project holders shall apply the data quality discount factors specified in Annex D of the BioCarbon Tool.

The highest applicable discount in the estimation chain shall be applied, unless:

(a) Project-specific data have been used and validated during verification; or

(b) Input parameters are fully consistent with national GHG inventory data of the host country (e.g., coastal wetlands data reported in FRELs, BURs, or National Inventory Reports).

15.3 Documentation and transparency requirements

Project holders shall document all uncertainty analyses and related assumptions in the Project Document and in each Monitoring Report. The documentation shall include, at minimum:

(a) A parameter-by-parameter uncertainty table, indicating data type (input, model-derived, fixed);

(b) The selected approach for uncertainty calculation (Tier 1 or Tier 2), including formulas or software used;

(c) Any conservative adjustments applied to emission reductions and removals;

(d) Rounding methods and final reported figures;

(e) Supporting calculation files and spreadsheets enabling full replication by third parties.

Where expert judgment is used to fill data gaps or support assumptions, the elicitation process shall be documented in accordance with Annex G of the BioCarbon Tool.

An example of uncertainty tables and calculation procedures is provided in Annex 3.

16 Monitoring requirements

The purpose of the monitoring plan is to define the procedures, data sources, responsibilities, and quality assurance measures required to track the implementation of Blue Carbon activities, verify GHG emission reductions and removals, and ensure compliance with safeguards and permanence requirements throughout the project's quantification period.

16.1 Parameters to be monitored

The project holder shall monitor the following elements, as applicable:

(a) Changes in ecosystem cover and condition within the project area (e.g., loss or gain of mangroves, marshes, or seagrass meadows);

(b) Changes in ecosystem condition or cover in potential leakage areas;

(c) GHG emissions and removals from relevant carbon pools (aboveground biomass, belowground biomass, soil organic carbon, and, where significant, CH_4 and N_2O);

(d) Implementation progress of project activities (e.g., hydrological restoration, revegetation, sustainable management);

(e) Compliance with environmental and social safeguards;

(f) Risks to permanence and effectiveness of mitigation results.

The parameters to be monitored and reported shall be consistent with the requirements of the BioCarbon MRV Tool and other applicable normative instruments.

Recommended monitoring frequencies and methods are provided in Annex 2.

16.2 Data sources and monitoring methods

The project holder shall describe the data sources, tools, and methods used for each parameter, which may include:

(a) Remote sensing (satellite imagery, aerial photography, drones) for land and ecosystem cover;

(b) GIS-based analysis for wetland dynamics, shoreline change, and erosion;

(c) Field data collection (e.g., biomass plots, soil core sampling, hydrological monitoring);

(d) Community monitoring, participatory diagnostics, or administrative records (for safeguards and activity implementation).

The same methodological approach, resolution, classification system, and spatial extent used for the baseline scenario shall be applied during monitoring to ensure consistency.

16.3 Monitoring frequency and reporting

The project holder shall define the frequency at which each parameter will be monitored and reported, in accordance with the requirements of this methodology and the applicable BioCarbon tools. The monitoring frequency shall be appropriate to the nature of the parameter and the level of risk or variability associated with it. At a minimum:

(a) Ecosystem cover change and project emissions/removals shall be monitored and reported at least once every 1 to 5 years, depending on the monitoring period.

(b) Project activities and safeguard indicators shall be monitored annually or biennially, based on their nature and implementation timeline.

(c) Risk and permanence indicators shall be reviewed at least once per monitoring period or immediately in case of reversals or disturbances.

All monitoring results shall be documented and made available for verification in accordance with the BioCarbon Validation and Verification Manual (2025e).

16.4 Monitoring of project activities and safeguards

The project holder shall establish and implement a monitoring plan to assess the execution and effectiveness of project activities, as well as to ensure continuous compliance with environmental and social safeguards.

The safeguard monitoring plan shall be aligned with the BioCarbon Sustainable Development Safeguards Tool (SDS Tool) and reflect the participatory processes established in the project design. Templates for activity and safeguard monitoring are provided in Annex 4.

