PV CLIMATE MODULE

PU##a

Mangrove conservation module

Version 0.9

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1 Summary

This module provides carbon accounting procedures for Plan Vivo Climate projects undertaking Mangrove *Conservation*. It is part of PM00X, the modular Coastal Blue Carbon Methodology.

Mangrove *Conservation* projects that fulfil the applicability conditions of this module lead to less Mangrove deforestation, compared to what would have happened without the project. This leads to CO_2 emission reductions because the carbon stored in Mangrove's wood, leaves and soils can be emitted to the atmosphere when Mangroves are deforested. These emission reductions have a positive impact on the climate (*Carbon Benefit*). As do the continuous CO_2 removals in the soil organic carbon (SOC) pool by the conserved intact Mangrove Forests, however these removals are small compared to the emission reductions and are thus conservatively excluded from the accounting in this module. Baseline CO_2 removals in all *Carbon Pools* except wood products are also assumed to be insignificant.

Mangrove degradation (i.e. when Mangrove vegetation is lost but the area remains classified as forest according to the relevant country's definition of forest) is challenging to accurately map over time. Therefore, this module only covers avoided deforestation and any emission reductions because of avoided degradation due to project activities are conservatively excluded. If sufficiently accurate and accessible approaches for monitoring Mangrove degradation over time at scale are developed, the scope of this module can be expanded.

Project Interventions that include Partial (selective) Harvesting and projects that lead to an increase in aboveground non-woody biomass (e.g. nypa palm) or deadwood harvesting within the *Project Area* (e.g. for fuelwood) cannot use this module until the Sustainable Mangrove wood management module (PU##d) is developed.

Similarly, if the wood that would have been produced by baseline deforestation would have been used to create products that last more than 5 years (e.g. as building poles or wood for boat building), this lessens the climate impact of the deforestation. If a project's baseline includes such wood products, they cannot use this module until the Sustainable Mangrove wood management module (PU##d) is developed.

Whilst Mangroves are known to be significant carbon stores, in certain situations they can also emit methane (CH_4), another greenhouse gas (GHG). Thus, Mangrove *Conservation* can lead to an increase in methane emissions compared to the baseline scenario. This module describes the situations where methane accounting is required and outlines the necessary procedures.

Projects that fulfil the applicability conditions of this module and PM00X are exempt from accounting for emissions from other emission sources.

For each key step, worked examples are provided to walk projects through the application of the procedures, using a hypothetical Mangrove Conservation project as an example.

The first step in this module is understanding, describing and quantifying the relative importance of the likely causes of deforestation in the *Project Area* in the absence of the project. At a minimum, these are to be categorised as agriculture/aquaculture, clearing, erosion, extreme climate, and settlement.

This module requires the definition of three key geographic areas:

- The *Project Area*, which is the Mangrove area that will be conserved due to the *Project Intervention*. Projects can have more than one *Project Area*. These are determined at the start of the project and remain fixed unless new *Project Areas* are added.

- The Reference Area, which is a region within which Mangroves are assumed to be affected by similar drivers of deforestation and degradation as the *Project Area* under the baseline scenario. This is area is based on jurisdictional boundaries and includes the *Project Area*.

- The Leakage Area, which contains the forest area where deforestation may move to due to the *Project Intervention*. This area is determined according to the activities and mobility of the specific stakeholder groups expected to engage in activities that cause deforestation in the *Project Area* under the baseline scenario, whose activities could be displaced due to the *Project Intervention*. If clearing for wood is identified as a driver of deforestation in the baseline scenario, the Leakage Area must also include any non-Mangrove Forest that may be targeted by the stakeholder groups responsible for deforestation in the baseline scenario.

Projects must define CO_2 Emission Factors for the Vegetation and Soil *Carbon Pools*. These can be derived from the Mangrove carbon stocks in each *Carbon Pool* and the percentage of these stocks that would be lost due to the driver(s) of deforestation. The data published in Sanderman et al., 2018[1] can be used to estimate carbon stocks in the soil organic carbon pool. Default values for the percentage of Mangrove carbon stocks that would be lost from the aboveground woody biomass, belowground biomass and soil organic carbon pools are provided for each marine province of the Marine Ecoregions of the World[2] (see Annex One).

At the start of each *Verification Period*, historical satellite imagery or land cover maps are used to determine the rate of Mangrove deforestation in the Reference Area over a 10-year historical Reference Period. This is assumed to represent the expected rate of deforestation in the *Project Area* during the *Verification Period* in the absence of the project (i.e. in the baseline scenario).

The publicly available Global Mangrove Watch[3] dataset can be used for all the mapping exercises in this module.

Conservative assumptions regarding the efficacy of the *Project Intervention* are used to estimate the amount of deforestation that is expected to occur in the *Project Area* despite the implementation of the *Project Intervention* (i.e. in the project scenario).

To calculate the expected CO_2 emissions due to Mangrove deforestation in the baseline and project scenarios during the *Verification Period*, the area of expected Mangrove deforestation is multiplied by the CO_2 Emission Factors for each *Carbon Pool*.

Conservative assumptions regarding the efficacy of leakage mitigation activities are used to estimate expected emissions due to leakage during the *Verification Period*.

[1] https://iopscience.iop.org/article/10.1088/1748-9326/aabe1c/meta
[2] https://academic.oup.com/bioscience/article-abstract/57/7/573/238419?redirectedFrom=PDF
[3] https://www.globalMangrovewatch.org/

Actual emissions are calculated at the end of each *Verification Period*. This is done by using historical satellite imagery or land cover maps to determine how much Mangrove deforestation occurred in the Reference Area and *Project Area* during the *Verification Period*. The amount of deforestation in the Reference Area together with the Emission Factors for each *Carbon Pool* are used to estimate the actual emissions in the baseline scenario during the *Verification Period*. The amount of deforestation in the *Project Area* together with the same Emission Factors are used to estimate the actual emissions in the project scenario during the *Verification Period*.

To estimate actual emissions due to leakage, firstly historical satellite imagery or land cover maps are used to determine any areas of deforestation in the Leakage Area in the project scenario over the *Verification Period*. This is then compared to what is expected to have been lost in the baseline scenario, by assuming that the deforestation rate in the Reference Region represents the baseline scenario in the Leakage Area. The difference between these areas is assumed to be deforestation caused by the *Project Intervention* and the resulting leakage emissions are calculated using the default values for each carbon pool.

Through the application of this module, projects will estimate values for the following parameters. Those used in PM00X are in **bold blue text** in this list and throughout the document.

= **Total expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Crediting Period*** (tCO_2e).

= **Total actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*** (tCO_2e).

= **Total expected baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Crediting Period*** (tCO_2e). Due to the applicability conditions of this module, this parameter = 0

= **Total actual baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*** (tCO_2e). Due to the applicability conditions of this module, this parameter = 0

= **Total expected baseline emissions from all emission sources across all Zones of the *Project Area* for each year of the *Crediting Period*** (tCO_2e)

= **Total actual baseline emissions from all emission sources across all Zones of the *Project Area* for each year of the *Verification Period*** (tCO_2e)

= **Total expected project emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Crediting Period*** (tCO_2e)

= **Total actual project emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*** (tCO_2e)

= **Total expected project CO_2 removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Crediting Period*** (tCO_2e) Conservatively excluded by this module.

= **Total actual project CO_2 removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*** (tCO_2e) Conservatively excluded by this module.

= **Total expected project emissions from all emission sources across all Zones of the *Project Area* for each year of the *Crediting Period*** (tCO_2e)

= **Total actual project emissions from all emission sources across all Zones of the *Project Area* for each year of the *Verification Period*** (tCO_2e)

2 Sources

This module adapts the procedures in the Plan Vivo Climate tool **PT002 (Estimation of carbon benefits from REDD in community managed forest)** for application by projects whose *Project Interventions* include Mangrove *Conservation*.

In addition to the modules and tools listed below, this module is designed to be applied in conjunction with PM00x for the estimation of carbon benefits from Mangrove Conservation.

This module includes procedures from the following CDM Methodologies and Tools:

AR-TOOL04 version 1.0 - Tool for testing significance of GHG emissions in A/R CDM project activities

This module also references the following guidance documents:

Coastal Blue Carbon; methods for assessing carbon stocks and emissions factors in Mangroves, tidal salt marshes, and seagrass meadows (Howard et al., 2014)[4]

3 Definitions

Capitalised terms in this module are defined in the latest version of PM00X and below. Terms that are both Capitalised and *italicised* are defined in the latest version of the Plan Vivo Climate Glossary.

Deforestation – The conversion of forest to non-forest. See below for the definition of Mangrove Forest used in this module.

Emission Factor – Emissions (in tCO_2e) per hectare from a *Carbon Pool* due to a certain driver of deforestation

Leakage Area – The area that contains the forest where deforestation may move to due to *Project Interventions*. The requirements of the Leakage Area are detailed in Section 5.2.3.

Mangrove Forest – An area of Mangroves which conforms to the national definition of forest in the country within which the project is located, with the exception of any requirement regarding tree height. For instance, if a country defines forest as "*Land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent*", then an area of Mangroves in this country is classed as forest if the area of the Mangroves is greater than 0.5 hectares and the canopy cover is greater than 10 percent.

Reference Area – A region within which Mangroves are assumed to be affected by similar drivers of Mangrove deforestation as the *Project Area* under the baseline scenario. Thus, the rates of Mangrove deforestation within the Reference Area are assumed to be representative of the baseline scenario in the *Project Area*. In this module the Reference Area is defined by jurisdictional boundaries. The requirements of the Reference Area are detailed in Section 5.2.2.

Reference Period – The time period over which historical rates of Mangrove deforestation are assumed to provide an indication of likely rates of Mangrove deforestation in the *Project Area* during the *Verification Period*.

[4] https://www.thebluecarboninitiative.org/manual

Soil Methanogenesis – the process by which microbes in waterlogged, oxygen-poor soils break down organic matter and produce methane gas, a greenhouse gas.

Woody Mangroves – A Mangrove tree or shrub that has a wood component to its structure. With the exception of *Nypa fruticans*, all of the dominant Mangrove species are woody (e.g. those of the genera *Avicennia, Lumnitzera, Bruguiera, Ceriops, Kandelia, Rhizophora* and *Sonneratia*).

Zone – Areas with similar characteristics, for instance Mangrove carbon stocks, drivers of deforestation, marine province or land tenure classification.

4 Applicability Conditions

This module is applicable to Plan Vivo Climate projects that conserve Mangrove ecosystems and prevent deforestation through community-led actions. This includes activities such as:

- Development of Mangrove management plans
- Creation and implementation of community-led protected areas (for instance, locally managed marine areas)
- Patrols to encourage enforcement of management plans and/or protected area rules
- Development of alternative sources of wood and/or income
- Locally led efforts to prevent loss of Mangroves due to natural forces such as erosion

All projects must fulfil the applicability conditions of the Coastal Blue Carbon methodology (PM00X). The following applicability conditions also apply to this module:

- The baseline scenario does not include planned deforestation that is documented in land management or planning documents
- The baseline scenario does not include effective community management.
- Project activities do not involve the use of heavy machinery
- Project activities do not include non-Mangrove wood use (e.g. to build sediment traps for Building with Nature initiatives) unless it can be demonstrated that the wood comes from a sustainable source.
- Project activities do not include Partial (selective) Harvesting and do not that lead to an increase in aboveground non-woody biomass (e.g. nypa palm) or deadwood harvesting within the *Project Area* (e.g. for fuelwood). Such activities will only be allowed once the Sustainable Mangrove wood management module (PU##d) is developed to enable projects to quantify the emissions associated with these activities.
- Projects where wood harvesting for timber is a driver of deforestation and the wood would have been used to create products that last more than 5 years (e.g. as building poles or wood for boat building) cannot use this module until PU##d is developed.

This module can be used to claim rPVCs and vPVCs. It cannot be used to claim fPVCs.

There are no geographical or project size limitations to this module.

5 Procedures

This section describes the steps that projects need to follow to estimate their *Carbon Benefit*. At the end of each section there is a box that lists any required outputs that must be detailed in the *Project Design Document* (PDD).

The Plan Vivo Climate Project Requirements (section 1.2) state that projects can have more than one *Project Area*. In this module, the term '*Project Area*' covers all project areas. Thus, if a project has multiple *Project Areas*, this term should be interpreted as '*Project Areas*'.

5.1 Understanding the causes of Mangrove deforestation and their relative influence

Projects identify and justify the baseline scenario for the project (e.g. continuation of pre-project land use) by applying the procedures in Section 6.2 of PM00X. To prepare for procedures later in the module, particularly if a project wants to use the default values in Annex One for the percentage of carbon stocks lost in each carbon pool detailed, projects need to further describe what is expected to happen to Mangroves in the *Project Area* in the absence of the *Project Interventions*.

Through documented participatory social research, projects must establish the causes (i.e. drivers) of deforestation that threaten the Mangroves in the *Project Area*. At a minimum, these must be categorised as:

- Agriculture/aquaculture
- Clearing for wood/charcoal
- Erosion
- Extreme climate, or
- Settlement.

But projects wishing to use their own emission factors have the option to define the drivers in more detail.

Complementary to the stakeholder analysis required for the *PDD*, projects must identify and describe the stakeholder groups that would be involved in each cause of deforestation in the absence of the *Project Interventions*.

If more than one driver exists, projects have two options:

1. Zone the *Project Area*, Reference Area and Leakage Area (see Section 5.2 below) according to the different drivers OR
2. Quantify the relative importance of each driver, in terms of % of annual Mangrove loss caused by each driver in the surrounding area in the ten years prior to the project *Start Date*. This can be done through social research, analysis of land cover change in Google Earth, remote sensing analyses or an assessment of peer-reviewed literature.

If a Mangrove Forest area is cleared for two reasons – for instance the trees are first cleared to harvest wood/charcoal and then the area is converted to rice agriculture – this trend and the associated stakeholders must be detailed in the *PDD*. But for the purposes of the *Carbon Benefit* calculations, it is the final cause that is used in this module. In the example above, this would be agriculture.

The procedures in this section must be repeated at least every 10 years and the updated results reported in the *PDD*.

Required outputs from Section 5.1:

- A list of the identified driver(s) of deforestation expected to threaten the *Project Area* in the absence of the project.
- A description of the stakeholder groups engaged in each driver of deforestation.
- If more than one driver exists and the *Project Area*, Reference Area and Leakage Area are not zoned according to deforestation driver, the relative importance of each driver, in terms of % of annual Mangrove loss caused by each driver in the surrounding area in the ten years prior to the project *Start Date*.

5.2 Geographic boundaries

To use this module, projects must define three areas: the *Project Area*, a Reference Area and a Leakage Area.

5.2.1 Project Area

The *Project Area* is the Mangrove Forest area that will be conserved due to the *Project Intervention*. The boundaries of the *Project Area* can be based on participatory mapping, mangrove management plans or Mangrove Forest maps.

It must not include any areas that will be planted for the purpose of leakage mitigation (for instance, areas for alternative fuelwood plantations).

Error! Reference source not found. in the worked example below shows an example for a hypothetical project.

A map of the *Project Area* must be included in the *PDD* and GIS files (e.g. Google Earth .kmz files) delineating the *Project Area* should be available.

5.2.2 Reference Area

The Reference Area is a region where it is assumed that Mangroves will be exposed to similar drivers of deforestation as Mangroves in the *Project Area*. Thus, it is assumed that patterns of deforestation that occur in the Reference Area during the *Project Period* would likely have occurred in the Mangroves in the *Project Area*, in the absence of the *Project Intervention*.

The Reference Area excludes the *Project Area*, so that Mangrove deforestation rates in the Reference Area can compared to those in the *Project Area*.

The Reference Area is determined by jurisdictional boundaries, as follows:

- If the *Project Area* is **in a country with less than 200,000 ha of Mangroves** at the project's *Start Date*, the **national boundary minus the *Project Area*** is the Reference Area.
- If the *Project Area* is **in a country with more than 200,000 ha of Mangroves** at the project's *Start Date*, the national boundary minus the *Project Area* may also be used as the Reference Area. Alternatively, the Reference Area can be **the largest administrative unit below the**

national boundary (for instance, Provinsi/Province in the case of Indonesia) **minus the *Project Area***. If projects use the largest administrative unit below the national boundary, in the *PDD* they must justify that this is a conservative decision, or that, in the *Baseline Scenario*, the *Project Area* would be threatened by drivers that are represented most accurately by trends within the administrative unit rather than the national boundary.

Error! Reference source not found. in the worked example below shows an example for a hypothetical project.

The Reference Area is established at the start of the project and is not revised unless, in the case of projects in countries with more than 200,000 ha of Mangroves, new evidence suggests that it is no longer appropriate.

A map of the Reference Area must be included in the *PDD* and GIS files (e.g. Google Earth .kmz files) delineating the Reference Area should be available.

5.2.3 Leakage Area

Leakage is defined as a reduction in carbon stocks outside the *Project Area*, as a result of project activities. In this module, the Leakage Area contains the forest area where deforestation may move to due to the *Project Intervention*.

The Leakage Area must be defined according to the mobility of specific stakeholder groups expected to engage in activities that cause deforestation in the *Project Area* under the *Baseline Scenario*, whose activities could be displaced because of the *Project Intervention*.

The delimitation of the Leakage Area should be informed by the analysis completed in Section 5.1. At a minimum:

- It must exclude any designated protected areas (such as national parks or marine protected areas) unless it can be clearly demonstrated that the protection of these areas is ineffective (for instance, with recent historical deforestation maps that show forest loss in the protected area).
- Beyond these protected areas, it must encompass all Mangroves within 10 km of the *Project Area* at the start of the *Verification Period*.
- If clearing for wood/charcoal was identified as a driver of deforestation in the *Baseline Scenario* (see Section 5.1), the Leakage Area must also include any non-Mangrove Forest within 10 km of the *Project Area* that may be targeted by the stakeholder groups responsible for deforestation in the *Baseline Scenario*.

Error! Reference source not found. in the worked example below shows an example for a hypothetical project.

If a project has more than one contiguous *Project Area*, Leakage Areas must be established around all *Project Areas*.

A map of the Leakage Area must be included in the *PDD* and GIS files (e.g. Google Earth .kmz files) delineating the Leakage Area should be available.

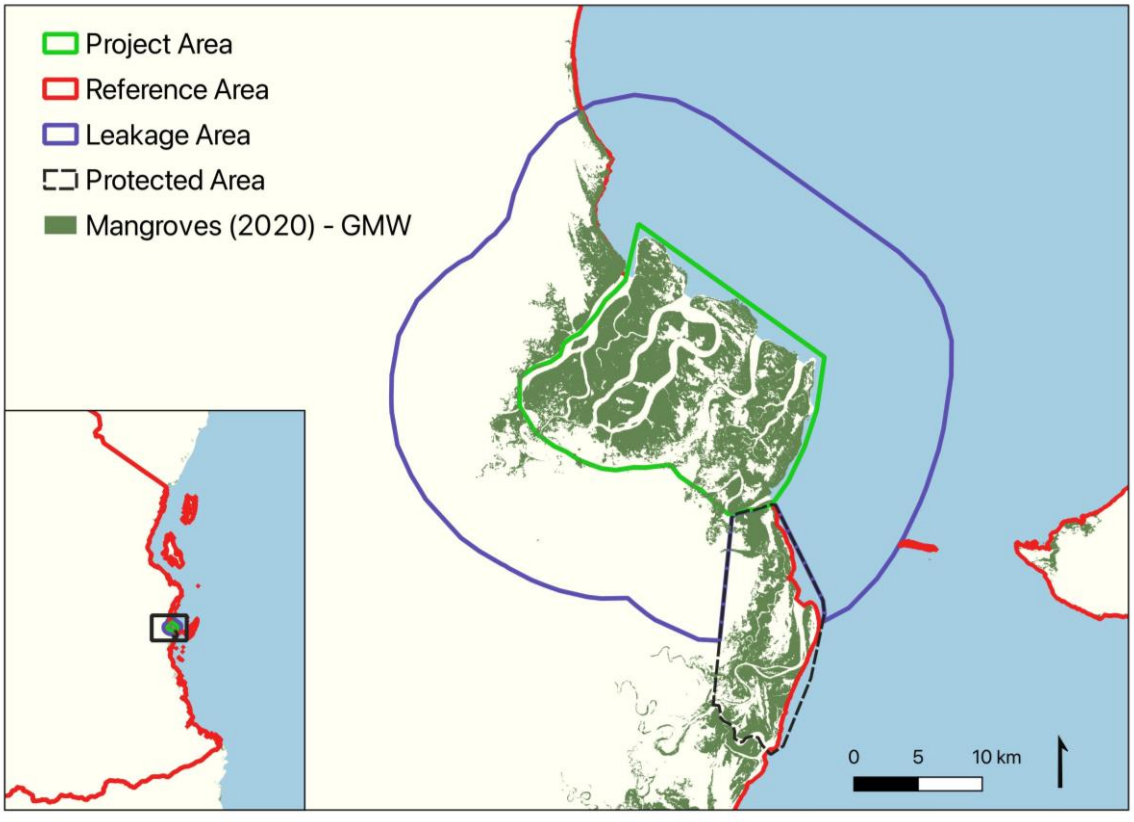
Worked example – Sections 5.2.1-3

Error! Reference source not found. shows a hypothetical Mangrove Conservation project. The *Project Area* (bright green polygon) is based on the *Conservation* area within a community-led mangrove management plan. The mangroves in 2020, according to Global Mangrove Watch, are shown in dark green.