The monitoring of safeguards shall be carried out in accordance with the requirements of the SDS Tool. This tool provides the mandatory indicators, monitoring methods, documentation requirements, and stakeholder engagement processes applicable to each safeguard. The safeguard monitoring results shall be included in each Monitoring Report and subject to independent verification.

Monitoring results shall also be made available to affected stakeholders upon request.

Each project activity implemented shall have a corresponding set of indicators to track its implementation status and outcomes, including:

(a) Identification of each activity (Activity ID and description);

(b) One or more indicators associated with the activity (Indicator ID);

(c) Definition of target values, measurement units, and expected results;

(d) Methodology and tools used to monitor the indicator;

(e) Frequency of data collection and responsible entity;

(f) Documentation to support the reported results.

16.5 Monitoring of safeguards

The project holder shall monitor the implementation and compliance of safeguards throughout the duration of the project. These include, at a minimum:

(a) Full and effective participation of stakeholders, including Indigenous Peoples and local communities;

(b) Respect for land tenure and customary rights;

(c) Conservation of biodiversity and ecosystem services;

(d) Enhancement of social and environmental benefits;

(e) Transparent governance and grievance mechanisms.

For each safeguard, the project holder shall define specific indicators, monitoring methods, and documentation procedures. Templates for activity and safeguard monitoring are provided in Annex 4.

16.6 Data quality and management

All monitored data shall be:

(a) Complete and representative of the project area;

(b) Supported by documentation (e.g., photos, field forms, remote sensing outputs);

(c) Validated through internal QA/QC procedures;

(d) Stored for a minimum of 10 years or two quantification periods, whichever is longer.

Where sampling is used, it shall be based on statistically robust approaches (e.g., stratified random sampling, IPCC-compliant SOC sampling).

If digital monitoring technologies (e.g., drones, LiDAR, automated sensors) are used, methods shall be validated and reproducible.

16.7 Monitoring of reversal risk and permanence conditions

Project holders shall monitor and report any changes that may affect the permanence of credited outcomes, including:

(a) Signs of illegal activity, drainage, or conversion;

(b) Natural disturbances (hurricanes, cyclones, tsunamis, storm surges, erosion, pests);

(c) Changes in legal status, governance, or stakeholder agreements;

(d) Effectiveness of applied risk mitigation measures (e.g., restoration structures, erosion barriers, community involvement).

Such data shall be used to update the Permanence and Risk Management Tool at each verification cycle and to support the classification of any potential reversal event as avoidable or unavoidable.

16.8 Data and record keeping

Project holders shall establish and maintain a data and record-keeping system that ensures the transparency, traceability, and accessibility of all information used in the design, implementation, monitoring, and verification of Blue Carbon activities.

This system shall support the independent verification of GHG emission reductions, the assessment and management of permanence risk, the monitoring of safeguards, and compliance with all applicable requirements of the BioCarbon Standard.

Project holders shall retain all relevant records and supporting documentation for a minimum of ten (10) years after the end of the last quantification period or for two (2) full verification cycles, whichever is longer. Records shall be:

(a) Accurate, complete, and consistent with the Project Document and monitoring plan;

(b) Archived in a secure, retrievable format;

(c) Made available to accredited Conformity Assessment Bodies (CABs) during validation and verification;

(d) Made available upon request for review by the BioCarbon Standard or its designated representatives.

Minimum documentation to be retained includes:

(a) GIS files and maps of project boundaries, stratification, and monitoring plots;

(b) Biomass measurements, SOC sampling data, hydrological monitoring data, and raw field data;

(c) Satellite imagery, aerial or drone outputs used for monitoring;

(d) Legal documentation: land titles, project authorization, community agreements;

(e) Monitoring and verification reports, field inspection records, data analysis files;

(f) Evidence of stakeholder consultations, grievance redress logs, and benefit-sharing documentation;

(g) Risk assessment scores and justifications from the Permanence Tool;

(h) Documentation related to reversals, loss events, or leakage incidents, including mitigation actions and corrective measures.

Project holders shall implement systems for QA/QC and version control, including:

- Consistent versioning of datasets and methodological inputs across reporting periods;
- Change logs for any corrections, updates, or revisions;
- Backups and audit trails with recorded date and time.

17 Quality Assurance and Quality Control (QA/QC)

Project holders shall implement a structured QA/QC system to ensure the accuracy, consistency, and transparency of all data, calculations, and procedures used in the quantification and monitoring of GHG emission reductions and removals under this methodology.

This section establishes the requirements for implementing a robust Quality Assurance and Quality Control framework to ensure that:

(a) All data and estimates are reliable, transparent, and verifiable;

(b) Errors, omissions, and inconsistencies are minimized;

(c) Monitoring, reporting, and verification (MRV) processes meet the highest standards of integrity;

(d) Claims of emission reductions and removals are defensible before third-party audits, host country authorities, and international market mechanisms.

The QA/QC procedures shall apply to both ex-ante and ex-post estimations and shall be documented in the Project Document and in each Monitoring Report.

Standardized templates for documenting QA/QC procedures are included in Annex 4.

17.1 Quality Assurance (QA)

Quality assurance refers to procedures implemented to prevent errors and ensure that data collection, processing, and reporting conform to methodological requirements. QA shall be proactive, focusing on accuracy and methodological rigor.

QA procedures shall include, as applicable:

(a) Independent review of stratification, sampling design, and monitoring protocols (e.g., SOC coring, biomass plots, hydrological monitoring);

(b) Validation of field crew training and calibration of measurement instruments, including GPS, soil augers, coring devices, and laboratory equipment;

(c) Cross-checks of input data, sources, and emission/removal factors against IPCC values, national inventories, or peer-reviewed literature;

(d) Peer review of emission reduction and removal calculations prior to submission;

(e) Documentation of data sources, assumptions, and justifications, with clear references and version control.

17.2 Quality Control (QC)

Quality control refers to routine technical activities that verify the integrity of data and calculations. QC is applied continuously during data collection, processing, and reporting.

QC measures shall include:

(a) Spot-checks or remeasurement of a statistically significant subset of sample plots, soil cores, or monitoring stations;

(b) Verification of field forms, GPS coordinates, geotagged photos, and data entries;

(c) Consistency checks across datasets, years, and versions to detect anomalies;

(d) Use of version control and audit trails for any modification of values or assumptions;

(e) Demonstration of reproducibility of results using documented methods, equations, and tools.

17.3 Corrective actions and traceability

Any detected errors, inconsistencies, or deviations shall be corrected in a transparent manner and documented. The QA/QC system shall ensure that:

(a) All data used in calculations can be traced to original records (field notes, laboratory results, raw satellite data);

(b) Changes in data or assumptions are justified, version-controlled, and reviewed;

(c) Results presented for verification are reproducible by an independent third party using the same datasets and procedures.

17.4 Documentation and archiving

All QA/QC actions shall be documented and archived. All monitored data shall be recorded in a transparent manner and archived in digital format.

At a minimum, the following shall be retained:

(a) Raw monitoring data, laboratory results, and processing scripts or spreadsheets;

(b) Version-controlled emission reduction and removal calculations;

(c) Field survey protocols and original field notes, including geotagged evidence;

(d) Copies of external reports, assessments, calibration certificates, and reviews;

(e) Documentation of all revisions, corrections, or updates to the methodology application.

All information shall be stored for a minimum of 15 years or two full quantification periods, whichever is longer, and made available upon request by the BioCarbon Standard or accredited third-party verifiers.

17.5 Continuous improvement

Project holders are encouraged to periodically review and update the QA/QC system, incorporating:

(a) Lessons learned from previous monitoring, verifications, or audits;

(b) Technological advancements (e.g., new remote sensing platforms, LiDAR, AI-assisted classification of wetlands, blockchain traceability tools);

(c) Feedback from stakeholders, verifiers, and host country authorities;

(d) Updates to the BioCarbon Standard, IPCC guidelines, or international best practices in carbon accounting and wetland science.