According to Global Mangrove Watch data, in 2020 there were 100,000 ha of mangroves in the country. This is less than 200,000, therefore the Reference Area (red polygon in **Error! Reference source not found.**) is the national boundary.

The analysis completed to fulfil the requirements in Section 5.1 indicated that fish aquaculture (agriculture/aquaculture deforestation driver category) and clearing for wood and charcoal would be the drivers of deforestation in the *Project Area* in the absence of the *Project Intervention*.

Due to land tenure restrictions, the stakeholder groups engaged in fish aquaculture do not have high mobility. The stakeholder groups engaged in clearing for wood and charcoal do have higher mobility but would not travel more than 5 km in search of wood for charcoal and timber. Therefore, the Leakage Area is defined as the 10 km-wide area around the *Project Area*, based on the minimum requirements for the Leakage Area. There is a protected area (dashed black polygon in **Error! Reference source not found.**) to the south of the *Project Area*, within this 10 km buffer Zone. It cannot be demonstrated that the protection of this area is ineffective, thus the protected area is removed from the buffer Zone to give the final Leakage Area (purple polygon in **Error! Reference source not found.**).



5.2.4 Zoning

Zoning (also known as stratification) is not strictly required by this module. However, to improve the accuracy of the *Carbon Benefit* estimates, projects may stratify the *Project Area*, Reference Area and Leakage Area into Zones with similar characteristics, particularly if Mangrove carbon stocks vary significantly across the *Project Area*. As detailed in Section 10.3 of PM00X, if the variance of sampled parameters is too high, an uncertainty deduction must be applied, which decreases the number of PVCs that a project can request issuance for.

In the following situations, zoning is required:

- If a project uses the default values in Annex One for the percentage decrease in carbon stocks due to the drivers of deforestation (see Section 5.3), the Project Area, Reference Area and Leakage Area must be zoned according to marine province[5].
- If clearing for wood/charcoal was identified as a driver of deforestation in the baseline scenario (see Section 5.1), at a minimum the Leakage Area must, at a minimum, be zoned into Mangrove and non-Mangrove Forest.

Beyond these requirements, projects may choose to zone their Project Area, Reference Area and Leakage Area according to the following factors:

- **Mangrove Forest class** (e.g. open-canopy or closed-canopy). The classification of Mangrove Forest class should reflect the main differences in Mangrove carbon stocks that occur in the *Project Area*. These are likely to include ecological classes as well as disturbance history.
- **Drivers of Mangrove deforestation**. As explained in Section 5.1, projects where more than one driver of deforestation threatens the Mangroves in the *Project Area* may choose to Zone the *Project Area*, Reference Area and Leakage Area according to driver of Mangrove deforestation.
- **Soil type** (e.g. organic or mineral). This can strongly influence emissions from the soil organic carbon pool.
- **Salinity**. Such zoning can be used to constrain the need for accounting for Soil Methanogenesis (see Section 5.3).
- **Legal classification**. The legal status of the forest and the activities that are legally permitted in the area are likely to affect how the forest is used; additional classifications can be added to reflect other relevant factors, for example efficacy of protection or enforcement, or land ownership.

With the exception of the non-Mangrove Forest Zone(s) in the Leakage Area, any zoning used must be applied to the *Project Area*, the Reference Area and the Leakage Area.

Maps and tables describing the characteristics of all Zones in the *Project Area*, Reference Area and Leakage Area must be provided in the *PDD*.

Required outputs from Section 5.2:

- Map(s) showing the *Project Area*, Reference Area and Leakage Area.
- GIS files (e.g. Google Earth .kmz files) containing the *Project Area*, Reference Area and Leakage Area
- Map(s) of all Zones in the *Project Area*, Reference Area and Leakage Area.
- Tables describing the characteristics of all Zones in the *Project Area*, Reference Area and Leakage Area.

Worked example – Sections 5.2.4

A Mangrove Forest inventory was completed across the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**. The results of this inventory indicate that Mangrove carbon stocks do not vary significantly across the *Project Area*. Mineral soils are dominant across the Project Area and salinity levels do not vary in a way that leads to variability in Mangrove carbon stocks. Land tenure does impact the distribution of the drivers of deforestation, but it is not possible to map tenure across the entire Reference Area. Instead, participatory research was conducted to quantify the relative importance of each driver, in terms of % of annual Mangrove loss caused by each driver in the surrounding area in the ten years prior to the project *Start Date* (see Section 5.1). Based on historical deforestation trends in the area surrounding the project, an understanding of demand for timber and charcoal together with the volumes of Mangrove biomass needed to fulfil this demand, and a clear understanding of the land tenure of potential pond owners in the *Project Area*, it is estimated that **30% of annual Mangrove loss would be caused by aquaculture and 70% due to clearing for wood and charcoal**.

The project wishes to use the default values in Annex One for the percentage decrease in carbon stocks due to the drivers of deforestation. Therefore, zoning according to marine province is necessary. However, the *Project Area*, Reference Area and Leakage Area are all within one province, therefore zoning by marine province is not necessary.

Given the relative importance of each driver is known and ecological characteristics do not vary significantly across the *Project Area*, the project only uses one Zone in the *Project Area* and the Reference Area: Mangrove Forest. Data from Global Mangrove Watch is used to show this Zone in Figure 2 (green polygons).

However, clearing for wood/charcoal is a driver of deforestation in the baseline scenario. Therefore, a non-Mangrove Forest Zone must be included in Leakage Area. Global Forest Watch provides maps of and data regarding tree cover across the tropics. A minimum tree cover of 30% is used to define the non-Mangrove Forest Zone (light blue polygons in Figure 2).

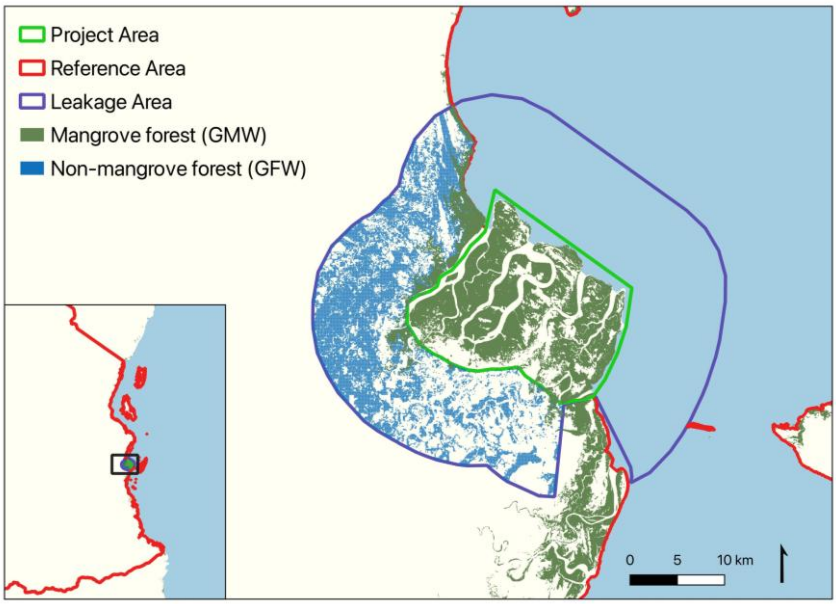


Figure 2 – A map showing the two Zones - Mangrove Forest and non-Mangrove Forest – across the Project Area, *Reference Area and Leakage Area. Global Mangrove Watch data is used to depict the Mangrove Forest Zone and*

5.3 Carbon stock estimates

5.3.1 Vegetation and Soil Carbon Pools

For the following *Carbon Pools*:

- above-ground woody biomass
- below-ground biomass and
- soil organic carbon

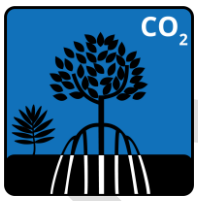
projects must provide a **CO_2 Emission Factor**, which quantifies the per-hectare CO_2 emissions from the *Carbon Pool* due to deforestation. This must be done for each Zone identified in Section 5.2.4 and for each driver of deforestation identified in Section 5.1.

CO_2 Emission Factors can be calculated using the following two parameters:

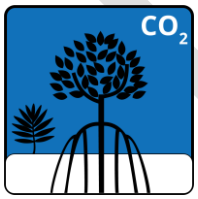
- the **carbon stock** in tCO_2e/ha in **each Zone** identified in Section 5.2.4
- the **percentage of the carbon stock that would be lost due to deforestation**, for **each driver** of deforestation identified in Section 5.1.

For each Zone, the carbon stock values are characterised by the following symbols:

= Carbon stock in the above-ground woody biomass *Carbon Pool* (tCO_2e/ha)



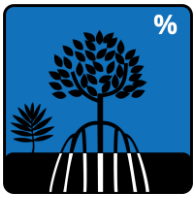
= Carbon stock in the below-ground woody biomass *Carbon Pool* (tCO_2e/ha)



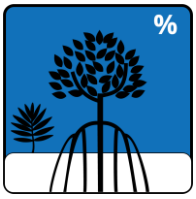
= Top 1m carbon stock in the soil organic carbon pool (tCO_2e/ha)

For each driver of deforestation, the percentage decrease in the carbon stocks due to deforestation are characterised by the following symbols:

= Percentage of above-ground woody biomass carbon stocks that would be lost due to the driver of deforestation (%)



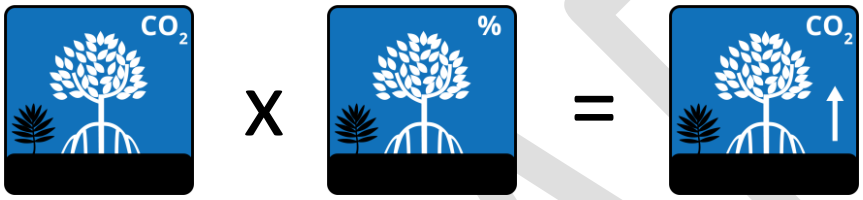
= Percentage of below-ground biomass carbon stocks that would be lost due to the driver of deforestation (%)



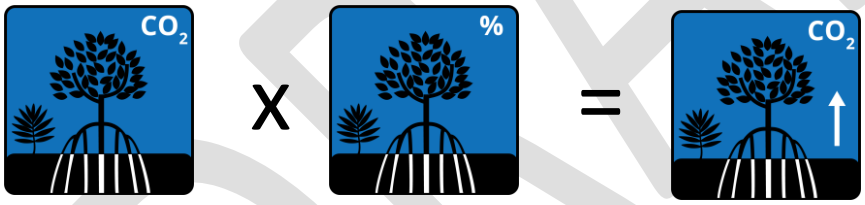
= Percentage of soil organic carbon stocks that would be lost due to the driver of deforestation (%)

For each Zone, these carbon stocks and percentage losses can be multiplied together to give a **CO_2 Emission Factor** (CO_2 emissions per hectare):

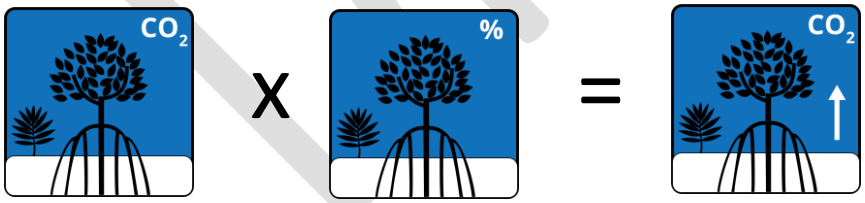
Equation 1:



Equation 2:

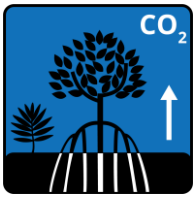


Equation 3:



Where:

= CO_2 Emission Factor for the above-ground woody biomass *Carbon Pool* due to the driver of deforestation (tCO_2e/ha)



= CO_2 Emission Factor for the below-ground biomass *Carbon Pool* due to the driver of deforestation (tCO_2e/ha)

= CO_2 Emission Factor for the soil organic carbon pool due to the driver of deforestation (tCO_2e/ha)

If a *Project Area* is at risk from more than one driver of deforestation and the *Project Area* is not zoned by driver of deforestation, for each *Carbon Pool* the emission factor weighted by the relative importance of each driver of deforestation (see Section 5.1) must be applied to all Zones. See the worked example below.

The above parameters can be defined using any of the following methods/sources:

- Forest inventory techniques following standard operating procedures that are aligned with national guidelines or international best practice, such as the IPCC 2019 refinement to the 2006 Guidelines for National GHG Inventories[6] or Howard et al., 2014[7].
- Data and/or emission factors provided in the forest reference emission level (FREL) or national greenhouse gas inventory reports of the country where the *Project Area* is located.
- Peer-reviewed literature detailing carbon stocks or emissions factors from the jurisdiction within which the *Project Area* is located. If peer-reviewed values are used, the applicability of the values must be explained in the *PDD*, for instance through similarities in species composition, climate, tidal dynamics, salinity levels and sediment type between the area covered by the peer-reviewed study and the *Project Area*. Also, the variance of sampled data must be known, in order to estimate uncertainty (see Section 10.3 of PM00X).
- The default values provided in Annex One for the percentage decrease in carbon stocks in each *Carbon Pool* for each of the drivers of deforestation detailed in Section 5.1., according to the provinces of the Marine Ecoregions of the World[8]. These default values were derived from Adame et al., 2021[9].
- The soil organic carbon stocks published in Sanderman et al., 2018[10] can be used for the soil organic carbon stock. The median value within the *Project Area*/Zone of the 30m resolution, 1 metre depth dataset must be used[11].

[6] https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html
[7] https://www.thebluecarboninitiative.org/manual
[8] Marine Ecoregions of the World https://academic.oup.com/bioscience/article-abstract/57/7/573/238419?redirectedFrom=PDF. This tool can be used to establish which marine province(s) the project is in: https://planvivo.shinyapps.io/bluecarbontool/
[9] https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.15571#gcb15571-bib-0015
[10] https://iopscience.iop.org/article/10.1088/1748-9326/aabe1c/meta
[11] The tiled raster datasets can be accessed here: https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/OCYUIT

It is not conservative to assume that the emissions from the soil organic carbon pool would happen immediately. Therefore, **for each Zone**, projects must also define the time period, in years, over which the emissions from the soil organic carbon pool would occur:

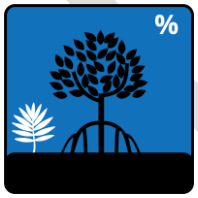
= The time period over which emissions from the soil organic carbon pool will occur, after deforestation (years)

The default for this parameter is **5 years**[12]. If projects use a shorter period, clear justification must be provided in the *PDD*, in the form of peer-reviewed field data or values derived from the jurisdiction within which the *Project Area* is located. The applicability of the value must be explained in the *PDD*, for instance through similarities in drivers of deforestation, species composition, tidal dynamics and sediment type between the area covered by the peer-reviewed study and the *Project Area*.

If a *Project Area* is at risk from more than one driver of deforestation and the *Project Area* is not zoned by driver of deforestation, if different time periods are applicable to each driver of deforestation, **the more conservative (longer) time period must be used for all Zones**.

Where applicable, projects can also the methods/sources listed above to quantify the carbon stocks, percentage losses and resulting emission factors for the above-ground non-woody biomass *Carbon Pool*, which are characterised by the symbols below. However, the default value for each of these variables is zero.

= Carbon stock in above-ground non-woody biomass (tCO_2e/ha). Default value = 0.



= Percentage decrease in above-ground non-woody biomass carbon stocks due to the driver of deforestation (%). Default value = 0.

(Mangroves_SOCS_0_100cm_30m.zip). Also, this tool can be used to establish the median value within a user-provided polygon: https://planvivo.shinyapps.io/bluecarbontool/

[12] Sippo et al., 2020 (https://aslopubs.onlinelibrary.wiley.com/doi/10.1002/lno.11476) measured a 36% decrease in carbon stocks in the upper 1 m of mangrove sediments following extreme climate stress. The default % loss for extreme climate = 31%, suggesting that SOC losses likely happen faster than 5 years. Lang'at et al., 2015 (https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0107868) shows that soil carbon loss mainly happens in the first 2 years following deforestation due to wood cutting and then stabilises.

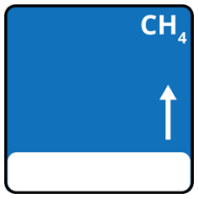
= CO_2 Emission Factor for the above-ground woody biomass *Carbon Pool* due to the driver of deforestation (tCO_2e/ha). Default value = 0.

5.3.2 Soil Methanogenesis

Projects are only required to account for Soil Methanogenesis if the Mangroves in the *Project Area* are threatened by **a driver of deforestation that causes wetland draining in a Zone where the salinity low point[13] is below 18 ppt**. This will lead to lower methane emissions in the baseline scenario.

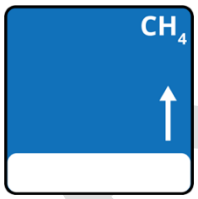
Where the driver of deforestation leads to a land use that has higher methane emissions compared to intact Mangroves (for instance, in some situations, flooded aquaculture or agriculture areas), projects may choose to account for these baseline methane emissions.

For all other projects, in each Zone:



= 0

Where:



= The difference between the annual per-hectare emissions due to Soil Methanogenesis in the post-deforestation land use and the annual per-hectare emissions due to Soil Methanogenesis in intact Mangroves (tCO_2e/ha/year)

Where the driver of deforestation leads to a land use that has higher methane emissions compared to intact Mangroves, this number will be **positive**. Where intact Mangroves have higher emissions than the post-deforestation land use, this number will be **negative**.

CH_4 emissions from soils may be estimated using any of the following methods/sources:

- Field-collected data
- Peer-reviewed published data

[13] The salinity low point should be measured on shallow pore water (within 30 cm from soil surface) using a handheld salinity refractometer or other accepted technology. The salinity low point must be calculated from observations that represent variation in salinity during periods of peak CH_4 emissions (e.g., during the growing season in temperate ecosystems or the wet season in tropical ecosystems).

- Emission factors from the Wetlands Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories[14]

Guidance on how to measure methane emissions in Mangroves can be found in the Howard et al., 2014[15].

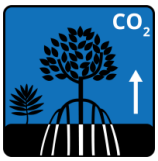
Peer-reviewed published data must be limited to systems that are in the same or similar region as the Project Area, share similar geomorphic, hydrologic, and biological properties, and are under similar management regimes unless any differences should not have a substantial effect on methane emissions.

To convert methane emissions to tCO_2e, the most recent 100-year IPCC Global Warming Potential must be used. The AR6 2021 Global Warming Potential for methane is 27.2[16].

Emissions due to Soil Methanogenesis in intact Mangroves in the Leakage Area are conservatively excluded.

Required outputs from Section 5.3:

CO_2 Emission Factor for the above-ground woody biomass *Carbon Pool* due to the driver of deforestation in each Zone (tCO_2e/ha)



CO_2 Emission Factor for the below-ground biomass *Carbon Pool* due to the driver of deforestation in each Zone (tCO_2e/ha)

CO_2 Emission Factor for the soil organic carbon pool due to the driver of deforestation in each Zone (tCO_2e/ha)

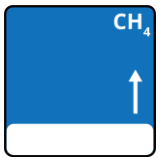
The time period over which emissions from the soil organic carbon pool will occur, after deforestation (years). **Default = 5 years**.

[14] 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands Methodological Guidance on Lands with Wet and Drained Soils, and Constructed Wetlands for Wastewater Treatment. https://www.ipcc.ch/publication/2013-supplement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories-wetlands/

[15] https://www.thebluecarboninitiative.org/manual

[16] https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/

CO_2 Emission Factor for the above-ground non-woody biomass *Carbon Pool* due to the driver of deforestation in each Zone (tCO_2e/ha). **Default = 0 tCO_2e/ha**.



The difference between the annual per-hectare emissions due to Soil Methanogenesis in the post-deforestation land use and the annual per-hectare emissions due to Soil Methanogenesis in intact Mangroves ($tCO_2e/ha/year$)

Worked example – Section 5.3

For the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**, data from a Mangrove Forest inventory is used to define the carbon stocks in the above-ground woody and belowground biomass *Carbon Pools* in the Mangrove Forest Zone (which are the same for each driver of deforestation). The median soil organic carbon stocks within the Project Area according to the data published in Sanderman et al., 2019[10] is used for the soil organic carbon stock in the Mangrove Forest Zone. The default values provided in Annex One are used for the percentage decrease in carbon stocks in each *Carbon Pool* due to the two of the drivers of deforestation in the Mangrove Forest Zone. The table below summarises all these parameters for the Mangrove Forest Zone.

As there is more than one driver of deforestation and the *Project Area* is not zoned by driver, the CO_2 Emission Factors for each *Carbon Pool* need to be weighted by the relative importance of each driver (30% for aquaculture and 70% for clearing for wood/charcoal) to calculate an average. This calculation is shown in the table below and gives the CO_2 Emission Factors for the aboveground woody biomass, belowground biomass and soil organic carbon pools in the Mangrove Forest Zone.

For the aboveground non-woody biomass *Carbon Pool*, the default emission factor is used:

= 0 tCO_2e/ha

Mangrove forest zone			
Parameter	Agriculture/ aquaculture	Clearing for wood/charcoal	**Weighted average CO_2 Emission Factors**
	275 tCO_2e/ha	275 tCO_2e/ha	
	83%	70%	
	275 x 83% = 228 tCO_2e/ha	275 x 70% = 192 tCO_2e/ha	(228 x 30%) + (192 x 70%) = **203 tCO_2e/ha**
	130 tCO_2e/ha	130 tCO_2e/ha	
	83%	70%	
	130 x 83% = 108 tCO_2e/ha	130 x 70% = 91 tCO_2e/ha	(108 x 30%) + (91 x 70%) = **96 tCO_2e/ha**
	920 tCO_2e/ha	920 tCO_2e/ha	
	52%	21%	
	920 x 52% = 478 tCO_2e/ha	920 x 21% = 193 tCO_2e/ha	(478 x 30%) + (193 x 70%) = **278 tCO_2e/ha**

The default value is used for the time period over which emissions from the soil organic carbon pool will occur after deforestation in the Mangrove Forest Zone:

= 5 years

The salinity low point within the Mangrove Forest Zone is greater than 18ppt and the drivers of deforestation do not lead wetland draining, therefore accounting for methanogenesis is not required. Therefore:

= 0 tCO_2e/ha/year

This completes the CO_2 Emission Factors for the Mangrove Zone.

The Leakage Belt also contains the non-Mangrove Forest Zone. The emission factors for each of the aboveground woody and belowground biomass *Carbon Pools*, taken from the national government's most recent FREL submission to the UNFCCC, are shown below. The FREL does not include the aboveground non-woody biomass or soil organic carbon pools, so these are conservatively assumed to be zero. There is only one driver of deforestation in this Zone, so a weighted average doesn't need to be calculated.

Because there is assumed to be no change in soil organic carbon stocks, the time period over which soil carbon stocks are assumed to be lost is also zero for the non-Mangrove Forest Zone.

Soil Methanogenesis is not included in leakage accounting so methane emission factors are not needed for Zones that are only present in the Leakage Area.

All parameters for the hypothetical Mangrove Conservation project required by Section 5.3 are summarised in the following table.

Parameter	**Mangrove forest zone**	**Non-mangrove forest zone**
	203 tCO_2e/ha	100 tCO_2e/ha
	96 tCO_2e/ha	54 tCO_2e/ha
	278 tCO_2e/ha	0 tCO_2e/ha
	5 years	0 years
	0 tCO_2e/ha	0 tCO_2e/ha
	0 tCO_2e/ha/year	N/A

5.4 Mapping before the project begins and at the start of each *Verification Period*

A series of land cover maps are required to determine the area of Mangrove Forest in the *Project Area*, Reference Area and Leakage Area at the start of the Verification Period (including at the project's *Start Date*), and how they are expected to change during the *Verification Period* under the *Baseline Scenario*. If zoning is used, the maps are required for each Zone.

For each Zone of the Reference Area, the following maps are required:

- A map showing the area of Mangroves **within 2 years** of the start of the *Verification Period*
- A second map showing the area of Mangroves **10 years before**[17] the first map

The time between these two maps – 10 years – is known as the Reference Period. The start year and end year of the Reference Period must be detailed in the *PDD* and must be the same for all Zones.

If clearing for wood/charcoal was identified as a driver of deforestation in the *Baseline Scenario* (see Section 5.1), changes in non-Mangrove forest must also be quantified over the Reference Period in

[17] If the map within 2 years of the Verification Period shows the Mangroves in the Reference Area in 2022, the second map should show the Mangroves in the Reference Area in 2012. Thus, the Reference Period Starts in 2012 and ends in 2022.

the Reference Area. Global Forest Watch[18] can be used to do this. Or projects can choose to map and monitor non-Mangrove forest in the Reference Area themselves.

For each Zone of the *Project Area*, the following map is required:

- A map showing the area of Mangroves **within 6 months** of the start of the *Verification Period*. This can be an annual composite map covering the year prior to the start of the *Verification Period*.

For each Zone of the Leakage Area, the following map is required:

- A map showing the area of Mangroves **within 6 months** of the start of the *Verification Period*. This can be an annual composite map covering the year prior to the start of the *Verification Period*. If clearing for wood/charcoal was identified as a driver of deforestation in the baseline scenario (see Section 5.1), this map also needs to show the area of non-Mangrove Forest within the Leakage Area.

These maps can be developed using any of the following methods/sources:

- Remote sensing analyses[19] using imagery with a spatial resolution of 30m or higher. The accuracy of such analyses must be greater than 80%. Any annual composites used should have cloud cover of less than 30%. Land cover maps compared between years must be derived from images that are either from the same season or reflect the same aspects of seasonality. Tidal variations must also be factored into analyses, to ensure changes in tidal height do not lead to erroneous areas of Mangrove loss and/or gain.
- Land cover maps developed by the government of the country within which the project is located.
- Projects that do not Zone their *Project Area* (see Section 5.2.4), or Zone only by deforestation driver, can use the Global Mangrove Watch[20] dataset to map Mangroves.
- Projects that include non-Mangrove Forest in their Leakage Area can use data from Global Forest Watch to map the non-Mangrove Forest in the Reference Area and Leakage Area.

For each Zone, the **same data sources and mapping approaches must be used** for all three areas (*Project Area*, Reference Area and Leakage Area), to ensure comparability when estimating land cover change. For example, if Global Mangrove Watch is used to map Mangroves in the Reference Area, it must also be for the *Project Area* and Leakage Area.

The *PDD* must describe the datasets and methodologies used to generate land cover maps, with sufficient detail that they could be repeated by a suitably qualified technician.

For **each Zone**, these land cover maps must be used to determine the following parameters:

= Area of forest in the Reference Area at the start of the Reference Period (ha)

[18] https://www.globalforestwatch.org/map/. Projects need to become a member to upload specific areas of interest.
[19] The Google Earth Engine Mangrove Mapping tool (GEM) can be used to develop land cover maps: https://play.google.com/store/apps/details?id=org.blueventures.gemdroid&hl=en_GB
[20] https://www.globalMangrovewatch.org/

= Area of forest deforested in the Reference Area during the 10-year Reference Period (ha)

= Area of Mangrove Forest in the *Project Area* at the start of the *Verification Period* (ha)

= Area of forest in the Leakage Area at the start of the *Verification Period* (ha)

Projects that have non-Mangrove Zone(s) can use data from Global Forest Watch to calculate  **and**  .

Required outputs from Section 5.4:

- The start and end year of the 10-year Reference Period.
- A description of the datasets and methodologies used to generate the land cover maps

Area of forest in each Zone of the Reference Area at the start of the Reference Period (ha)

Area of forest deforested in each Zone of the Reference Area during the 10-year Reference Period (ha)

Area of Mangrove Forest in each Zone of the *Project Area* at the start of the *Verification Period* (ha)

Area of forest in each Zone of the Leakage Area at the start of the *Verification Period* (ha)

Worked example – Section 5.4

The *Start Date* of the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.** was 1st January 2021.

Mangrove coverage data from Global Mangrove Watch is used to create maps for the Mangrove Forest Zone in the *Project Area*, Reference Area and Leakage Area.

The Global Mangrove Watch data from 2020 (an annual composite map covering the year prior to the start of the *Verification Period*) is used to calculate the extent of the Mangrove Forest Zone in the *Project Area* and Leakage Area at the start of the *Verification Period*. See the table below for the results.

The same 2020 dataset was also used to map the Mangrove Forest Zone in the Reference Area. Therefore, the Reference Period ends in 2020. Ten years prior to this is 2010. Thus, the Reference Period is 2010-2020. Global Mangrove Watch data from 2010 is used to calculate the area of the Mangrove Forest in the Reference Area at the start and end of the Reference Period. The results for the Reference Area are shown in the table below.

	Mangrove Forest Zone		
	Area of Mangrove Forest in the Mangrove Forest Zone at the start of the *Verification Period* (2020) (ha)	Area of Mangrove Forest in the Mangrove Forest Zone at the start of the Reference Period (2010) (ha)	Area of Mangrove Forest in the Mangrove Forest Zone at the end of the Reference Period (2020) (ha)
Project Area	15,000	N/A	N/A
Reference Area	N/A	105,000	100,000
Leakage Area	3,500	N/A	N/A

The 2010 and 2020 tree cover maps provided by Global Forest Watch are used to establish change in the non-Mangrove Forest Zone (minimum tree cover of 30%) across the Reference Area and Leakage Belt. The results are shown in the following table:

	Non-Mangrove Forest Zone		
	Area of forest in the non- Mangrove Forest Zone at the start of the *Verification Period* (ha)	Area of forest in the non-Mangrove Forest Zone at the start of the Reference Period (2010) (ha)	Area of forest in the non-Mangrove Forest Zone at the end of the Reference Period (2020) (ha)
Project Area	N/A	N/A	N/A
Reference Area	N/A	24,700,000	22,900,000
Leakage Area	21,000	N/A	N/A

These results are used to estimate the parameters required in Section 5.4:

Parameter	Mangrove forest zone	Non-mangrove forest zone
RA ha	105,000 ha	24,700,000 ha
RA ha	105,000 - 100,000 = 5,000 ha	24,700,000 - 22,900,000 = 1,800,000 ha
PA ha	15,000 ha	N/A
LA ha	3,500 ha	21,000 ha

5.5 Estimate expected amount of deforestation

It is assumed that if the *Project Area* is not brought under effective community management it will be affected by similar drivers of deforestation to Mangroves within the Reference Area.

It is further assumed that the average annual amount of deforestation observed in the Reference Area during the Reference Period (expressed as a proportion of the Mangroves present at the start of the Reference Period) will provide a conservative estimate of the annual amount of Mangrove deforestation (expressed as a proportion of Mangroves present at the start of the verification period) that would occur in the *Project Area* in the baseline scenario.

For each Mangrove Zone, the average annual amount of deforestation in the Reference Area during the Reference Period, as a proportion of the forest area present at the start of the reference period, is calculated as follows:

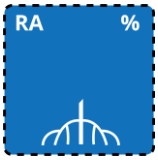
Equation 4:

Where:

= Average proportion of the Mangroves in each Zone of the Reference Area that was deforested in each year of the Reference Period

This parameter must be provided with at least four decimal places (e.g. 0.0012).

Required outputs from Section 5.5:



Average proportion of the Mangroves in each Zone of the Reference Area that was deforested in each year of the Reference Period (unitless)

Worked example – Section 5.5

For the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**, using the results from the Worked Example in Section 5.4 the required parameter in Section 5.5 is calculated using Equation 4 as follows:

Parameter	**Mangrove forest zone**	**Non-mangrove forest zone**
RA ha	105,000 ha	24,700,000 ha
RA ha	5,000 ha	1,800,000 ha
RA %	5,000 ÷ (105,000 x 10) = 0.0048	1,800,000 ÷ (24,700,000 x 10) = 0.0073

5.6 Expected emissions and removals during the *Verification Period*

5.6.1 Estimate project effectiveness

For describing the expected effectiveness of project intervention, and potential leakage; conservative assumptions are applied for the first verification period. These assumptions must then be updated at the end of each *Verification Period* for the subsequent *Verification Period*, based on observed effectiveness and leakage.

PDDs must include estimates of the following two parameters:

= An estimate of **expected effectiveness of project activities** in reducing emissions from Mangrove deforestation, expressed as a proportion of baseline scenario emissions that can conservatively be expected to be avoided as a result of project activities (0-1, with 0 being completely ineffective and 1 being completely effective).
This parameter is used to estimate expected project emissions in the *Project Area* (see Section 5.6.3).

= An estimate of expected emissions from deforestation that result from displacement of activities from the *Project Area* to areas outside the *Project Area*, as a result of project activities. Expressed as a **proportion of *Carbon Benefits* that are expected to be lost because of leakage** (0-1, with 0 meaning all *Carbon Benefits* will be lost due to leakage and 1 meaning no *Carbon Benefits* will be lost due to leakage).
This parameter is used to estimate expected leakage emissions in the Leakage Area (see Section 5.6.3).

Justification for both values must be provided, demonstrating that the values are likely to be conservative.

If a *Project Area* is at risk from more than one driver of deforestation, the average effectiveness of project activities that address the drivers of deforestation weighted by the relative importance of each driver of deforestation can be used. See the worked example below.

Similarly, if a *Project Area* is at risk from more than one driver of deforestation, the proportion of *Carbon Benefits* that are expected to be lost because of leakage due to the driver of deforestation weighted by the relative importance of each driver of deforestation can be used. See the worked example below.

The final *Annual Report* of each *Verification Period* must include all of the following:

A value for  that will be applied in the following *Verification Period*, with details of how this was estimated based on observed effectiveness of project activities (see Section 5.9.6).

A value for  that will be applied in the following *Verification Period*, with details of how this was estimated based on observed leakage.

Required outputs from Section 5.6.1:

In the PDD:

An estimate of expected effectiveness of project activities in reducing emissions from Mangrove deforestation, expressed as a proportion of baseline scenario emissions that can conservatively be expected to be avoided as a result of project activities.

An estimate of expected emissions from deforestation that result from displacement of activities from the *Project Area* to areas outside the *Project Area*, as a result of project activities. Expressed as a proportion of *Carbon Benefits* that are expected to be lost because of leakage.

In the final *Annual Report* of each *Verification Period*:

A value for  that will be applied in the following *Verification Period*, with details of how this was estimated based on observed effectiveness of project activities.

A value for  that will be applied in the following *Verification Period*, with details of how this was estimated based on observed leakage.

Worked example – Section 5.6.1

For the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**, due to strong engagement with aquaculture farmers and landowners the expected effectiveness of activities in reducing deforestation and the resulting emissions due to aquaculture is estimated to be 1. However, as a conservative measure for the first *Verification Period* the project uses a value of 0.9. There is a risk of people from outside the villages where the *Project Participants* live coming to the *Project Area* to harvest wood for timber and charcoal in the Mangrove Forest Zone. It is predicted that this harvesting may lead to up to 20% of the deforestation that would have happened without the *Project Intervention*. Thus, the expected effectiveness of activities in reducing deforestation and the resulting emissions due to clearing for wood/charcoal is estimated to be 0.8.

Since aquaculture is closely tied to land tenure and the landowners in the *Project Area* do not own Mangrove land in the Leakage Area, the proportion of *Carbon Benefits* that are expected to be lost because of leakage due to aquaculture is 0. The volume of Mangrove wood needed to fulfil the local timber and charcoal needs have been calculated and wood plantations outside of the *Project Area* are planned accordingly, as a leakage mitigation activity for wood and charcoal harvesting. However, the success of these plantations is not fully known, thus it is conservatively assumed that the proportion of *Carbon Benefits* that are expected to be lost because of leakage due to clearing for wood/charcoal is 0.2.

To derive single values for the expected effectiveness and the proportion of *Carbon Benefits* that are expected to be lost because of leakage, the individual values are be weighted by the relative importance of each driver (30% for aquaculture and 70% for clearing for wood/charcoal) to calculate an average. This calculation is shown is shown in the table below.

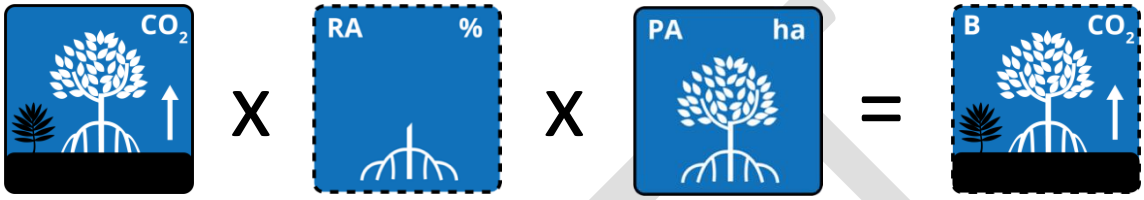
Parameter	Agriculture/ aquaculture	Clearing for wood/charcoal	**Weighted averages**
	0.9	0.8	(0.9 x 30%) + (0.8 x 70%) = **0.83**
	0	0.2	(0 x 30%) + (0.2 x 70%) = **0.14**

5.6.2 Calculate expected baseline emissions

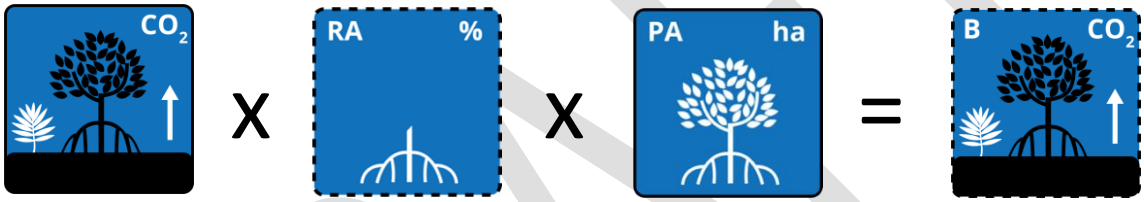
5.6.2.1 Expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools*

For each Zone of the *Project Area*, for each year of the *Verification Period* the expected baseline CO_2 emissions from the vegetation *Carbon Pools* are calculated by multiplying the Zone's relevant emission factor by the average proportion of the Mangroves that was deforested in the Zone of the Reference Area in each year of the Reference Period and the area of Mangrove Forest in the Zone of the *Project Area* at the start of the *Verification Period*:

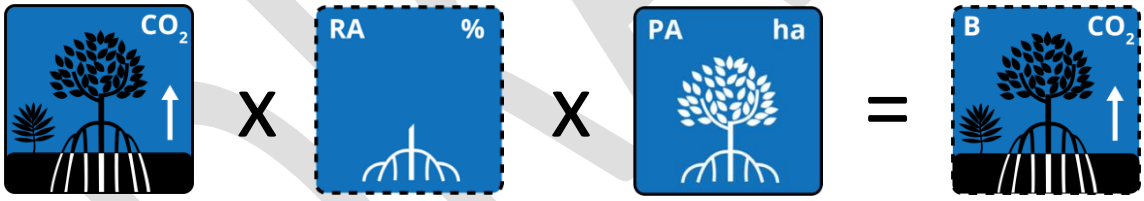
Equation 5:



Equation 6:

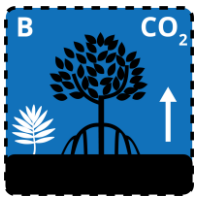


Equation 7:

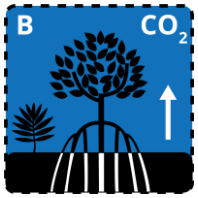


Where:

= Expected baseline CO_2 emissions in the aboveground woody biomass *Carbon Pool* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*



= Expected baseline CO_2 emissions in the aboveground non-woody biomass *Carbon Pool* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

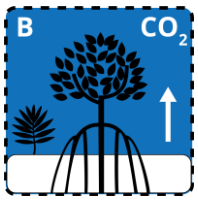


= Expected baseline CO_2 emissions in the belowground biomass *Carbon Pool* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

The expected annual baseline CO_2 emissions from the soil organic carbon pool are calculated as follows:

Equation 8:

Where:



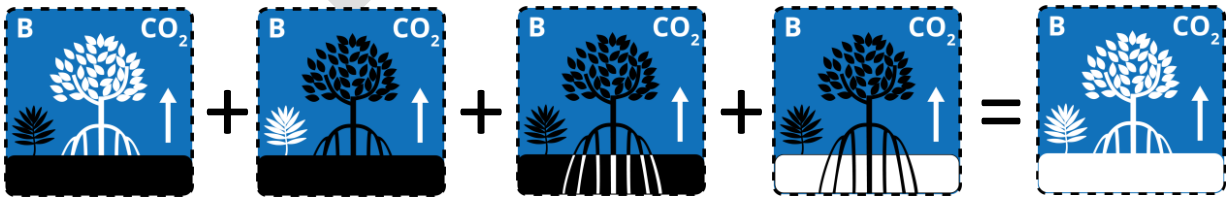
= Expected baseline CO_2 emissions in the soil organic carbon in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

However, **these annual emissions should be applied in each year following deforestation for an amount of time equal to** 

. In each year of the *Verification Period*, the total CO_2 emissions from the soil organic *Carbon Pool* are equal to the sum of the emissions due to the current year's deforestation and any ongoing emissions due to deforestation in previous years. See the worked example below.