18 Document status and publication format

18.1 Status

This draft methodology has been prepared in accordance with the BioCarbon procedures for the development and revision of methodological documents. This version is released for public consultation and is not yet authorized for use under the BioCarbon Standard.

18.2 Version

Public Consultation Version. September 3, 2025

Approved by: Technical Committee of BioCarbon

Supersedes: N/A

18.3 Publication Format

This methodology is published in digital format (PDF) on the official website of BioCarbon. Any printed copies or unofficial reproductions shall be cross-checked against the version available in the official site. In case of discrepancy, the digital version in force shall prevail.

Project monitoring summaries and VCC issuance/retirement data shall be publicly accessible via the registry website.

19 References

BioCarbon Cert . (2025a). BCR STANDARD, Empowering sustainability, redefining standards. BioCarbon Standard. https://biocarbonstandard.com/wp-content/uploads/BCR_Estandar.pdf

BioCarbon Cert . (2025b). BIOCARBON TOOL Conservative approach and uncertainty management. BCR carbon credits are measured applying mechanism for managing uncertainty in the baseline quantification and mitigation results. In BioCarbon Standard.

https://biocarbonstandard.com/wp-content/uploads/Conservative_Approach_and_Uncertainty_Management_tool.pdf

BioCarbon Cert . (2025c). BIOCARBON TOOL Identification of a baseline scenario and demonstration of additionality GHG projects generate Verified Carbon Credits (VCC) that represent emissions reductions, avoidance, or removals that are additional. In BioCarbon Standard. BioCarbon Standard. https://biocarbonstandard.com/wp-content/uploads/Baseline_additionality_tool.pdf

BioCarbon Cert . (2025d). BIOCARBON TOOL MONITORING, REPORTING AND VERIFICATION (MRV). In BioCarbon Standard. https://biocarbonstandard.com/wp-content/uploads/BCR_Monitoring-reporting-and-verification.pdf

BioCarbon Cert . (2025e). VALIDATION AND VERIFICATION MANUAL GREENHOUSE GAS PROJECTS BIOCARBON CERT®, Version 3.0. https://biocarbonstandard.com/wp-content/uploads/BCR_validation-and-verification-manual.pdf

BioCarbon Cert . (2025f). Sustainable Development Safeguards SDSs Tool BIOCARBON CERT, Version 2.0. https://biocarbonstandard.com/wp-content/uploads/BCR_Sustainable_development_safeguards.pdf

BioCarbon Cert . (2025g). BIOCARBON TOOL Permanence and Risk Management. Version 2.0. https://biocarbonstandard.com/wp-content/uploads/BCR_risk-and-permanence.pdf

CDM Executive Board. (2005). EB23, Annex 18: Definition of Renewable Biomass. UNFCCC. https://cdm.unfccc.int/EB/023/eb23_repan18.pdf

ICAO. (2024). Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Www.icao.int. https://www.icao.int/corsia

ICVCM. (2023). ICVCM - Transparency for Voluntary Carbon Markets, Offsets & Credits. ICVCM. https://icvcm.org/

IPCC. (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use (AFOLU). Institute for Global Environmental Strategies. https://www.ipcc-nggip.iges.or.jp/public/2006gl/

IPCC. (2014). 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (eds). Published: IPCC, Switzerland . https://www.ipcc-nggip.iges.or.jp/public/wetlands/

IPCC. (2018). Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 541-562. https://doi.org/10.1017/9781009157940.008.

IPCC. (2019). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. IPCC. https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

IPCC. (2021). Chapter 7: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In IPCC Sixth Assessment Report Working Group 1: The Physical Science Basis. IPCC. https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-7/#7.6

IPCC. (2022). Annex I: Glossary [van Diemen, R., J.B.R. Matthews, V. Möller, J.S. Fuglestvedt, V. Masson-Delmotte, C. Méndez, A. Reisinger, S. Semenov (eds)]. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://doi.org/10.1017/9781009157926.020

International Organization for Standardization. (2019a). ISO 14064-2:2019… https://www.iso.org/standard/66454.html

International Organization for Standardization. (2019b). ISO 14064-3. In ISO: Global standards for trusted goods and services. https://www.iso.org/standard/66455.html

Ramsar. (1987). Convention on Wetlands of International Importance especially as Waterfowl Habitat .https://www.ramsar.org/sites/default/files/documents/library/current_convention_text_e.pdf

UNFCCC. (2015). Paris Agreement, Article 6. In United Nations. Climate Action (pp. 7–8). https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

20 Annexes

The following annexes form an integral part of this methodology. They provide technical guidance, default values, and standardized templates to ensure the consistent application, monitoring, and verification of Blue Carbon projects.

Project holders shall apply the annexes in conjunction with the BioCarbon Standard and its associated tools. Where project-specific or higher-tier data are available, they shall take precedence over Tier 1 default values included in these annexes.

Annex 1 – Default emission factors and parameters: Tier 1 default values from the IPCC 2013 Wetlands Supplement and the 2019 Refinement.

Annex 2 – Monitoring guidance: Recommended parameters, frequencies, and methods for Blue Carbon ecosystem monitoring.

Annex 3 – Uncertainty assessment guidance: Procedures for quantifying and addressing uncertainty.

Annex 4 – Templates for Monitoring and Reporting: Standardized formats to ensure transparency and replicability in reporting.

Annex 1 – Default emission factors and parameters

This annex provides default values from the IPCC 2013 Wetlands Supplement and the 2019 Refinement, which may be used where project-specific data are not available. These values are Tier 1 defaults and shall be applied conservatively. Where higher-tier data (Tier 2/3) exist, project holders are encouraged to use those values.

A.1 Soil Organic Carbon (SOC) stock values (0–1 m depth)

Ecosystem type	Soil type	Default SOC stock (tC/ha)	95% Confidence Interval	Source
Mangroves	Mineral	286	247 – 330	IPCC 2013, Table 4.11
Mangroves	Organic	471	436 – 510	IPCC 2013, Table 4.11
Tidal marshes	Mineral	226	202 – 252	IPCC 2013, Table 4.11
Tidal marshes	Organic	340	315 – 366	IPCC 2013, Table 4.11
Seagrass meadows	Mineral	108	84 – 139	IPCC 2013, Table 4.11

A.2 Default emission factors for rewetting and drainage of coastal wetlands (IPCC 2013 Wetlands Supplement)

Activity / Ecosystem	EF (tC/ha/yr)	95% CI (tC/ha/yr)	Range (tC/ha/yr)	n	EF (tCO_2/ha/yr)	95% CI (tCO_2/ha/yr)	Range (tCO_2/ha/yr)
Mangrove	-1.62	1.3-2.0	0.10-10.2	69	-5.94	4.77-7.33	0.37-37.40
Tidal marsh	-0.91	0.7-1.1	0.05-4.65	66	-3.34	2.57-4.03	0.18-17.05
Seagrass meadow	-0.43	0.2-0.7	0.09-1.12	6	-1.58	0.73-2.57	0.33-4.11
Drainage (tidal marshes & mangroves)	7.9	5.2-11.8	1.2-43.9	22	28.97	19.07-43.27	4.40-160.97

Notes:
1. Emission factors (EFs) are expressed as tonnes of carbon per hectare per year (tC/ha/yr). Conversion to CO_2-equivalent (tCO_2/ha/yr) was performed by multiplying by 44/12.
2. Negative values indicate removals.

3. Values are Tier 1 defaults from the 2013 IPCC Wetlands Supplement, Volume 4, Chapter 4: Coastal Wetlands, Tables 4.12 and 4.13. 4. For drainage, Tier 1 provides an aggregate factor for tidal marshes and mangroves; further disaggregation by climate or soil type requires Tier 2/3 data at national or regional level.