Total expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* are calculated as follows:

Equation 9:



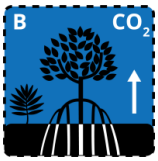
Where:

= **Total expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

Required outputs from Section 5.6.2.1:

Expected baseline CO_2 emissions from the aboveground woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Expected baseline CO_2 emissions in the aboveground non-woody biomass pool in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)



Expected baseline CO_2 emissions from the belowground biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Expected baseline CO_2 emissions from the soil organic *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Total expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Worked example – Section 5.6.2.1

In the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**, the *Project Area* only contains one Zone: the Mangrove Forest Zone. Over a five-year *Verification Period*, the annual expected baseline CO_2 emissions from the vegetation *Carbon Pools* are estimated using the parameters in Sections 5.3.1, 5.4 and 5.5 as follows using Equations 5-7:

Mangrove forest zone – Aboveground woody biomass				
Year	(tCO_2e/ha)	unitless	(ha)	(tCO_2e)
1	203	0.0048	15,000	203 x 0.0048 x 15,000 = 14,616
2	203	0.0048	15,000	203 x 0.0048 x 15,000 = 14,616
3	203	0.0048	15,000	203 x 0.0048 x 15,000 = 14,616
4	203	0.0048	15,000	203 x 0.0048 x 15,000 = 14,616
5	203	0.0048	15,000	203 x 0.0048 x 15,000 = 14,616

Mangrove forest zone – Aboveground non-woody biomass				
Year	(tCO_2e/ha)	unitless	(ha)	(tCO_2e)
1	0	0.0048	15,000	0 x 0.0048 x 15,000 = 0
2	0	0.0048	15,000	0 x 0.0048 x 15,000 = 0
3	0	0.0048	15,000	0 x 0.0048 x 15,000 = 0
4	0	0.0048	15,000	0 x 0.0048 x 15,000 = 0
5	0	0.0048	15,000	0 x 0.0048 x 15,000 = 0

Mangrove forest zone – belowground biomass				
Year	(tCO_2e/ha)	unitless	(ha)	(tCO_2e)
1	96	0.0048	15,000	96 x 0.0048 x 15,000 = 6,912
2	96	0.0048	15,000	96 x 0.0048 x 15,000 = 6,912
3	96	0.0048	15,000	96 x 0.0048 x 15,000 = 6,912
4	96	0.0048	15,000	96 x 0.0048 x 15,000 = 6,912
5	96	0.0048	15,000	96 x 0.0048 x 15,000 = 6,912

The annual expected baseline CO_2 emissions from the soil organic carbon pool are calculated using Equation 8 as follows:

Using the parameters in Sections 5.3.1, 5.4 and 5.5, this gives:

$$(278 \div 5) \times 0.0048 \times 15{,}000 = 4{,}003\ tCO_2e$$

Given that 

= 5, this value should be applied annually for five years following deforestation. The total annual expected baseline CO_2 emissions from the soil organic carbon pool are most easily calculated in a table as follows:

		Year				
		1	2	3	4	5
Deforested area	1	4,003	4,003	4,003	4,003	4,003
	2		4,003	4,003	4,003	4,003
	3			4,003	4,003	4,003
	4				4,003	4,003
	5					4,003
B CO2		**4,003**	4,003 + 4,003 = **8,006**	4,003 + 4,003 + 4,003 = **12,009**	4,003 + 4,003 + 4,003 + 4,003 = **16,012**	4,003 + 4,003 + 4,003 + 4,003 + 4,003 = **20,015**

For subsequent Verification Periods, the ongoing emissions from deforested areas 2-5 can be accounted for. For instance, if during the second five-year *Verification Period* the annual expected baseline CO_2 emissions from the soil organic carbon pool are estimated to be 3,500 tCO_2e, the total annual expected emissions in the second *Verification Period* would be calculated in a table as follows:

		Year									
		1	2	3	4	5	6	7	8	9	10
Deforested area	1	4,003	4,003	4,003	4,003	4,003					
	2		4,003	4,003	4,003	4,003	4,003				
	3			4,003	4,003	4,003	4,003	4,003			
	4				4,003	4,003	4,003	4,003	4,003		
	5					4,003	4,003	4,003	4,003	4,003	
	6						3,500	3,500	3,500	3,500	3,500
	7							3,500	3,500	3,500	3,500
	8								3,500	3,500	3,500
	9									3,500	3,500
	10										3,500
B CO2							**19,512**	**19,009**	**18,506**	**18,003**	**17,500**

These results can be added together using Equation 9 to give the total expected baseline CO_2 emissions in the Mangrove Forest Zone from the Vegetation and Soil *Carbon Pools*, as follows:

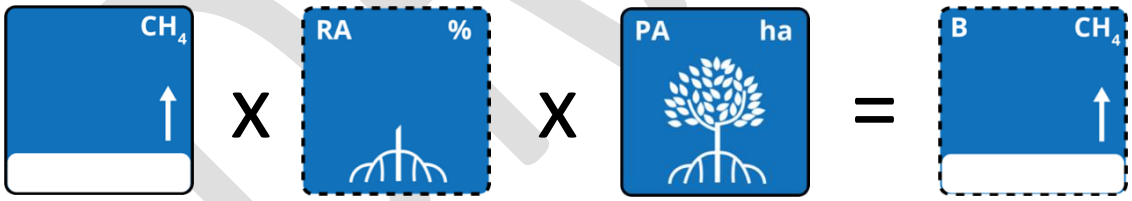
Mangrove forest zone					
Year	(B CO_2) (tCO_2e)	(B CO_2) (tCO_2e)	(B CO_2) (tCO_2e)	(B CO_2) (tCO_2e)	(B CO_2) (tCO_2e)
1	14,616	0	6,912	4,003	14,616 + 0 + 6,912 + 4,003 = 25,531
2	14,616	0	6,912	8,006	14,616 + 0 + 6,912 + 8,006 = 29,534
3	14,616	0	6,912	12,009	14,616 + 0 + 6,912 + 12,009 = 33,537
4	14,616	0	6,912	16,012	14,616 + 0 + 6,912 + 16,012 = 37,540
5	14,616	0	6,912	20,015	14,616 + 0 + 6,912 + 20,015 = 41,543

5.6.2.2 Expected baseline emissions from emission sources

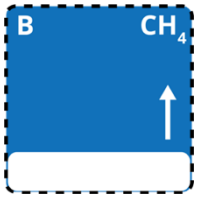
Given the applicability conditions of PM00X and this module, the only emission source that must be accounted for is Soil Methanogenesis.

For each Zone of the *Project Area*, for each year of the *Verification Period* the expected baseline emissions due to Soil Methanogenesis are calculated by multiplying the Zone's emission factor by the average proportion of the Mangroves that was deforested in the Zone of the Reference Area in each year of the Reference Period and the area of Mangrove Forest in the Zone of the *Project Area* at the start of the *Verification Period*:

Equation 10:



Where:

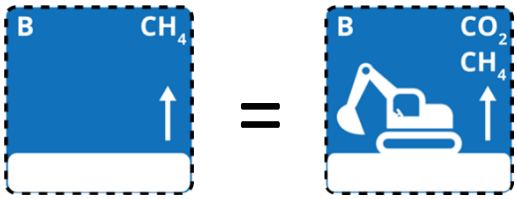


= Expected baseline emissions due to Soil Methanogenesis in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

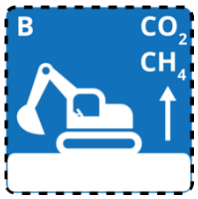
Similar to the CO_2 emissions from the soil organic carbon pool, **these annual emissions should be applied in each year following deforestation for the remainder of the *Crediting Period***. In each year of the *Verification Period* are calculated by adding the current year's emissions to the emissions that occurred in the previous years of the *Verification Period*. See the worked example below. See the worked example below.

Since Soil Methanogenesis is the only emission source relevant in this module:

Equation 11:

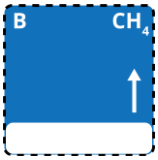


Where:

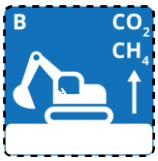


= **Total expected baseline emissions from all emission sources in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

Required outputs from Section 5.6.2.2:



Expected baseline emissions due to Soil Methanogenesis in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)



Total expected baseline emissions from all emission sources in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Worked example – Section 5.6.2.2

As explained in the worked example in Section 5.3, accounting for Soil Methanogenesis is not required for the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**. Therefore, for each year of the *Verification Period*:

= 0 tCO_2e

and

= 0 tCO_2e

However, to provide an example of how methanogenesis accounting works, take a project whose annual expected baseline emissions due to Soil Methanogenesis are 50 tCO_2e per year in the first five-year *Verification Period* and 40 tCO_2e per year in the second five-year *Verification Period*. Across the two *Verification Periods*, the total annual expected baseline emissions due to Soil Methanogenesis can be calculated using the table below:

		Year									
		1	2	3	4	5	6	7	8	9	10
Deforested area	1	50	50	50	50	50	50	50	50	50	50
	2		50	50	50	50	50	50	50	50	50
	3			50	50	50	50	50	50	50	50
	4				50	50	50	50	50	50	50
	5					50	50	50	50	50	50
	6						40	40	40	40	40
	7							40	40	40	40
	8								40	40	40
	9									40	40
	10										40
B CH_4		**50**	50 x 2 = **100**	50 x 3 = **150**	50 x 4 = **200**	50 x 5 = **250**	(50 x 5) + 40 = **290**	(50 x 5) + (40 x 2) = **330**	(50 x 5) + (40 x 3) = **370**	(50 x 5) + (40 x 4) = **410**	(50 x 5) + (40 x 5) = **450**

5.6.3 Calculate expected project emissions

Expected project emissions are estimated using the assumptions regarding expected effectiveness of project activities from Section 5.6.1.

5.6.3.1 Expected project emissions from the Vegetation and Soil *Carbon Pools*

For each Zone of the *Project Area*, expected project emissions from the Vegetation and Soil *Carbon Pools* are estimated as follows:

Equation 12:

Where:

= **Total expected project CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

For the first *Verification Period*, a conservative value of  should be used. For subsequent *Verification Periods*, this parameter should be informed by the actual effectiveness achieved in previous *Verification Periods* (see Section 5.9.6).

Required outputs from Section 5.6.3.1:

Total expected project emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Worked example – Section 5.6.3.1

For the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**, using the parameters estimated in the worked examples in Sections 5.6.1 and 5.6.2.1, the total expected project emissions from the Vegetation and Soil *Carbon Pools* in the Mangrove Zone for each year for the *Verification Period* are calculated using Equation 12 as follows:

Mangrove forest zone			
Year	 (tCO_2e)	 (unitless)	 (tCO_2e)
1	25,531	0.83	25,531 x (1 - 0.83) = 4,340
2	29,534	0.83	29,534 x (1 - 0.83) = 5,020
3	33,537	0.83	33,537 x (1 - 0.83) = 5,701
4	37,540	0.83	37,540 x (1 - 0.83) = 6,382
5	41,543	0.83	41,543 x (1 - 0.83) = 7,062

5.6.3.2 Expected project emissions from emission sources

For each Zone, expected project emissions from the Vegetation and Soil *Carbon Pools* are estimated as follows:

Equation 13:

Where:

= **Total expected project emissions from emission sources in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

Required outputs from Section 5.6.3.1:

Total expected project emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

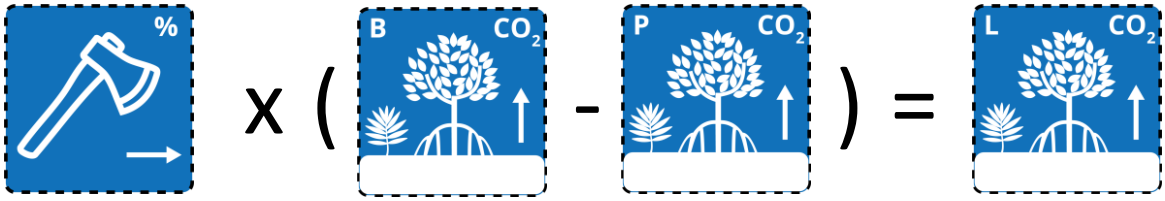
5.6.4 Calculate potential leakage emissions

Potential leakage emissions are estimated using the assumptions regarding the proportion of *Carbon Benefits* that are expected to be lost because of leakage from Section 5.6.1.

5.6.4.1 Potential leakage emissions from the Vegetation and Soil *Carbon Pools*

For each Zone of the *Project Area*, potential leakage emissions from the Vegetation and Soil *Carbon Pools* are estimated as follows:

Equation 14:



Where:

= **Total potential CO_2 emissions from the Vegetation and Soil *Carbon Pools* due to leakage from each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

For the first *Verification Period*, a conservative value of  should be used. For subsequent *Verification Periods*, this parameter should be informed by the actual leakage emissions in previous *Verification Periods* (see Section 5.9.3).

Required outputs from Section 5.6.3.1:

Total potential emissions from the Vegetation and Soil *Carbon Pools* due to leakage from each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Worked example – Section 5.6.3.1

For the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**, using the parameters estimated in the worked examples in Sections 5.6.1, 5.6.2.1 and 5.6.3.1, the total potential emissions from the Vegetation and Soil *Carbon Pools* due to leakage from the Mangrove Forest Zone for each year for the *Verification Period* are calculated using Equation 14 as follows:

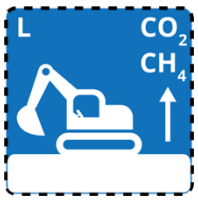
Mangrove forest zone				
Year	 (unitless)	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)
1	0.14	25,531	4,340	0.14 x (25,531 – 4,340) = 2,967
2	0.14	29,534	5,020	0.14 x (29,534 – 5,020) = 3,432
3	0.14	33,537	5,701	0.14 x (33,537 – 5,701) = 3,897
4	0.14	37,540	6,382	0.14 x (37,540 – 6,382) = 4,362

5.6.4.2 Potential leakage emissions from emission sources

For Zones where  is less than or equal to zero:

= 0

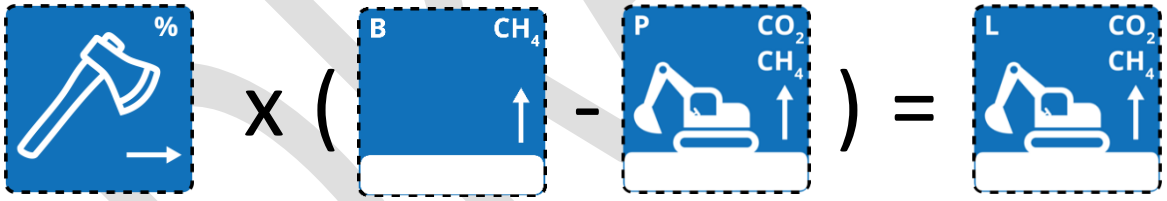
Where:



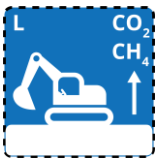
= **Total potential emissions from all emission sources due to leakage from each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

For Zones where  is greater than zero:

Equation 15:



Required outputs from Section 5.6.4.2:



Total potential emissions from all emission sources due to leakage from each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

5.6.5 Expected removals

The only baseline CO_2 removals likely in a Mangrove *Conservation* project would be in the wood products *Carbon Pool*. The applicability conditions of this module exclude such projects until PU##d is developed.

Project CO_2 removals are conservatively excluded.

Therefore, in this module:

$$= 0\ tCO_2e$$

$$= 0\ tCO_2e$$

Where:

= **Total expected baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

= **Total expected project CO_2 removals in the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

5.6.6 Calculate total expected emissions and removals across all Zones

The final step is to calculate the total expected removals and emissions in the baseline and project scenarios across **all Zones** for **each year of the *Verification Period***. This is done by summing the values in all Zones for the following parameters:

= **Total expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period***

= **Total expected baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period*.** The assumptions of this module mean this parameter = 0.

= **Total expected baseline emissions from all emission sources across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period*.**

= **Total expected project CO_2 emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period*.**

= **Total expected project removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period*.** Conservatively excluded.

= **Total expected project emissions from all emission sources across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period*.**

= **Total potential CO_2 emissions from the Vegetation and Soil *Carbon Pools* due to leakage across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period***

= **Total potential emissions from all emission sources due to leakage across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period*.**

These parameters are then used in Section 10.1 of PM00X to estimate the expected *Carbon Benefit* of the project.

For each year of the *Verification Period*, these values must be presented in the *PDD* in table format[21].

[21] This spreadsheet shows an example table that is suitable for the PDD (see the 'Expected' sheet). For illustration purposes, the example project has two Zones when the hypothetical project referenced in this module only has one Zone. The equations are for explanation, in line with the other worked examples, and do

5.7 Mapping at the end of the *Verification Period*

At the end of each *Verification Period*, land cover maps are required to determine how the area of forest evolved in each Zone of the *Project Area*, Reference Area and Leakage Area over the *Verification Period*.

For each Zone of the Reference Area, the following maps are required:

- A map showing the area of Mangrove **within 6 months** of the start of the *Verification Period*. If the map used for the start of the Reference Period in Section 5.4 fulfils this time requirement it can also be used here.
- A map showing the area of Mangrove **within 6 months** of the end of the *Verification Period*. Note that, to calculate expected emissions and removals during the next *Verification Period*, this same map can be used in Section 5.4 for the map of the Reference Area at the start of the next Reference Period.

If clearing for wood/charcoal was identified as a driver of deforestation in the baseline scenario (see Section 5.1), changes in non-Mangrove forest must also be quantified. Global Forest Watch[22] can be used to do this. Or projects can choose to map and monitor non-Mangrove forest in the Reference Area themselves.

For each Zone of the *Project Area*, the following map is required:

- A map showing the area of Mangroves **within 6 months** of the end of the *Verification Period*. This can be an annual composite map covering the year prior to the end of the *Verification Period*.

Note that, to calculate expected emissions and removals during the next *Verification Period*, this same map can be used in Section 5.4 for the map of the *Project Area* at the start of the next *Verification Period*.

For each Zone of the Leakage Area, the following map is required:

- A map showing the area of Mangroves **within 6 months** of the end of the *Verification Period*. This can be an annual composite map covering the year prior to the end of the *Verification Period*. If clearing for wood/charcoal was identified as a driver of deforestation in the baseline scenario (see Section 5.1), this map also needs to show the area of non-Mangrove Forest within the Leakage Area.

Note that, to calculate expected emissions and removals during the next *Verification Period*, this same map can be used in Section 5.4 for the map of the Leakage Area at the start of the next *Verification Period*.

These maps can be developed using any of the following methods/sources:

not need to be visible in the table in the PDD: https://docs.google.com/spreadsheets/d/1df05DKCxfSVkF26coZjvqnjJWBVOe3FoaKIsvzbPdXc/edit?usp=sharing

[22] https://www.globalforestwatch.org/map/. Projects need to become a member to upload specific areas of interest.

- Remote sensing analyses[23] using imagery with a spatial resolution of 30m or higher. The accuracy of such analyses must be greater than 80%. Any annual composites used should have cloud cover of less than 30%. Land cover maps compared between years must be derived from images that are either from the same season or reflect the same aspects of seasonality. Tidal variations must also be factored into analyses, to ensure changes in tidal height do not lead to erroneous areas of Mangrove loss and/or gain.
- Land cover maps developed by the government of the country within which the project is located.
- Projects that do not Zone their *Project Area* (see Section 5.2.4), or Zone only by deforestation driver, can use the Global Mangrove Watch[24] dataset to map Mangroves.
- Projects that include non-Mangrove Forest in their Leakage Area can use data from Global Forest Watch[25] to map the non-Mangrove Forest in the Reference Area and Leakage Area.

For each Zone, the **same data sources and mapping approaches must be used** for all three areas (*Project Area*, Reference Area and Leakage Area), to ensure comparability when estimating land cover change. For example, if Global Mangrove Watch is used to map Mangroves in the Reference Area, it must also be for the *Project Area* and Leakage Area.

The PDD must describe the datasets and methodologies used to generate land cover maps, with sufficient detail that they could be repeated by a suitably qualified technician.

For **each Zone**, these land cover maps must be used to determine the following parameters:

= Area of forest in the Reference Area at the start of the *Verification Period* (ha)

= Area of forest deforested in the Reference Area during the *Verification Period* (ha)

= Area of Mangrove deforested in the *Project Area* during the *Verification Period* (ha)

= Area of forest deforested in the Leakage Area during the *Verification Period* (ha)

[23] The Google Earth Engine Mangrove Mapping tool (GEM) can be used to develop land cover maps
[24] https://www.globalMangrovewatch.org/
[25] https://www.globalforestwatch.org/map/. Projects need to become a member to upload specific areas of interest.

Projects that have non-Mangrove Zone(s) can use data from Global Forest Watch to calculate  **and**  .

If different mapping methods are used for the *Project Area* and/or Leakage Area maps at the end of the *Verification Period* compared to at the start of the *Verification Period* (Section 5.4), the following parameters must be recalculated accordingly, using data created using the new mapping methods:

= Area of Mangrove Forest in the *Project Area* at the start of the *Verification Period* (ha)

= Area of forest in the Leakage Area at the start of the *Verification Period* (ha)

Required outputs from Section 5.7:

- A description of the datasets and methodologies used to generate the land cover maps

Area of forest in each Zone of the Reference Area at the start of the *Verification Period* (ha)

Area of forest deforested in each Zone of the Reference Area during *Verification Period* (ha)

Area of Mangrove deforested in each Zone of the *Project Area* during *Verification Period* (ha)

Area of forest deforested in each Zone of the Reference Area during *Verification Period* (ha)

If different mapping methods are used for the *Project Area* and/or Leakage Area maps at the end of the *Verification Period* compared to at the start of the *Verification Period* (Section 5.4), recalculated values for the following parameters:

Area of Mangrove Forest in each Zone of the *Project Area* at the start of the *Verification Period* (ha)

Area of forest in each Zone of the Leakage Area at the start of the *Verification Period* (ha)

Worked example – Section 5.7

31st December 2025 is the end of the first five-year *Verification Period* of the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**.

The 2020 Global Mangrove Watch data used to map the Mangrove Forest Zone in the Reference Area at the end of the Reference Period (see worked example in Section 5.4) fulfils the requirements of the data needed to quantify the area of Mangroves in the Mangrove Forest Zone in the Reference Area at the start of the *Verification Period*. Therefore, the results in the worked example in Section 5.4 can be used to establish this parameter.

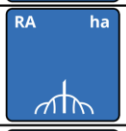
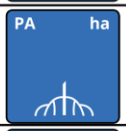
Global Mangrove Watch data was used to map the area of the Mangrove Forest Zone in the *Project Area* and Leakage Area at the start of the Verification Period. Therefore, to ensure data consistency, Global Mangrove Watch data from 2025 (an annual composite map covering the year prior to the end of the *Verification Period*) is used to establish the area of Mangrove loss in the Mangrove Forest Zone during the *Verification Period* in the *Project Area*, Reference Area and Leakage Area. See the tables below for the results.

	Mangrove Forest Zone	
	Area of Mangrove Forest in the Mangrove Forest Zone at the start of the *Verification Period* (2020) (ha)	Area of Mangrove Forest in the Mangrove Forest Zone at the end of the *Verification Period* (2025) (ha)
Project Area	15,000	14,900
Reference Area	100,000	96,000
Leakage Area	3,500	3,300

Global Forest Watch data can be used to establish changes in the non-Mangrove Forest Zone in the Leakage Area and Reference Area. The results from the maps at the start of the Verification Period and the information from the 2025 Global Forest Watch data are shown in the table below:

	Non-Mangrove Forest Zone	
	Area of Mangrove Forest in the Mangrove Forest Zone at the start of the *Verification Period* (2020) (ha)	Area of Mangrove Forest in the Mangrove Forest Zone at the end of the *Verification Period* (2025) (ha)
Project Area	N/A	N/A
Reference Area	22,900,000	21,900,000
Leakage Area	21,000	20,890

These results are used to estimate the parameters required in Section 5.7:

Parameter	**Mangrove forest zone**	**Non-mangrove forest zone**
	100,000 ha	22,900,000 ha
	100,000 - 96,000 = 4,000 ha	22,900,000 - 21,900,000 = 1,000,000 ha
	15,000 - 14,900 = 100 ha	N/A
	3,500 - 3,300 = 200 ha	21,000 - 20,200 = 800 ha

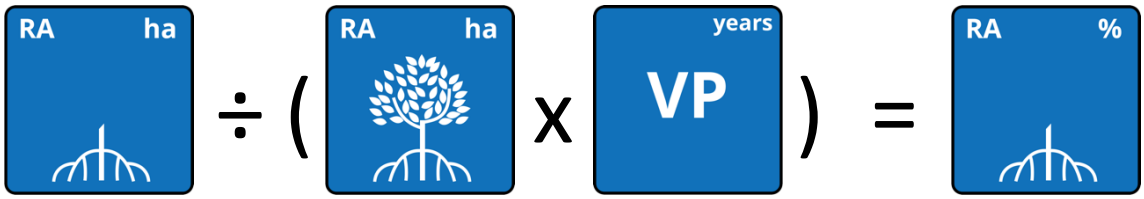
5.8 Refine the expected amount of deforestation

It is assumed that if the *Project Area* were not brought under effective community management it would have been affected by similar drivers of deforestation to Mangroves within the Reference Area.

It is further assumed that the average annual amount of deforestation observed in the Reference Area during the *Verification Period* (expressed as a proportion of the Mangroves present at the start of the *Verification Period*) will provide a conservative estimate of the annual amount of Mangrove deforestation (expressed as a proportion of Mangroves present at the start of the verification period) that would have occurred in the *Project Area* in the baseline scenario.

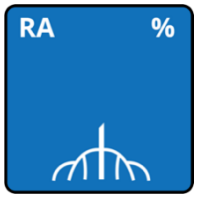
At the end of each *Verification Period*, for each Mangrove Zone, the average annual amount of deforestation in the Reference Region during the *Verification Period*, as a proportion of the Mangrove area present at the start of the *Verification Period*, is calculated as follows:

Equation 16:



Where:

= Length of the *Verification Period* (years)

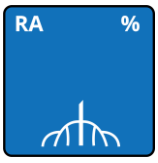


= Average proportion of the Mangroves in each Zone of the Reference Area that was deforested in each year of the *Verification Period*

This parameter must be provided with at least four decimal places (e.g. 0.0012).

Required outputs from Section 5.8:

Length of the *Verification Period* (years)



Average proportion of the Mangroves in each Zone of the Reference Area that was deforested in each year of the *Verification Period* (unitless)

Worked example – Section 5.8

For the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**, using the results from the Worked Example in Section 5.4 the required parameter in Section 5.5 is calculated using Equation 16 as follows:

Parameter	Mangrove forest zone	Non-mangrove forest zone
RA ha	100,000 ha	22,900,000 ha
RA ha	4,000 ha	1,000,000 ha
years VP	5 years	5 years
RA %	4,000 ÷ (100,000 x 5) = 0.0080	1,000,000 ÷ (22,900,000 x 5) = 0.0087

5.9 Actual emissions during the *Verification Period*

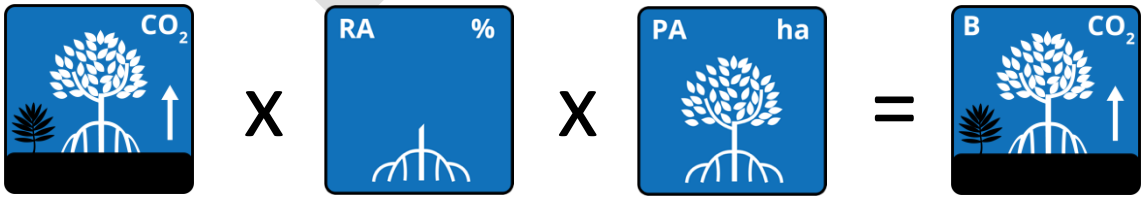
5.9.1 Calculate actual baseline emissions

At the end of each *Verification Period*, the actual baseline emissions that would have occurred during the *Verification Period* are estimated by considering deforestation that occurred within the Reference Area during the *Verification Period*.

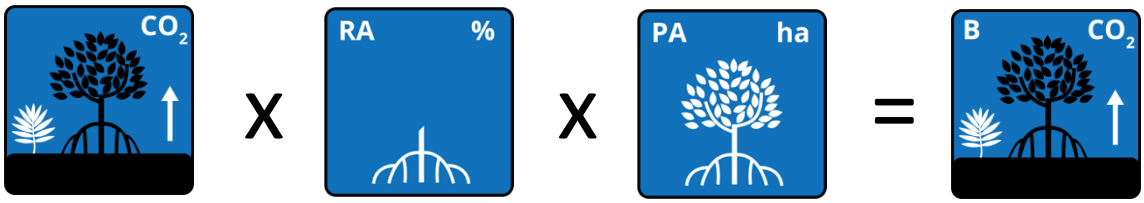
5.9.1.1 Actual baseline emissions from Vegetation and Soil *Carbon Pools*

For each Zone of the *Project Area*, for each year of the *Verification Period* the actual baseline CO_2 emissions from the vegetation *Carbon Pools* are calculated by multiplying the Zone's relevant emission factor by the average proportion of the Mangroves that was deforested in the Zone of the Reference Area in each year of the *Verification Period* and the area of Mangrove Forest in the Zone of the *Project Area* at the start of the *Verification Period*:

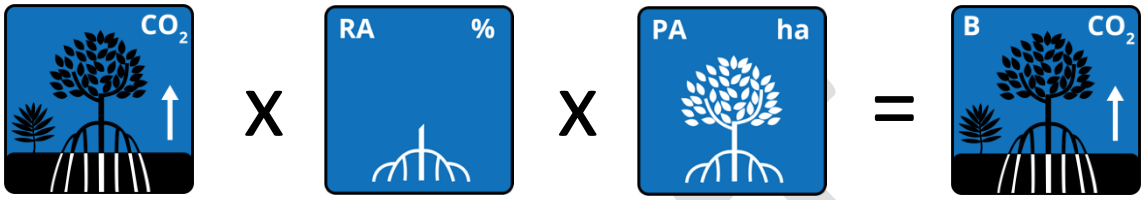
Equation 17:



Equation 18:



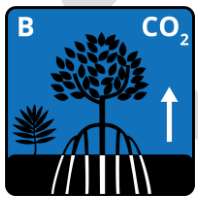
Equation 19:



Where:

= Actual baseline CO_2 emissions in the aboveground woody biomass *Carbon Pool* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

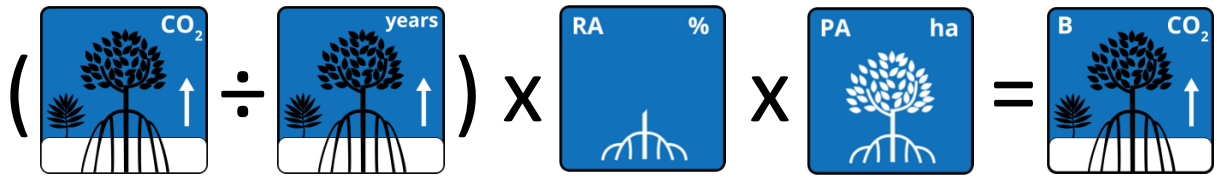
= Actual baseline CO_2 emissions in the aboveground non-woody biomass *Carbon Pool* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*



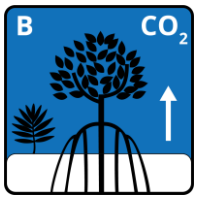
= Actual baseline CO_2 emissions in the belowground biomass *Carbon Pool* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

The actual annual baseline CO_2 emissions from the soil organic carbon pool are calculated as follows:

Equation 20:



Where:



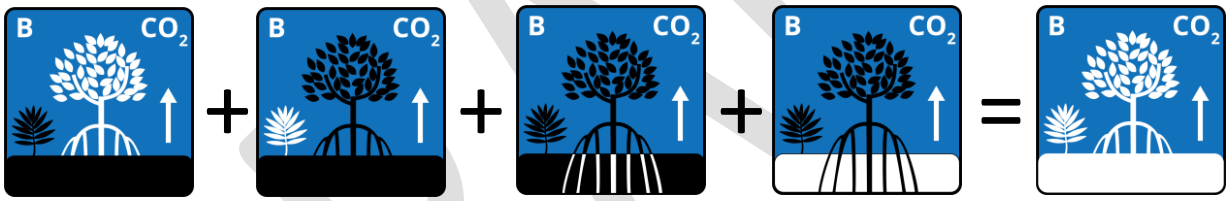
= Actual baseline CO_2 emissions in the soil organic carbon pool in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

However, **these annual emissions should be applied in each year following deforestation for an amount of time equal to** 

. In each year of the *Verification Period*, the total CO_2 emissions from the soil organic carbon pool are equal to the sum of the emissions due to the current year's deforestation and any ongoing emissions due to deforestation in previous years. See the worked example in Section 5.6.2.1 for more information.

Total actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* are calculated as follows:

Equation 21:



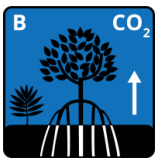
Where:

= Total actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

Required outputs from Section 5.9.1.1:

Actual baseline CO_2 emissions from the aboveground woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Actual baseline CO_2 emissions in the aboveground non-woody biomass pool in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)



Actual baseline CO_2 emissions from the belowground biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Actual baseline CO_2 emissions from the soil organic *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Total actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Worked example – Section 5.9.1.1

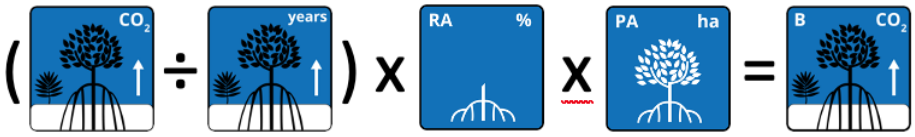
In the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**, the *Project Area* only contains one Zone: the Mangrove Forest Zone. Over the five-year *Verification Period*, the annual baseline CO_2 emissions from the vegetation *Carbon Pools* are estimated using the parameters in Sections 5.3.1, 5.7 and 5.8, and Equations 17-19 as follows:

Mangrove forest zone – Aboveground woody biomass				
Year	CO_2 (tCO_2e/ha)	RA % unitless	PA ha (ha)	B CO_2 (tCO_2e)
1	203	0.0080	15,000	203 x 0.0080 x 15,000 = 24,360
2	203	0.0080	15,000	203 x 0.0080 x 15,000 = 24,360
3	203	0.0080	15,000	203 x 0.0080 x 15,000 = 24,360
4	203	0.0080	15,000	203 x 0.0080 x 15,000 = 24,360
5	203	0.0080	15,000	203 x 0.0080 x 15,000 = 24,360

Mangrove forest zone – Aboveground non-woody biomass				
Year	CO_2 (tCO_2e/ha)	RA % unitless	PA ha (ha)	B CO_2 (tCO_2e)
1	0	0.0080	15,000	0 x 0.0080 x 15,000 = 0
2	0	0.0080	15,000	0 x 0.0080 x 15,000 = 0
3	0	0.0080	15,000	0 x 0.0080 x 15,000 = 0
4	0	0.0080	15,000	0 x 0.0080 x 15,000 = 0
5	0	0.0080	15,000	0 x 0.0080 x 15,000 = 0

Mangrove forest zone – belowground biomass				
Year	CO_2 (tCO_2e/ha)	RA % unitless	PA ha (ha)	B CO_2 (tCO_2e)
1	96	0.0080	15,000	96 x 0.0080 x 15,000 = 11,520
2	96	0.0080	15,000	96 x 0.0080 x 15,000 = 11,520
3	96	0.0080	15,000	96 x 0.0080 x 15,000 = 11,520
4	96	0.0080	15,000	96 x 0.0080 x 15,000 = 11,520
5	96	0.0080	15,000	96 x 0.0080 x 15,000 = 11,520

The annual expected baseline CO_2 emissions from the soil organic carbon pool are calculated using the Equation 20:



Using the parameters in Sections 5.3.1, 5.7 and 5.8, this gives:

$$(278 \div 5) \times 0.0080 \times 15{,}000 = 6{,}672\ tCO_2e$$

Given that 

= 5, this value should be applied annually for five years following deforestation. The total annual expected baseline CO_2 emissions from the soil organic carbon pool are most easily calculated in a table as follows:

		Year				
		1	2	3	4	5
Deforested area	1	6,672	6,672	6,672	6,672	6,672
	2		6,672	6,672	6,672	6,672
	3			6,672	6,672	6,672
	4				6,672	6,672
	5					6,672
B CO2		**6,672**	6,672 + 6,672 = **13,344**	6,672 + 6,672 + 6,672 = **20,016**	6,672 + 6,672 + 6,672 + 6,672 = **26,688**	6,672 + 6,672 + 6,672 + 6,672 + 6,672 = **33,360**

The totals from these tables can be summed to give the total actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* in the Mangrove Forest Zone (Equation 21):

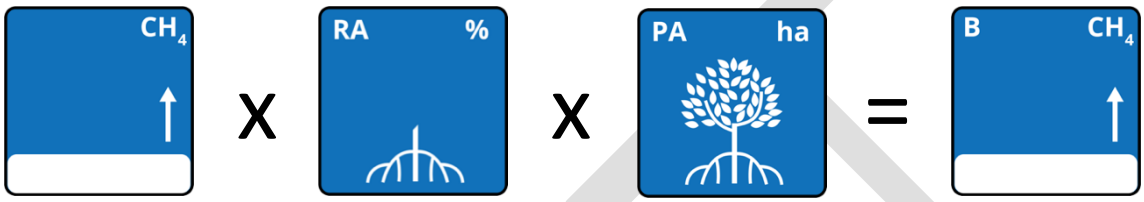
Mangrove forest zone					
Year	B CO2 (tCO_2e)	B CO2 (tCO_2e)	B CO2 (tCO_2e)	B CO2 (tCO_2e)	B CO2 (tCO_2e)
1	24,360	0	11,520	6,672	24,360 + 0 + 11,520 + 6,672 = **42,552**
2	24,360	0	11,520	13,344	24,360 + 0 + 11,520 + 13,344 = **49,224**
3	24,360	0	11,520	20,016	24,360 + 0 + 11,520 + 20,016 = **55,896**
4	24,360	0	11,520	26,688	24,360 + 0 + 11,520 + 6,672 = **62,568**
5	24,360	0	11,520	33,360	24,360 + 0 + 11,520 + 6,672 = **69,240**

5.9.1.2 Actual baseline emissions from emission sources

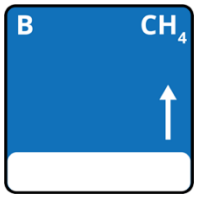
Given the applicability conditions of PM00X and this module, the only emission source that must be accounted for is Soil Methanogenesis.

For each Zone of the *Project Area*, in each year of the *Verification Period* the actual baseline emissions due to Soil Methanogenesis are calculated by multiplying the Zone's emission factor by the average proportion of the Mangroves that was deforested in the Zone of the Reference Area in each year of the *Verification Period* and the area of Mangrove Forest in the Zone of the *Project Area* at the start of the *Verification Period*:

Equation 22:



Where:

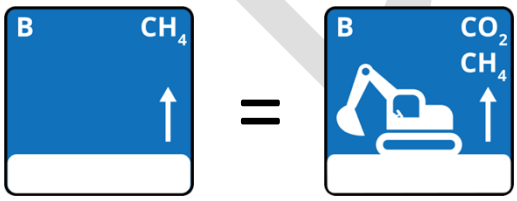


= Actual baseline emissions due to Soil Methanogenesis in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

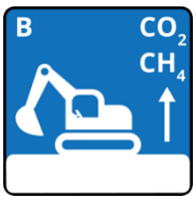
Similar to the CO_2 emissions from the soil organic carbon pool, **these annual emissions should be applied in each year following deforestation for the remainder of the *Crediting Period***. In each year of the *Verification Period*, the total baseline emissions due to Soil Methanogenesis are equal to the sum of the emissions due to the current year's deforestation and the emissions due to deforestation in previous years. See the worked example in Section 5.6.2.2 for more information.

Since Soil Methanogenesis is the only emission source relevant in this module:

Equation 23:

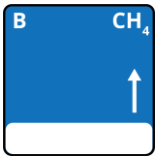


Where:

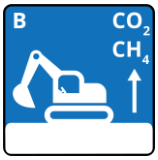


= **Total actual baseline emissions from all emission sources in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

Required outputs from Section 5.6.2.2:



Actual baseline emissions due to Soil Methanogenesis in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)



Total actual baseline emissions from all emission sources in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

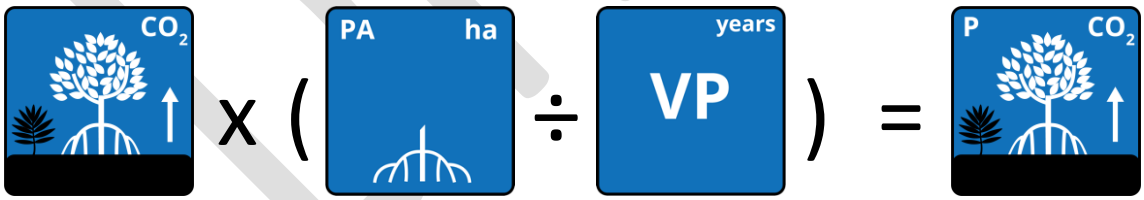
5.9.2 Calculate actual project emissions

At the end of each *Verification Period*, the actual project emissions that occurred during the *Verification Period* are estimated by considering deforestation that occurred within the *Project Area* during the *Verification Period*.