A.3 Default emission factors for methane (CH_4) in flooded land and constructed waterbodies (IPCC 2019 Refinement, Ch. 7)

System / Zone	**EF (kg CH_4/ha/yr)**	**Notes**	**Source**
Flooded Land Remaining Flooded Land			
Boreal	13.0	Tier 1 default for natural flooded land (wetlands)	IPCC 2019, Table 7.9
Temperate	220.0	Tier 1 default for natural flooded land (wetlands)	IPCC 2019, Table 7.9
Tropical	1400.0	Tier 1 default for natural flooded land (wetlands)	IPCC 2019, Table 7.9
Constructed waterbodies (ponds, canals, reservoirs)			
Freshwater/brackish ponds	1050.0	Includes aquaculture ponds, non-saline constructed	IPCC 2019, Table 7.12
Saline ponds	230.0	Constructed ponds with salinity ≥20 ppt	IPCC 2019, Table 7.12
Notes: Emission factors (EFs) are expressed in kg CH_4/ha/yr. For consistency with carbon accounting, values shall be converted to tCO_2e/ha/yr using the applicable Global Warming Potential (GWP) for CH_4 (e.g., 28 under IPCC AR5 or 27 under AR6). Where project-specific or nationally determined emission factors exist (Tier 2 or 3), those shall take precedence over the Tier 1 defaults.			

A.4. Emission Factor (EF_F) for N2O emission from aquaculture use in mangroves, tidal, marshes and seagrass meadows

Default EF	**95% CI[1]**	**Reference**
0.00169 kg N2O-N per kg fish produced	0, 0.0038	Hu et al., 2012 (IPCC 2013, Table 4.15)
[1] 95% CI of the geometric mean. Note: Approach used by Hu et al. (2012) using N in feed to fish biomass: Hargreaves, 1998; Protein content of fish biomass: USDA nutrient database for Standard Reference Nutrient Data Laboratory; N content of protein: Nelson and Cox, 2013; N to N2O conversion: Hu et al., 2013; Kong et al., 2013; Kampschrew et al., 2008; Ahn et al., 2010 (refer to Annex 4A.5)		

For the purposes of this Methodology, nitrous oxide (N_2O) emissions shall only be included where significant anthropogenic sources of nitrogen are present within the project boundary. In particular:

(a) Aquaculture: Where aquaculture is practiced within mangroves, tidal marshes, or seagrass meadows, N_2O emissions shall be quantified using the default emission factor provided in the 2013 IPCC Wetlands Supplement (Table 4.15), or higher-tier factors where available.

(b) Other activities: In the absence of aquaculture or other relevant nitrogen inputs (e.g., fertilizer application, industrial discharge), N_2O emissions from natural tidal wetlands are considered negligible at Tier 1 and shall not be included, unless project-specific or nationally determined Tier 2/Tier 3 data demonstrate significant fluxes.

A.5 Global warming potentials (GWPs)

Gas	**AR5 100-year GWP**	**AR6 100-year GWP (optional)**
CO_2	1	1
CH_4	28	27.0
N_2O	265	273

Note: BioCarbon projects shall apply the most recent IPCC GWPs in force at the time of validation.

Annex 2 – Monitoring guidance

This annex provides guidance on the monitoring of parameters required under this Methodology. It is intended to support consistency, transparency, and replicability of monitoring systems in Blue Carbon projects. Project holders shall apply the BioCarbon MRV Tool in all cases; where project-specific designs differ, justification shall be provided.

A.2.1 Parameters and monitoring frequency

Parameter	Unit	Monitoring frequency	Monitoring methods / data sources	Notes
Ecosystem cover and condition (mangroves, marshes, seagrass meadows)	ha, % cover	At least once every monitoring period (1–5 years); recommended annually via remote sensing	Satellite imagery (Landsat, Sentinel, Planet), aerial photography, drones; GIS-based change detection	Mandatory; stratification by ecosystem type required
Aboveground biomass	tC/ha	Every 5 years or at each verification	Field plots, allometric equations, LiDAR, national forest/wetland inventory data	Default root-to-shoot ratios may be used if local equations unavailable
Belowground biomass	tC/ha	Every 5 years or when aboveground biomass is updated	Root-to-shoot ratios, field coring, IPCC defaults	Applies to mangroves, marshes, and seagrass
Soil Organic Carbon (SOC)	tC/ha	Minimum once every 10 years	Stratified random soil coring, bulk density, %C analysis in laboratory	1 m depth (IPCC Wetlands Supplement 2013 (IPCC, 2014)); deeper if justified