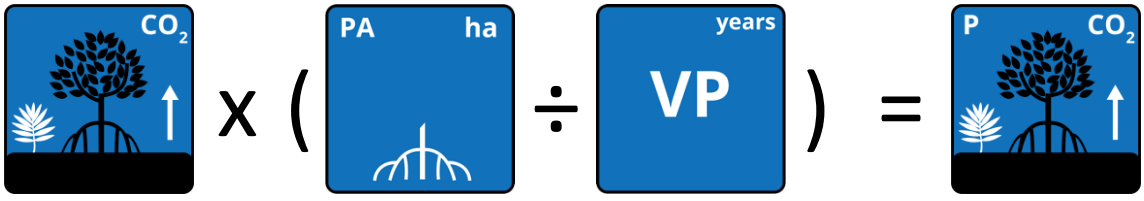
5.9.2.1 Actual project emissions from Vegetation and Soil *Carbon Pools*

For each Zone of the *Project Area*, for each year of the *Verification Period* the actual project CO_2 emissions from the vegetation *Carbon Pools* are calculated by multiplying the Zone's relevant emission factor by the area of Mangrove Forest deforested in the Zone of the *Project Area* during the *Verification Period* divided by the length of the *Verification Period*:

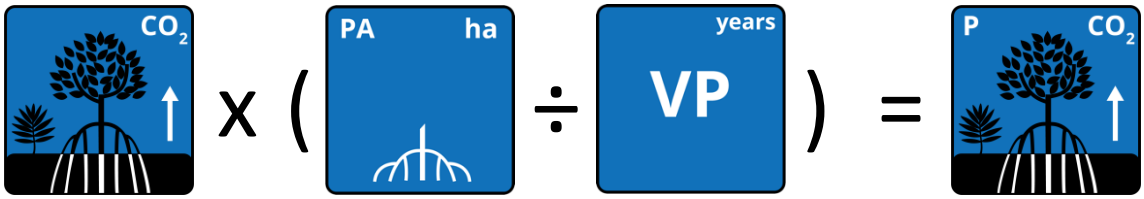
Equation 24:



Equation 25:



Equation 26:



Where:

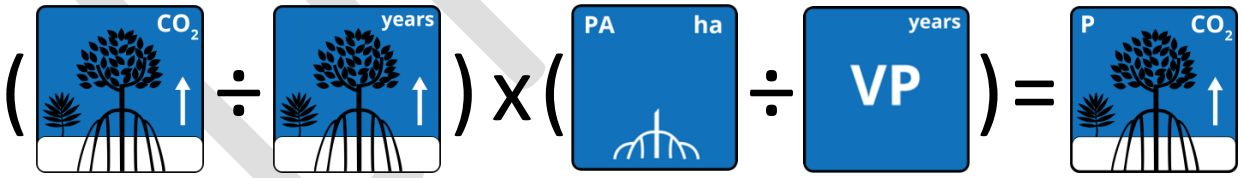
= Actual project CO_2 emissions in the aboveground woody biomass *Carbon Pool* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

= Actual project CO_2 emissions in the aboveground non-woody biomass *Carbon Pool* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

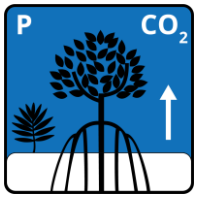
= Actual project CO_2 emissions in the belowground biomass *Carbon Pool* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

The actual annual project CO_2 emissions from the soil organic carbon pool are calculated as follows:

Equation 27:



Where:



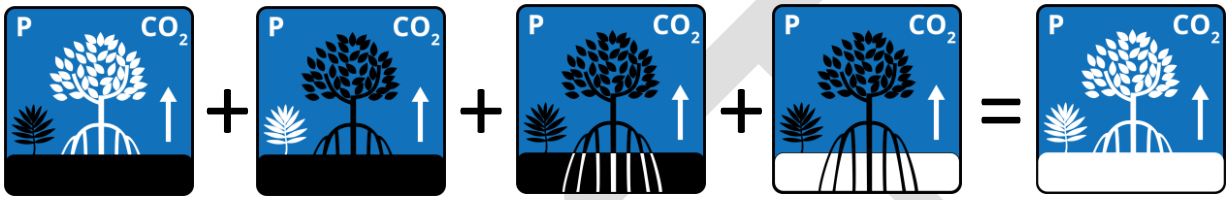
= Actual project CO_2 emissions in the soil organic carbon in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

However, **these annual emissions should be applied in each year following deforestation for an amount of time equal to** 

. In each year of the *Verification Period*, the total CO_2 emissions from the soil organic carbon pool are equal to the sum of the emissions due to the current year's deforestation and any ongoing emissions due to deforestation in previous years. See the worked example in Section 5.6.2.1 for more information.

Total actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools* are calculated as follows:

Equation 28:



Where:

= **Total actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

Required outputs from Section 5.9.1.1:

Actual project CO_2 emissions from the aboveground woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Actual project CO_2 emissions in the aboveground non-woody biomass pool in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Actual project CO_2 emissions from the belowground biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Actual project CO_2 emissions from the soil organic *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Total actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

Worked example – Section 5.9.2.1

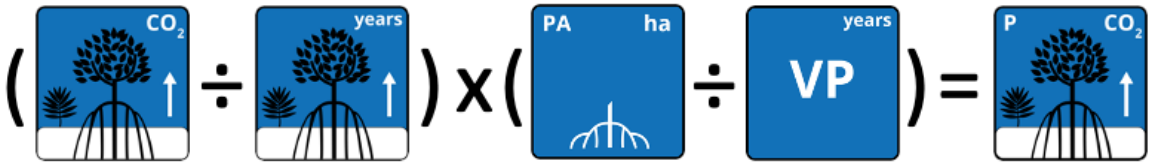
In the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**, the *Project Area* only contains one Zone: the Mangrove Forest Zone. Over the five-year *Verification Period*, the annual project CO_2 emissions from the vegetation *Carbon Pools* are estimated using Equations 24-26 and the parameters in Sections 5.3.1 and 5.7 as follows:

Mangrove forest zone – Aboveground woody biomass				
Year	(tCO_2e/ha)	(ha)	(years)	(tCO_2e)
1	203	100	5	203 x (100 ÷ 5) = 4,060
2	203	100	5	203 x (100 ÷ 5) = 4,060
3	203	100	5	203 x (100 ÷ 5) = 4,060
4	203	100	5	203 x (100 ÷ 5) = 4,060
5	203	100	5	203 x (100 ÷ 5) = 4,060

Mangrove forest zone – Aboveground non-woody biomass				
Year	(tCO_2e/ha)	(ha)	(years)	(tCO_2e)
1	0	100	5	0 x (100 ÷ 5) = 0
2	0	100	5	0 x (100 ÷ 5) = 0
3	0	100	5	0 x (100 ÷ 5) = 0
4	0	100	5	0 x (100 ÷ 5) = 0
5	0	100	5	0 x (100 ÷ 5) = 0

Mangrove forest zone – belowground biomass				
Year	(tCO_2e/ha)	(ha)	(years)	(tCO_2e)
1	96	100	5	96 x (100 ÷ 5) = 1,920
2	96	100	5	96 x (100 ÷ 5) = 1,920
3	96	100	5	96 x (100 ÷ 5) = 1,920
4	96	100	5	96 x (100 ÷ 5) = 1,920
5	96	100	5	96 x (100 ÷ 5) = 1,920

The annual expected baseline CO_2 emissions from the soil organic carbon pool are calculated using Equation 27:



Using the parameters in Sections 5.3.1 and 5.7, this gives:

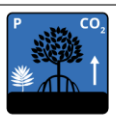
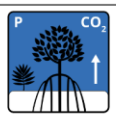
$$(278 \div 5) \times (100 \div 5) = 1{,}112 \text{ tCO}_2\text{e}$$

Given that 

= 5, this value should be applied annually for five years following deforestation. The total annual expected baseline CO_2 emissions from the soil organic carbon pool are most easily calculated in a table as follows:

		Year				
		1	2	3	4	5
Deforested area	1	1,112	1,112	1,112	1,112	1,112
	2		1,112	1,112	1,112	1,112
	3			1,112	1,112	1,112
	4				1,112	1,112
	5					1,112
		**1,112**	1,112 + 1,112 = **2,224**	1,112 + 1,112 + 1,112 = **3,336**	1,112 + 1,112 + 1,112 + 1,112 = **4,448**	1,112 + 1,112 + 1,112 + 1,112 + 1,112 = **5,560**

The totals from these tables can be summed to give the total actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools* in the Mangrove Forest Zone (Equation 28):

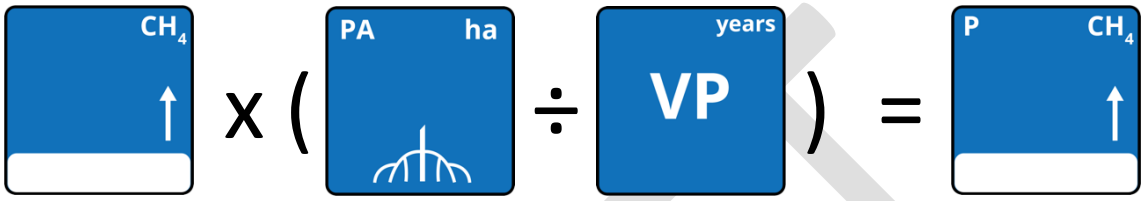
Mangrove forest zone					
Year	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)
1	4,060	0	1,920	1,112	4,060 + 0 + 1,920 + 1,112 = **7,092**
2	4,060	0	1,920	2,224	4,060 + 0 + 1,920 + 2,224 = **8,204**
3	4,060	0	1,920	3,336	4,060 + 0 + 1,920 + 3,336 = **9,316**
4	4,060	0	1,920	4,448	4,060 + 0 + 1,920 + 4,448 = **10,428**
5	4,060	0	1,920	5,560	4,060 + 0 + 1,920 + 5,560 = **11,540**

5.9.2.2 Actual project emissions from emission sources

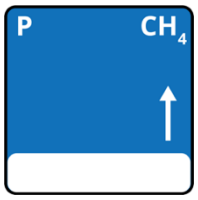
Given the applicability conditions of PM00X and this module, the only emission source that must be accounted for is Soil Methanogenesis.

For each Zone of the *Project Area*, in each year of the *Verification Period* the actual project emissions due to Soil Methanogenesis are calculated by multiplying the Zone's emission factor by the area of Mangrove Forest deforested in the Zone of the *Project Area* during the *Verification Period* divided by the length of the *Verification Period*:

Equation 29:



Where:

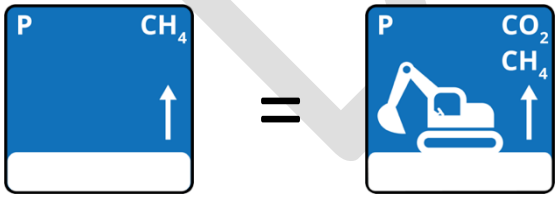


= Actual baseline emissions due to Soil Methanogenesis in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*

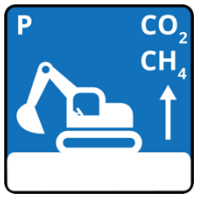
Similar to the CO_2 emissions from the soil organic carbon pool, **these annual emissions should be applied in each year following deforestation for the remainder of the *Crediting Period***. In each year of the *Verification Period*, the total project emissions due to Soil Methanogenesis are equal to the sum of the emissions due to the current year's deforestation and the emissions due to deforestation in previous years. See the worked example in Section 5.6.2.2 for more information.

Since Soil Methanogenesis is the only emission source relevant in this module:

Equation 30:

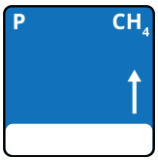


Where:

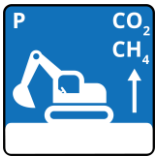


= **Total actual project emissions from all emission sources in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

Required outputs from Section 5.6.2.2:



Actual project emissions due to Soil Methanogenesis in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)



Total actual project emissions from all emission sources in each Zone of the *Project Area* for each year of the *Verification Period* (tCO_2e)

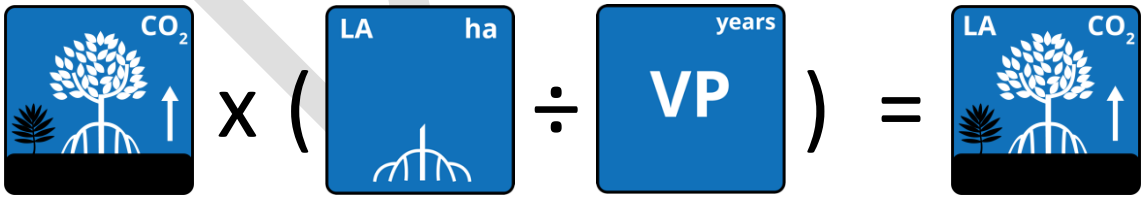
5.9.3 Calculate actual leakage emissions

At the end of the *Verification Period*, deforestation is monitored in each Zone of the Leakage Area. To estimate the emissions due to leakage caused by project activities, the emissions due to deforestation within each Zone of the Leakage Area must be compared to the emissions that would have occurred if the proportion of deforestation in the Leakage Area was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area.

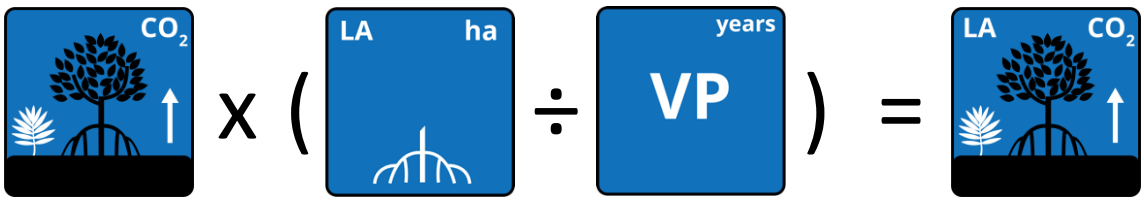
5.9.3.1 Actual and expected emissions in the Leakage Area from the Vegetation and Soil *Carbon Pools*

For each Zone of the Leakage Area, for each year of the *Verification Period* the actual CO_2 emissions from the vegetation *Carbon Pools* are calculated by multiplying the Zone's relevant emission factor by the area of forest deforested in the Zone of the Leakage Area during the *Verification Period* divided by the length of the *Verification Period*:

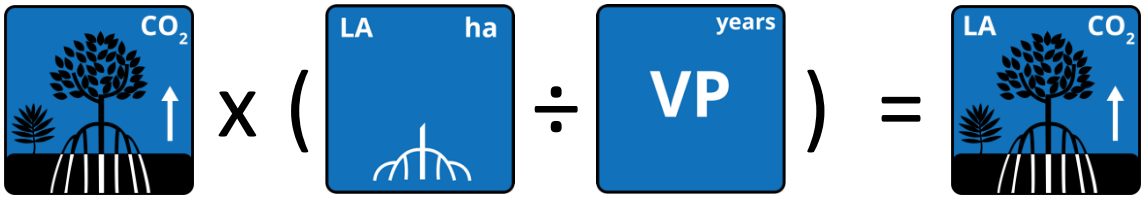
Equation 31:



Equation 32:



Equation 33:



Where:

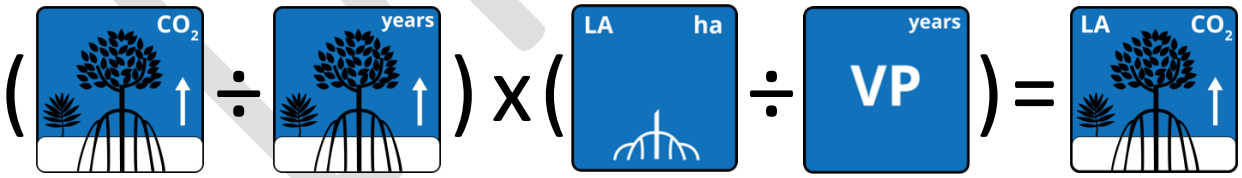
= Actual CO_2 emissions in the aboveground woody biomass *Carbon Pool* in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*

= Actual CO_2 emissions in the aboveground non-woody biomass *Carbon Pool* in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*

= Actual CO_2 emissions in the belowground biomass *Carbon Pool* in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*

The actual annual CO_2 emissions from the soil organic carbon pool in each Zone of the Leakage Area are calculated as follows:

Equation 34:



Where:

= Actual CO_2 emissions in the soil organic carbon in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*

These annual emissions should be applied in each year following deforestation for an amount of time equal to 

. In each year of the *Verification Period*, the total CO_2 emissions from the soil organic carbon pool are equal to the sum of the emissions due to the current year's deforestation and any ongoing emissions due to deforestation in previous years. See the worked example in Section 5.6.2.1 for more information.

Total actual CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the Leakage Area are calculated as follows:

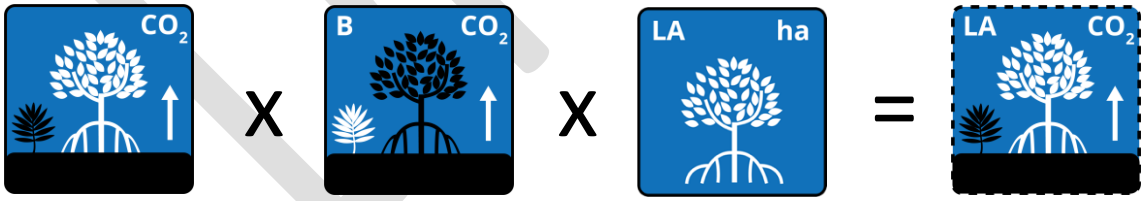
Equation 35:

Where:

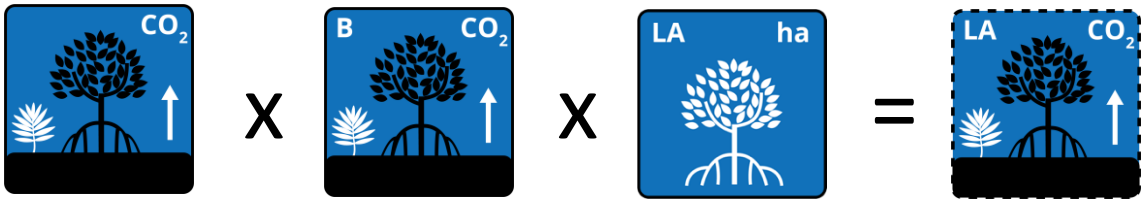
= Total actual CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*

The following procedures are used to estimate the emissions from the vegetation *Carbon Pools* that would have occurred in each Zone of the Leakage Area if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area:

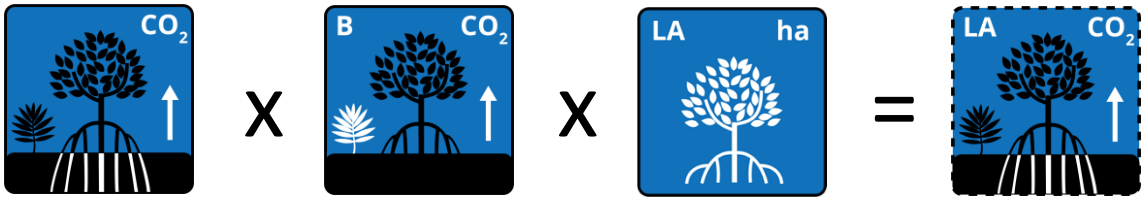
Equation 36:



Equation 37:



Equation 38:



Where:

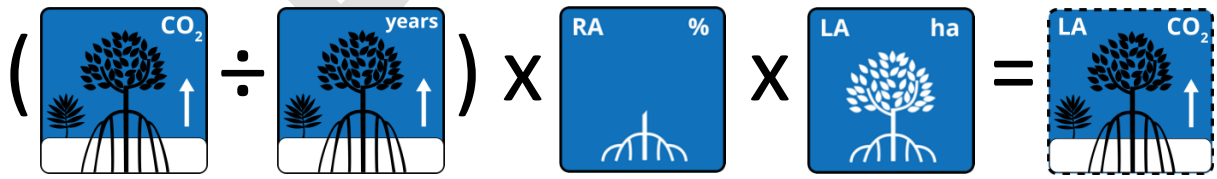
= The expected CO_2 emissions that would have occurred in the aboveground woody biomass *Carbon Pool* in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area.

= The expected CO_2 emissions that would have occurred in the aboveground non-woody biomass *Carbon Pool* in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area.

= The expected CO_2 emissions that would have occurred in the belowground biomass *Carbon Pool* in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area.

The expected annual CO_2 emissions from the soil organic carbon pool in each Zone of the Leakage Area, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area, are calculated as follows:

Equation 39:



Where:

= The expected CO_2 emissions that would have occurred in the soil organic carbon pool in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area.

These annual emissions should be applied in each year following deforestation for an amount of time equal to 

. In each year of the *Verification Period*, the total CO_2 emissions from the soil organic carbon pool are equal to the sum of the emissions due to the current year's deforestation and any ongoing emissions due to deforestation in previous years. See the worked example in Section 5.6.2.1 for more information.

The total expected annual CO_2 emissions from the Vegetation and Soil *Carbon Pools* that would have occurred in each Zone of the Leakage Area, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area, are calculated as follows:

Equation 40:

Where:

= Total expected CO_2 emissions that would have occurred from the Vegetation and Soil *Carbon Pools* in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area.

Required outputs from Section 5.9.3.1:

Total actual CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period* (tCO_2e)

Total expected CO_2 emissions that would have occurred from the Vegetation and Soil *Carbon Pools* in each Zone of the Leakage Area for each year of the *Verification Period*, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area (tCO_2e)

5.9.3.2 Actual emissions due to leakage from the Vegetation and Soil *Carbon Pools*

In each year of the Verification Period, for each Zone of the Leakage area the actual CO_2 emissions from the Vegetation and Soil *Carbon Pools* due to leakage are estimated as the difference between the expected and actual emissions in the Leakage Area:

Equation 41:

Where:

= **Total actual CO_2 emissions from the Vegetation and Soil *Carbon Pools* due to leakage in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period***

This parameter cannot be less than zero.

Required outputs from Section 5.9.3.2:

Total actual emissions from the Vegetation and Soil *Carbon Pools* due to leakage in each Zone of the Leakage Area for each year of the *Verification Period* (tCO_2e). **Cannot be less than zero**.

Worked example – Sections 5.9.3.1-2

In the hypothetical Mangrove Conservation project shown in **Error! Reference source not found.**, the Leakage Area contains two Zones: the Mangrove Forest Zone and the non-Mangrove Forest Zone. For each year of the five-year *Verification Period*, the actual CO_2 emissions in the Leakage Area from the vegetation *Carbon Pools* in the two Zones are estimated using the parameters in Sections 5.3.1 and 5.7 as follows:

Mangrove forest zone – Aboveground woody biomass				
Year	(tCO_2e/ha)	(ha)	(years)	(tCO_2e)
1	203	200	5	203 x (200 ÷ 5) = 8,120
2	203	200	5	203 x (200 ÷ 5) = 8,120
3	203	200	5	203 x (200 ÷ 5) = 8,120
4	203	200	5	203 x (200 ÷ 5) = 8,120
5	203	200	5	203 x (200 ÷ 5) = 8,120

Non-mangrove forest zone – Aboveground woody biomass				
Year	(tCO_2e/ha)	(ha)	(years)	(tCO_2e)
1	100	800	5	100 x (800 ÷ 5) = 16,000
2	100	800	5	100 x (800 ÷ 5) = 16,000
3	100	800	5	100 x (800 ÷ 5) = 16,000
4	100	800	5	100 x (800 ÷ 5) = 16,000
5	100	800	5	100 x (800 ÷ 5) = 16,000

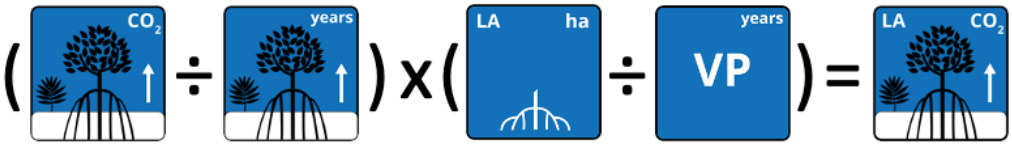
Mangrove forest zone – Aboveground non-woody biomass				
Year	(tCO_2e/ha)	(ha)	(years)	(tCO_2e)
1	0	200	5	0 x (200 ÷ 5) = 0
2	0	200	5	0 x (200 ÷ 5) = 0
3	0	200	5	0 x (200 ÷ 5) = 0
4	0	200	5	0 x (200 ÷ 5) = 0
5	0	200	5	0 x (200 ÷ 5) = 0

Non-mangrove forest zone – Aboveground non-woody biomass				
Year	(tCO_2e/ha)	(ha)	(years)	(tCO_2e)
1	0	800	5	0 x (800 ÷ 5) = 0
2	0	800	5	0 x (800 ÷ 5) = 0
3	0	800	5	0 x (800 ÷ 5) = 0
4	0	800	5	0 x (800 ÷ 5) = 0
5	0	800	5	0 x (800 ÷ 5) = 0

Mangrove forest zone – Belowground biomass				
Year	(tCO_2e/ha)	(ha)	(years)	(tCO_2e)
1	96	200	5	96 x (200 ÷ 5) = 3,840
2	96	200	5	96 x (200 ÷ 5) = 3,840
3	96	200	5	96 x (200 ÷ 5) = 3,840
4	96	200	5	96 x (200 ÷ 5) = 3,840
5	96	200	5	96 x (200 ÷ 5) = 3,840

Non-mangrove forest zone – Belowground biomass				
Year	(tCO_2e/ha)	(ha)	(years)	(tCO_2e)
1	54	800	5	54 x (800 ÷ 5) = 8,640
2	54	800	5	54 x (800 ÷ 5) = 8,640
3	54	800	5	54 x (800 ÷ 5) = 8,640
4	54	800	5	54 x (800 ÷ 5) = 8,640
5	54	800	5	54 x (800 ÷ 5) = 8,640

The annual actual CO_2 emissions from the soil organic carbon pool in the Leakage Area are calculated using the Equation 34:



Using the parameters in Sections 5.3.1 and 5.7, this gives:

$$(278 \div 5) \times (200 \div 5) = 2{,}224\ tCO_2e \quad \text{for the Mangrove Forest Zone}$$

As per the data outlined in the worked example in Section 5.3, emissions from the soil organic carbon pool following deforestation of non-Mangrove Forest are zero.

For the Mangrove Forest Zone, given that 

= 5, this value should be applied annually for five years following deforestation. The total annual CO_2 emissions from the soil organic carbon pool in the Mangrove Forest Zone in the Leakage Area are most easily calculated in a table as follows:

Mangrove forest zone						
		Year				
		1	2	3	4	5
Deforested area	1	2,224	2,224	2,224	2,224	2,224
	2		2,224	2,224	2,224	2,224
	3			2,224	2,224	2,224
	4				2,224	2,224
	5					2,224
LA CO_2		**2,224**	2,224 + 2,224 = **4,448**	2,224 + 2,224 + 2,224 = **6,672**	2,224 + 2,224 + 2,224 + 2,224 = **8,896**	2,224 + 2,224 + 2,224 + 2,224 + 2,224 = **11,120**

The totals from these tables can be summed to give the total actual CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*:

Mangrove forest zone					
Year	LA CO_2 (tCO_2e)	LA CO_2 (tCO_2e)	LA CO_2 (tCO_2e)	LA CO_2 (tCO_2e)	LA CO_2 (tCO_2e)
1	8,120	0	3,840	2,224	8,120 + 0 + 3,840 + 2,224 = **14,184**
2	8,120	0	3,840	4,448	8,120 + 0 + 3,840 + 4,448 = **16,408**
3	8,120	0	3,840	6,672	8,120 + 0 + 3,840 + 6,672 = **18,632**
4	8,120	0	3,840	8,896	8,120 + 0 + 3,840 + 8,896 = **20,856**
5	8,120	0	3,840	11,120	8,120 + 0 + 3,840 + 11,120 = **23,080**

Non-mangrove forest zone					
Year	LA CO_2 (tCO_2e)	LA CO_2 (tCO_2e)	LA CO_2 (tCO_2e)	LA CO_2 (tCO_2e)	LA CO_2 (tCO_2e)
1	16,000	0	8,640	0	16,000 + 0 + 8,640 + 0 = **24,640**
2	16,000	0	8,640	0	16,000 + 0 + 8,640 + 0 = **24,640**
3	16,000	0	8,640	0	16,000 + 0 + 8,640 + 0 = **24,640**
4	16,000	0	8,640	0	16,000 + 0 + 8,640 + 0 = **24,640**
5	16,000	0	8,640	0	16,000 + 0 + 8,640 + 0 = **24,640**

The next step is to estimate the expected CO_2 emissions that would have occurred in each of the Zones, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area, using the parameters in 5.3, 5.4 and 5.5 as follows:

Mangrove forest zone – Aboveground woody biomass				
Year	(tCO_2e/ha)	(unitless)	(ha)	(tCO_2e)
1	203	0.0080	3,500	203 x 0.0080 x 3,500 = 5,684
2	203	0.0080	3,500	203 x 0.0080 x 3,500 = 5,684
3	203	0.0080	3,500	203 x 0.0080 x 3,500 = 5,684
4	203	0.0080	3,500	203 x 0.0080 x 3,500 = 5,684
5	203	0.0080	3,500	203 x 0.0080 x 3,500 = 5,684

Non-mangrove forest zone – Aboveground woody biomass				
Year	(tCO_2e/ha)	(unitless)	(ha)	(tCO_2e)
1	100	0.0087	21,000	100 x 0.0087 x 21,000 = 18,270
2	100	0.0087	21,000	100 x 0.0087 x 21,000 = 18,270
3	100	0.0087	21,000	100 x 0.0087 x 21,000 = 18,270
4	100	0.0087	21,000	100 x 0.0087 x 21,000 = 18,270
5	100	0.0087	21,000	100 x 0.0087 x 21,000 = 18,270

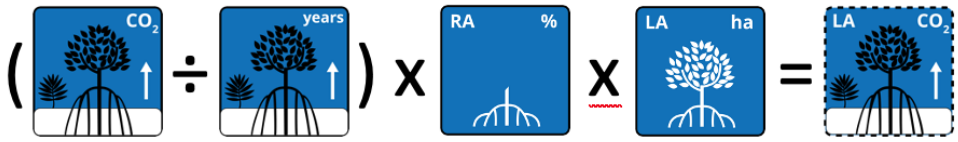
Mangrove forest zone – Aboveground non-woody biomass				
Year	(tCO_2e/ha)	(unitless)	(ha)	(tCO_2e)
1	0	0.0080	3,500	0 x 0.0080 x 3,500 = 0
2	0	0.0080	3,500	0 x 0.0080 x 3,500 = 0
3	0	0.0080	3,500	0 x 0.0080 x 3,500 = 0
4	0	0.0080	3,500	0 x 0.0080 x 3,500 = 0
5	0	0.0080	3,500	0 x 0.0080 x 3,500 = 0

Non-mangrove forest zone – Aboveground non-woody biomass				
Year	(tCO_2e/ha)	(unitless)	(ha)	(tCO_2e)
1	0	0.0087	21,000	0 x 0.0087 x 21,000 = 0
2	0	0.0087	21,000	0 x 0.0087 x 21,000 = 0
3	0	0.0087	21,000	0 x 0.0087 x 21,000 = 0
4	0	0.0087	21,000	0 x 0.0087 x 21,000 = 0
5	0	0.0087	21,000	0 x 0.0087 x 21,000 = 0

Mangrove forest zone – Belowground biomass				
Year	(tCO_2e/ha)	(unitless)	(ha)	(tCO_2e)
1	96	0.0080	3,500	96 x 0.0080 x 3,500 = 2,688
2	96	0.0080	3,500	96 x 0.0080 x 3,500 = 2,688
3	96	0.0080	3,500	96 x 0.0080 x 3,500 = 2,688
4	96	0.0080	3,500	96 x 0.0080 x 3,500 = 2,688
5	96	0.0080	3,500	96 x 0.0080 x 3,500 = 2,688

Non-mangrove forest zone – Belowground biomass				
Year	(tCO_2e/ha)	(unitless)	(ha)	(tCO_2e)
1	54	0.0087	21,000	54 x 0.0087 x 21,000 = 9,866
2	54	0.0087	21,000	54 x 0.0087 x 21,000 = 9,866
3	54	0.0087	21,000	54 x 0.0087 x 21,000 = 9,866
4	54	0.0087	21,000	54 x 0.0087 x 21,000 = 9,866
5	54	0.0087	21,000	54 x 0.0087 x 21,000 = 9,866

The annual CO_2 emissions from the soil organic carbon pool in each Zone of the Leakage Area, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area are calculated using Equation 39:



Using the parameters in Sections 5.3.1 and 5.7, this gives:

(278 ÷ 5) x 0.0080 x 3,500 = 1,557 tCO_2e for the Mangrove Forest Zone

As per the data outlined in the worked example in Section 5.3, emissions from the soil organic carbon pool following deforestation of non-Mangrove Forest are zero.

For the Mangrove Forest Zone, given that 

= 5, this value should be applied annually for five years following deforestation. The total annual CO_2 emissions from the soil organic carbon pool in the Mangrove Forest Zone in the Leakage Area are most easily calculated in a table as follows:

		Mangrove forest zone				
		Year				
		1	2	3	4	5
Deforested area	1	1,557	1,557	1,557	1,557	1,557
	2		1,557	1,557	1,557	1,557
	3			1,557	1,557	1,557
	4				1,557	1,557
	5					1,557
		**1,557**	1,557 + 1,557 = **3,114**	1,557 + 1,557 + 1,557 = **4,671**	1,557 + 1,557 + 1,557 + 1,557 = **6,228**	1,557 + 1,557 + 1,557 + 1,557 + 1,557 = **7,785**

The totals from these tables can be summed to give the expected CO_2 emissions that would have occurred in each of the Zones, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area, for each year of the *Verification Period*:

Mangrove forest zone					
Year	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)
1	5,684	0	2,688	1,557	5,684 + 0 + 2,688 + 1,557 = **9,929**
2	5,684	0	2,688	3,114	5,684 + 0 + 2,688 + 3,114 = **11,486**
3	5,684	0	2,688	4,671	5,684 + 0 + 2,688 + 4,671 = **13,043**
4	5,684	0	2,688	6,228	5,684 + 0 + 2,688 + 6,228 = **14,600**
5	5,684	0	2,688	7,785	5,684 + 0 + 2,688 + 7,785 = **16,157**

Non-mangrove forest zone					
Year	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)
1	18,270	0	9,866	0	18,270 + 0 + 9,866 + 0 = **28,136**
2	18,270	0	9,866	0	18,270 + 0 + 9,866 + 0 = **28,136**
3	18,270	0	9,866	0	18,270 + 0 + 9,866 + 0 = **28,136**
4	18,270	0	9,866	0	18,270 + 0 + 9,866 + 0 = **28,136**
5	18,270	0	9,866	0	18,270 + 0 + 9,866 + 0 = **28,136**

These totals are then used to calculate the total actual CO_2 emissions from the Vegetation and Soil *Carbon Pools* due to leakage from each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period:*

Mangrove forest zone			
Year	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)
1	14,184	9,929	14,184 - 9,929 = 4,255
2	16,408	11,486	16,408 - 11,486 = 4,922
3	18,632	13,043	18,632 - 13,043 = 5,589
4	20,856	14,600	20,856 - 14,600 = 6,256
5	23,080	16,157	23,080 - 16,157 = 6,293

Non-mangrove forest zone			
Year	 (tCO_2e)	 (tCO_2e)	 (tCO_2e)
1	24,640	28,136	24,640 - 28,136 = -3,496 = **0**
2	24,640	28,136	24,640 - 28,136 = -3,496 = **0**
3	24,640	28,136	24,640 - 28,136 = -3,496 = **0**
4	24,640	28,136	24,640 - 28,136 = -3,496 = **0**
5	24,640	28,136	24,640 - 28,136 = -3,496 = **0**

Total actual leakage emissions from the Vegetation and Soil *Carbon Pools* cannot be less than zero. Therefore, the leakage emissions in the non-Mangrove forest Zone are zero.

5.9.3.3 Actual and expected emissions in the Leakage Area from emission sources

Actual emissions from emission sources in the Leakage Area are calculated in a similar way as for emissions from *Carbon Pools*. For each Zone of the Leakage Area, for each year of the *Verification Period* the actual emissions from emission sources are calculated by multiplying the Zone's relevant emission factor by the area of forest deforested in the Zone of the Leakage Area during the *Verification Period* divided by the length of the *Verification Period*.

Given the applicability conditions of PM00X and this module, the only emission source that must be accounted for is Soil Methanogenesis. It is conservative to exclude methane emissions from intact Mangroves in the Leakage Area.

Therefore, for Zones where  is **less than or equal to zero**:

Equation 42:

= 0

Equation 43:

= 0

Where:

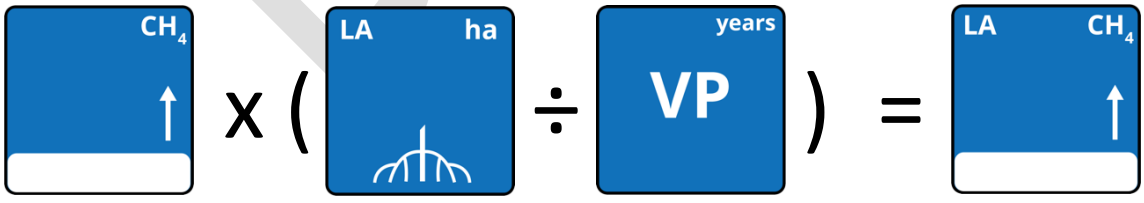
= Total actual emissions from all emission sources in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*

= Total expected emissions from emission sources that would have occurred in each Zone of the Leakage Area (tCO_2e) during each year of the *Verification Period*, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area.

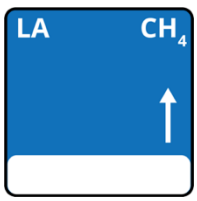
For Zones where 

is **greater than zero**:

Equation 44:



Where:

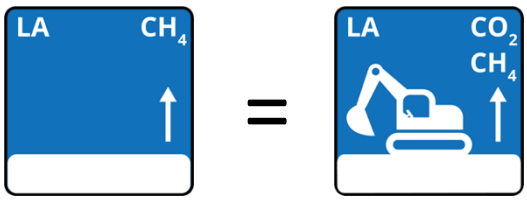


= Actual emissions due to Soil Methanogenesis in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period*

These annual emissions should be applied in each year following deforestation for the remainder of the *Crediting Period*. In each year of the *Verification Period*, the total actual emissions due to Soil Methanogenesis in the Leakage Area are equal to the sum of the emissions due to the current year's deforestation and the emissions due to deforestation in previous years. See the worked example in Section 5.6.2.2 for more information.

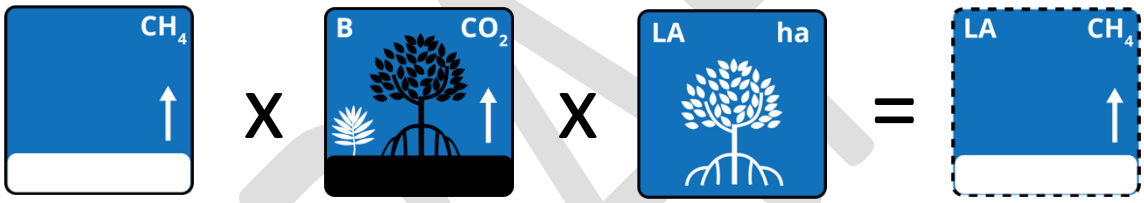
Since Soil Methanogenesis is the only emission source relevant in this module:

Equation 45:



The emissions from emission sources that would have occurred in each Zone of the Leakage Area if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area:

Equation 46:



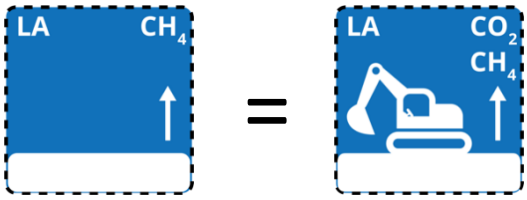
Where:

= Expected emissions from Soil Methanogenesis that would have occurred in each Zone of the Leakage Area (tCO_2e) during each year of the *Verification Period*, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area.

These annual emissions should be applied in each year following deforestation for the remainder of the *Crediting Period*. In each year of the *Verification Period*, the total expected emissions due to Soil Methanogenesis in the Leakage Area are equal to the sum of the emissions due to the current year's deforestation and the emissions due to deforestation in previous years. See the worked example in Section 5.6.2.2 for more information.

Since Soil Methanogenesis is the only emission source relevant in this module:

Equation 47:



Required outputs from Section 5.9.3.3:

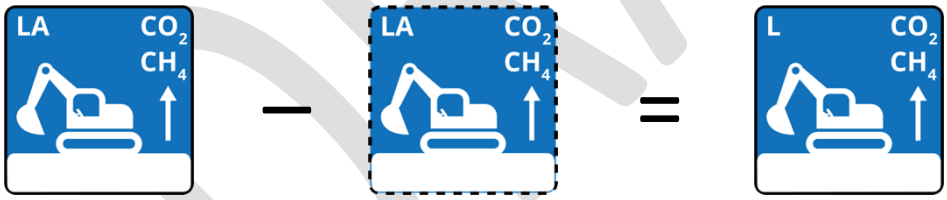
Total actual emissions from all emission sources in each Zone of the Leakage Area (tCO_2e) for each year of the *Verification Period* (tCO_2e)

Total expected emissions that would have occurred from all emission sources in each Zone of the Leakage Area for each year of the *Verification Period*, if the proportion of deforestation was the same as the proportion of deforestation in the same Zone in the rest of the Reference Area (tCO_2e)

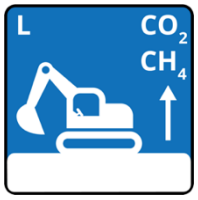
5.9.3.4 Actual emissions due to leakage from emission sources

In each year of the Verification Period, for each Zone of the Leakage area the actual emissions from emission sources due to leakage are estimated as the difference between the expected and actual emissions in the Leakage Area:

Equation 48:



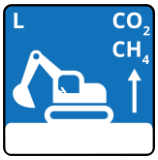
Where:



= **Total actual emissions from emission sources due to leakage from each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

This parameter cannot be less than zero.