Parameter	Unit	Monitoring frequency	Monitoring methods / data sources	Notes
CH_4 fluxes (tidal wetlands)	tCO_2e/ha	Once per monitoring period or when management alters hydrology	Flux chambers, eddy covariance, or IPCC default EF by salinity	Required when salinity <18 ppt or evidence of emissions
N_2O fluxes (fertilized/managed wetlands)	tCO_2e/ha	Once per monitoring period or when fertilizers are applied	IPCC default EF; field measurements where feasible	May be excluded if de minimis and justified
Hydrological parameters (water level, salinity)	m, ppt	Continuous or at least quarterly	Piezometers, salinity probes, hydrological models	Important for SOC stability and CH_4/N_2O flux estimation
Leakage drivers (aquaculture, fuelwood harvest, fishing pressure)	Qualitative / ha	At each verification period	Field surveys, interviews, stakeholder consultations, GIS	Required if risk of displacement exists
Safeguard indicators	Qualitative / quantitative	Annually or biennially	SDS Tool participatory monitoring, surveys, administrative records	Shall align with BioCarbon SDS Tool (BioCarbon Cert, 2025f)
Permanence risk indicators (erosion, extreme events, land tenure, governance)	Qualitative / ha	Reviewed at each verification cycle, or immediately following a reversal	Project-specific records, field inspections, disaster reports	Used in Permanence and Risk Tool (BioCarbon, 2025g)

A.2.2 Documentation requirements

(a) All monitored data shall be archived in digital format, georeferenced where applicable, and retained for at least 10 years after the last quantification period or two full verification cycles, whichever is longer.

(b) QA/QC procedures shall include cross-checks of data, calibration of instruments, and reproducibility of calculations.

(c) Where expert judgment is applied, the process shall be documented according to the BioCarbon MRV Tool.

Annex 3 – Uncertainty assessment guidance

This annex provides guidance on how to apply the BioCarbon Uncertainty Assessment Tool in Blue Carbon projects. It sets out the minimum requirements for documenting, calculating, and applying conservative adjustments when uncertainty affects the quantification of GHG emission reductions and removals.

A.3.1 Confidence level and adjustment rule

(a) Uncertainty shall be expressed as a **two-sided 90% confidence interval**.

(b) The **relative half-width** (RH) of this interval shall determine the conservative adjustment applied to net emission reductions and removals:

$$RH = \frac{(Upper\ CI - Lower\ CI)}{2 \times Mean} \times 100$$

<u>Adjustment rule</u>

If RH ≤ 30%: no deduction is applied.

If RH > 30%: The excess percentage above 30% shall be deducted from net emission reductions/removals prior to credit issuance.

A.3.2 Uncertainty sources

Project holders shall consider and document uncertainty in the following parameters:

(a) **Activity data**

- Area of ecosystem change (loss, restoration, management).
- Derived from remote sensing, GIS, field mapping.

(b) **Emission/removal factors**

- Biomass expansion factors, root-to-shoot ratios, SOC densities.
- IPCC defaults or project-specific data.

(c) **GHG fluxes**

- CH_4 and N_2O emission factors (salinity, fertilization).
- Measurement or IPCC defaults.

(d) **Sampling and measurement systems**

- Biomass plots, soil coring, bulk density, %C analysis.

(e) **Modeling assumptions, proxies, expert judgment**

- Hydrological modeling, interpolation of data.

A.3.3 Calculation approaches

Project holders shall apply one of the following approaches:

- **Tier 1 – Error propagation method** (deterministic):

$$Var(Y) = \sum \left(\left(\frac{\partial f}{\partial x_i} \right)^2 Var(x_i) \right)$$

  Applied when uncertainty estimates for input parameters are available.

- **Tier 2 – Probabilistic methods** (e.g., Monte Carlo simulation):
  - Applied when data quality and variability justify stochastic approaches.
  - Requires at least 5,000 iterations and clear documentation of distributions used.

A.3.4 Example of parameter-by-parameter uncertainty table

Parameter	Data type	Mean value	Uncertainty (± %)	Source
Area of mangrove loss (ha)	Remote sensing	500	±10%	Landsat/Sentinel imagery, 95% CI
AGB carbon stock (tC/ha)	Input (field plots)	120	±15%	Field inventory, allometric equations
SOC stock (tC/ha, 0–1 m)	Input (soil cores)	286	±20%	Soil coring, lab analysis
CH_4 EF (tCH_4/ha/yr)	Default factor	0.011	±50%	IPCC 2013 Wetlands Supplement
Fossil fuel use (tCO_2)	Administrative	200	±5%	Fuel records

Net uncertainty is calculated by combining individual contributions via error propagation or Monte Carlo.

A.3.5 Documentation requirements

(a) A parameter-by-parameter uncertainty table shall be included in each Monitoring Report.

(b) All assumptions, formulas, software, and input distributions (for Monte Carlo) shall be documented.

(c) Expert judgment shall follow elicitation procedures in Annex G of the BioCarbon Tool.

(d) Supporting calculation files (Excel, R, Python, etc.) shall be archived and made available for verification.

Annex 4 – Templates for Monitoring and Reporting

This annex provides standardized templates to support the documentation and reporting of monitoring results in Blue Carbon projects. Project holders shall adapt these tables to their project context and include them in each Monitoring Report submitted for verification.

A.4.1 Project activities monitoring template

Activity ID	A1
Activity description	Hydrological restoration of degraded mangrove
Indicator ID	IND-01
Indicator name	Area restored
Target value	100
Measurement unit	ha
Methodology/tool	Remote sensing + field verification
Monitoring frequency	Annual
Responsible entity	Project holder and community monitors
Results (current period)	95 ha restored
Supporting documents	GIS shapefiles, photos
Observations	Slight delay due to weather conditions

A.4.2 Safeguard compliance monitoring template

Safeguard ID	S1
Indicator ID	SAF-01
Indicator name	Effective participation of Indigenous Peoples and local communities
Type (quant./qual.)	Qualitative

Target	Evidence of FPIC process
Methodology/tool	SDS Tool participatory monitoring
Frequency	Biennial
Responsible entity	Project holder and community representatives
Results (current period)	FPIC process completed
Supporting documents	FPIC records, meeting minutes
Observations	Grievance log maintained

A.4.3 Permanence and reversal risk monitoring template

Risk category	Natural disturbances
Indicator	Shoreline erosion rate
Measurement unit	m/year
Baseline risk score	2
Updated risk score	3
Method/tool	Piezometer data, GIS shoreline change analysis
Corrective actions	Additional erosion barriers installed
Supporting documents	Field survey reports, drone imagery

A.4.4 Uncertainty assessment template

Parameter	SOC stock (0–1 m depth)
Data type	Field sampling
Mean value	286 tC/ha
Uncertainty (±%)	±20%

Source	Soil coring, lab analysis
Method (Tier 1/Tier 2)	Tier 1 (error propagation)
Final adjustment applied	–2% deduction

A.4.5 Leakage monitoring template

Leakage driver	Displacement of aquaculture
Potential impact	Conversion of adjacent marsh to ponds
Indicator	Area converted (ha)
Monitoring method	Remote sensing + field visits
Frequency	Annual
Mitigation action	Provide alternative livelihood support
Results (current period)	0 ha converted
Supporting documents	Satellite imagery, stakeholder interviews

Document history

Type of document. Methodological Document for Blue Carbon projects

Version	Date	Nature of the review
Public Consultation Version	September 3, 2025	Initial version – Document submitted for public consultation