Required outputs from Section 5.9.3.2:



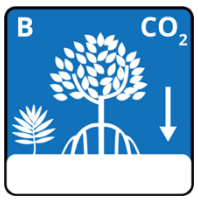
Total actual emissions from emission sources due to leakage from each Zone of the Leakage Area for each year of the *Verification Period* (tCO_2e). **Cannot be less than zero**.

5.9.4 Actual removals

The only applicable baseline CO_2 removals likely in a Mangrove *Conservation* project would be in the wood products *Carbon Pool*. Projects where wood harvesting for timber is a driver of deforestation and the wood would have been used to create products that last more than 5 years (e.g. as building poles or wood for boat building) cannot use this module until PU00d is available to account for the wood products *Carbon Pool*.

Project CO_2 removals are conservatively excluded.

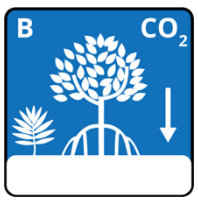
Therefore, in this module:



$$= 0\ tCO_2e$$

$$= 0\ tCO_2e$$

Where:



= **Total actual baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period***

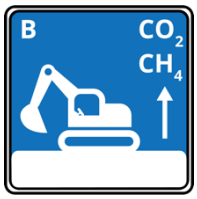
= **Total actual project CO_2 removals in the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period.***

5.9.5 Calculate total actual removals and emissions across all Zones

The final step is to calculate the total expected removals and emissions in the baseline and project scenarios across **all Zones** for **each year of the *Verification Period***. This is done by summing the values in all Zones for the following parameters:

= Total actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period*

= Total actual baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period*. The assumptions of this module mean this parameter = 0.



= Total actual baseline emissions from all emission sources across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period.*

= Total actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period.*

= Total actual project removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period.* Conservatively excluded.

= Total actual project emissions from all emission sources across all Zones of the *Project Area* (tCO_2e) for each year of the *Verification Period.*

= Total actual CO_2 emissions from the Vegetation and Soil *Carbon Pools* due to leakage across all Zones of the Leakage Area (tCO_2e) for each year of the *Verification Period.*

= **Total actual emissions from all emission sources due to leakage across all Zones of the Leakage Area (tCO_2e) for each year of the *Verification Period.***

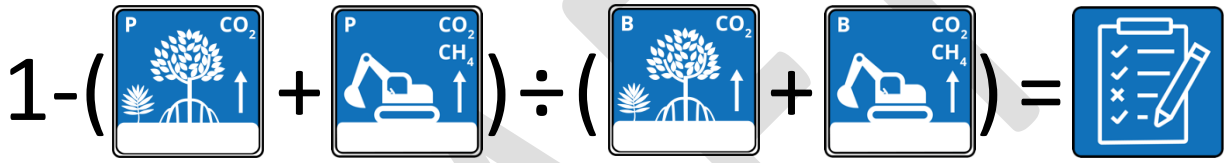
These parameters are then used in PM00X to estimate the actual *Carbon Benefit* of the project.

For each year of the *Verification Period*, these values must be presented in the PDD in table format[26].

5.9.6 Estimate the actual effectiveness of project activities

To inform the update of the expected effectiveness of project activities during the next *Verification Period* (see Section 5.5), the actual effectiveness of project activities across all Zones during the previous *Verification Period* can be calculated as follows:

Equation 49:



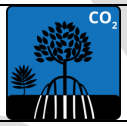
Where:

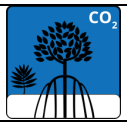
= The **actual effectiveness of project activities** in reducing emissions from Mangrove deforestation, expressed as a proportion of baseline scenario emissions that were likely avoided as a result of project activities (0-1, with 0 being completely ineffective and 1 being completely effective).

[26] This spreadsheet shows an example table that is suitable for the PDD (see the 'Actual' sheet), using the hypothetical *Project Area* referenced throughout the worked examples in this module. The equations are for explanation, in line with the other worked examples, and do not need to be visible in the table in the PDD: https://docs.google.com/spreadsheets/d/1df05DKCxfSVkF26coZjvqnjJWBVOe3FoaKIsvzbPdXc/edit?usp=sharing

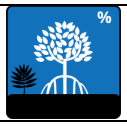
6 Parameters

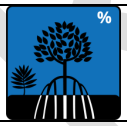
Data/Parameter	
Units	tCO_2e/ha
Description	Carbon stock in the above-ground woody biomass *Carbon Pool*. To be provided for each Zone.
Equations	1
Source	Forest inventories, FRELs, peer-reviewed values from the jurisdiction where the *Project Area* is located.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Established, accessible approaches for defining above-ground carbon stocks, in line with IPCC good practice guidance.
Purpose of Data	Estimation of above-ground woody biomass stocks lost following mangrove loss.
Comments	N/A

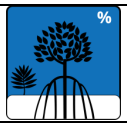
Data/Parameter	
Units	tCO_2e/ha
Description	Carbon stock in the below-ground woody biomass *Carbon Pool*. To be provided for each Zone.
Equations	2
Source	Forest inventories, FRELs, peer-reviewed values from the jurisdiction where the *Project Area* is located.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Established, accessible approaches for defining below-ground carbon stocks, in line with IPCC good practice guidance.
Purpose of Data	Estimation of below-ground woody biomass stocks lost following mangrove loss.
Comments	N/A

Data/Parameter	
Units	tCO_2e/ha
Description	Top 1m carbon stock in the soil organic carbon pool. To be provided for each Zone.
Equations	3
Source	Sanderman et al., 2018 (median value within the *Project Area*/Zone of the 30m resolution 1m dataset), forest inventories, FRELs, peer-

	reviewed values from the jurisdiction where the *Project Area* is located.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Peer-reviewed dataset incorporating field data from locations across the tropics. Established, accessible approaches for defining soil organic carbon stocks, in line with IPCC good practice guidance.
Purpose of Data	Estimation of soil organic carbon stocks lost following mangrove loss.
Comments	N/A

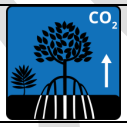
Data/Parameter	
Units	%
Description	Percentage of above-ground woody biomass carbon stocks that would be lost due to each driver of deforestation.
Equations	1
Source	Default values in Annex One, forest inventories, FRELs, peer-reviewed values from the jurisdiction where the *Project Area* is located.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Peer-reviewed dataset incorporating field data from locations across the tropics. Established, accessible approaches for defining loss of above-ground carbon stocks, in line with IPCC good practice guidance.
Purpose of Data	Estimation of above-ground woody biomass stocks lost following mangrove loss.
Comments	N/A

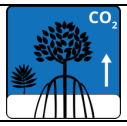
Data/Parameter	
Units	%
Description	Percentage of below-ground woody biomass carbon stocks that would be lost due to each driver of deforestation.
Equations	2
Source	Default values in Annex One, forest inventories, FRELs, peer-reviewed values from the jurisdiction where the *Project Area* is located.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Peer-reviewed dataset incorporating field data from locations across the tropics. Established, accessible approaches for defining loss of below-ground carbon stocks, in line with IPCC good practice guidance.
Purpose of Data	Estimation of below-ground woody biomass stocks lost following mangrove loss.
Comments	N/A

Data/Parameter	

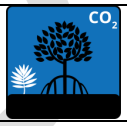
Units	%
Description	Percentage of soil organic carbon stocks that would be lost due to each driver of deforestation.
Equations	3
Source	Default values in Annex One, forest inventories, FRELs, peer-reviewed values from the jurisdiction where the *Project Area* is located.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Peer-reviewed dataset incorporating field data from locations across the tropics. Established, accessible approaches for defining loss of soil organic carbon stocks, in line with IPCC good practice guidance.
Purpose of Data	Estimation of above-ground woody biomass stocks lost following mangrove loss.
Comments	N/A

Data/Parameter	
Units	tCO_2e/ha
Description	CO_2 Emission Factor for the above-ground woody biomass *Carbon Pool* due to each driver of deforestation in each Zone.
Equations	1, 5, 17, 24, 31
Source	Calculated by Equation 1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Standard carbon accounting, in line with IPCC good practice guidance.
Purpose of Data	Estimation of above-ground woody biomass stocks lost following mangrove loss.
Comments	N/A

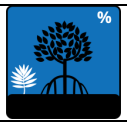
Data/Parameter	
Units	tCO_2e/ha
Description	CO_2 Emission Factor for the below-ground woody biomass *Carbon Pool* due to each driver of deforestation in each Zone.
Equations	2, 7, 19, 26, 33
Source	Calculated by Equation 2.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Standard carbon accounting, in line with IPCC good practice guidance.
Purpose of Data	Estimation of below-ground woody biomass stocks lost following mangrove loss.
Comments	N/A

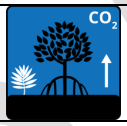
Data/Parameter	
Units	tCO_2e/ha
Description	CO_2 Emission Factor for the soil organic carbon pool due to each driver of deforestation in each Zone.
Equations	3, 8, 20, 27, 34
Source	Calculated by Equation 3.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Standard carbon accounting, in line with IPCC good practice guidance.
Purpose of Data	Estimation of soil organic carbon stocks lost following mangrove loss.
Comments	N/A

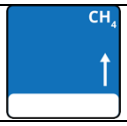
Data/Parameter	
Units	Years
Description	The time period over which emissions from the soil organic carbon pool will occur after deforestation due to each driver of deforestation in each Zone.
Equations	8, 20, 27, 39
Source	Default value or peer-reviewed field data or values derived from the jurisdiction within which the *Project Area* is located.
Value	Default = 5 years
Justification of choice of data or description of measurement methods and procedures applied	Standard carbon accounting, in line with IPCC good practice guidance.
Purpose of Data	Estimation of soil organic carbon stocks lost following mangrove loss.
Comments	N/A

Data/Parameter	
Units	tCO_2e/ha
Description	Carbon stock in the above-ground non-woody biomass *Carbon Pool* in each Zone.
Equations	N/A
Source	Forest inventories, FRELs, peer-reviewed values from the jurisdiction where the *Project Area* is located.
Value	Default = 0 tCO_2e/ha
Justification of choice of data or description of measurement methods and procedures applied	Established, accessible approaches for defining above-ground carbon stocks, in line with IPCC good practice guidance.

Purpose of Data	Estimation of above-ground non-woody biomass stocks lost following mangrove loss.
Comments	N/A

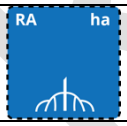
Data/Parameter	
Units	%
Description	Percentage of above-ground non-woody biomass carbon stocks that would be lost due to each driver of deforestation.
Equations	N/A
Source	Forest inventories, FRELs, peer-reviewed values from the jurisdiction where the *Project Area* is located.
Value	Default = 0 tCO_2e/ha
Justification of choice of data or description of measurement methods and procedures applied	Established, accessible approaches for defining above-ground carbon stocks, in line with IPCC good practice guidance.
Purpose of Data	Estimation of above-ground non-woody biomass stocks lost following mangrove loss.
Comments	N/A

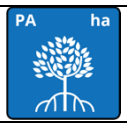
Data/Parameter	
Units	tCO_2e/ha
Description	CO_2 Emission Factor for the above-ground woody biomass *Carbon Pool* due to each driver of deforestation.
Equations	6, 18, 25, 32
Source	Forest inventories, FRELs, peer-reviewed values from the jurisdiction where the *Project Area* is located.
Value	Default = 0 tCO_2e/ha
Justification of choice of data or description of measurement methods and procedures applied	Established, accessible approaches for defining above-ground carbon stocks, in line with IPCC good practice guidance.
Purpose of Data	Estimation of above-ground non-woody biomass stocks lost following mangrove loss.
Comments	N/A

Data/Parameter	
Units	$tCO_2e/ha/year$
Description	The difference between the annual per-hectare emissions due to Soil Methanogenesis in the post-deforestation land use and the annual per-hectare emissions due to Soil Methanogenesis in intact Mangroves.
Equations	10, 22, 29, 44, 46

Source	Field-collected data, peer-reviewed published data, IPCC Guidelines for National Greenhouse Gas Inventories.
Value	If drivers of mangrove loss do not lead to wetland draining and the salinity low point is above 18ppt then = 0 tCO_2e/ha/year.
Justification of choice of data or description of measurement methods and procedures applied	In line with IPCC good practice guidance.
Purpose of Data	Estimation of emissions due to methanogenesis due to project activities.
Comments	N/A

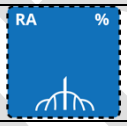
Data/Parameter	
Units	ha
Description	Area of forest in the Reference Area at the start of the Reference Period. To be provided for each Zone.
Equations	4
Source	Land cover maps; Global Mangrove Watch; Global Forest Watch.
Value	N/A.
Justification of choice of data or description of measurement methods and procedures applied	Mapping guidance follows best practice. Global Mangrove Watch is an established global dataset with an estimated mapping accuracy of 87.4% (95th conf. int.: 86.2–88.6%).
Purpose of Data	Activity data generation.
Comments	A_{RR} in PT002

Data/Parameter	
Units	ha
Description	Area of forest deforested in the Reference Area during the 10-year Reference Period. To be provided for each Zone.
Equations	4
Source	Land cover maps; Global Mangrove Watch; Global Forest Watch.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Mapping guidance follows best practice. Global Mangrove Watch is an established global dataset with an estimated mapping accuracy of 87.4% (95th conf. int.: 86.2–88.6%).
Purpose of Data	Activity data generation.
Comments	A_{Def} in PT002.

Data/Parameter	
Units	ha

Description	Area of Mangrove Forest in the *Project Area* at the start of the *Verification Period*. To be provided for each Zone of the *Project Area*.
Equations	5-8, 10, 17-20, 22
Source	Land cover maps; Global Mangrove Watch
Value	N/A.
Justification of choice of data or description of measurement methods and procedures applied	Mapping guidance follows best practice. Global Mangrove Watch is an established global dataset with an estimated mapping accuracy of 87.4% (95th conf. int.: 86.2–88.6%).
Purpose of Data	Activity data generation.
Comments	A_{PA} in PT002

Data/Parameter	
Units	ha
Description	Area of Mangrove Forest in the Leakage Area at the start of the *Verification Period*. To be provided for each Zone of the Leakage Area.
Equations	46
Source	Land cover maps; Global Forest Watch
Value	N/A.
Justification of choice of data or description of measurement methods and procedures applied	Mapping guidance follows best practice.
Purpose of Data	Activity data generation.
Comments	A_{LA} in PT002

Data/Parameter	
Units	ha
Description	Average proportion of the Mangroves in each Zone of the Reference Area that was deforested in each year of the Reference Period
Equations	4-8, 10
Source	Land cover maps; Global Mangrove Watch; Global Forest Watch.
Value	N/A.
Justification of choice of data or description of measurement methods and procedures applied	Mapping guidance follows best practice. Global Mangrove Watch is an established global dataset with an estimated mapping accuracy of 87.4% (95th conf. int.: 86.2–88.6%).
Purpose of Data	Activity data generation.
Comments	D_{RR} in PT002

Data/Parameter	
Units	Unitless

Description	An estimate of expected effectiveness of project activities in reducing emissions from Mangrove deforestation, expressed as a proportion of baseline scenario emissions that can conservatively be expected to be avoided as a result of project activities (0-1, with 0 being completely ineffective and 1 being completely effective)
Equations	12
Source	Justified estimation.
Value	Between 0-1
Justification of choice of data or description of measurement methods and procedures applied	Projects must clearly explain and justify the assumptions.
Purpose of Data	Estimating project effectiveness in preventing GHG emissions.
Comments	F in PT002

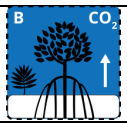
Data/Parameter	
Units	Unitless
Description	An estimate of expected emissions from deforestation that result from displacement of activities from the *Project Area* to areas outside the *Project Area*, as a result of project activities. Expressed as a proportion of *Carbon Benefits* that are expected to be lost because of leakage (0-1, with 0 meaning all *Carbon Benefits* will be lost due to leakage and 1 meaning no *Carbon Benefits* will be lost due to leakage).
Equations	14-15
Source	Justified estimation.
Value	Between 0-1
Justification of choice of data or description of measurement methods and procedures applied	Projects must clearly explain and justify the assumptions.
Purpose of Data	Estimating project effectiveness in preventing GHG emissions due to leakage.
Comments	L in PT002

Data/Parameter	
Units	tCO_2e
Description	Expected baseline CO_2 emissions in the aboveground woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	5, 9
Source	See Section 5.6.2.1.
Value	N/A
Justification of choice of data or description of	See Section 5.6.2.1.

measurement methods and procedures applied	
Purpose of Data	Estimating expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

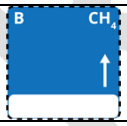
Data/Parameter	
Units	tCO_2e
Description	Expected baseline CO_2 emissions in the aboveground non-woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	6, 9
Source	See Section 5.6.2.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.2.1.
Purpose of Data	Estimating expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

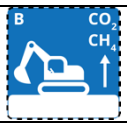
Data/Parameter	
Units	tCO_2e
Description	Expected baseline CO_2 emissions in the belowground woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	7, 9
Source	See Section 5.6.2.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.2.1.
Purpose of Data	Estimating expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Expected baseline CO_2 emissions in the soil organic carbon pool in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	8-9

Source	See Section 5.6.2.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.2.1.
Purpose of Data	Estimating expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

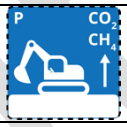
Data/Parameter	
Units	tCO_2e
Description	Total expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	9, 12, 14
Source	See Section 5.6.2.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.2.1.
Purpose of Data	Estimating expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total expected baseline emissions due to methanogenesis in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	10
Source	See Section 5.6.2.2.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.2.2.
Purpose of Data	Estimating expected baseline emissions from the *Emission Sources*.
Comments	N/A

Data/Parameter	
Units	tCO_2e

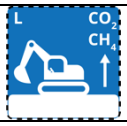
Description	Total expected baseline emissions from all emission sources in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	11, 15
Source	See Section 5.6.2.2.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.2.2.
Purpose of Data	Estimating expected baseline emissions from the *Emission Sources*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total expected project CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	12, 14
Source	See Section 5.6.3.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.3.1.
Purpose of Data	Estimating expected project CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total expected project emissions from all emission sources in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	13, 15
Source	See Section 5.6.3.2.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.3.2.
Purpose of Data	Estimating expected project emissions from the *Emission Sources*.
Comments	N/A

Data/Parameter	

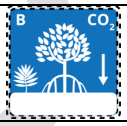
Units	tCO_2e
Description	Total potential CO_2 emissions from the Vegetation and Soil *Carbon Pools* due to leakage from each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	14
Source	See Section 5.6.4.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.4.1.
Purpose of Data	Estimating expected CO_2 emissions due to leakage.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total potential emissions from all emission sources due to leakage from each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	15
Source	See Section 5.6.4.2.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.4.2.
Purpose of Data	Estimating expected CO_2 emissions due to leakage.
Comments	N/A

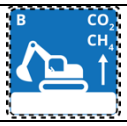
Data/Parameter	
Units	tCO_2e
Description	Total expected baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.6.5.
Value	0
Justification of choice of data or description of measurement methods and procedures applied	The applicability conditions of this module exclude projects that may lead to baseline CO_2 removals.
Purpose of Data	Estimating expected baseline CO_2 removals.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total expected project CO_2 removals in the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.6.5.
Value	0
Justification of choice of data or description of measurement methods and procedures applied	It is conservative to exclude CO_2 removals in the project scenario.
Purpose of Data	Estimating expected project CO_2 removals.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total expected baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.6.6.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.6.
Purpose of Data	Estimating total expected emissions and removals across all Zones.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total expected baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.6.6.
Value	0
Justification of choice of data or description of measurement methods and procedures applied	The applicability conditions of this module exclude projects that may lead to baseline CO_2 removals.
Purpose of Data	Estimating total expected emissions and removals across all Zones.

Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total expected baseline CO_2 emissions from all emission sources across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.6.6.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.6.
Purpose of Data	Estimating total expected emissions and removals across all Zones.
Comments	N/A

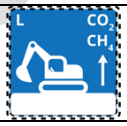
Data/Parameter	
Units	tCO_2e
Description	Total expected project CO_2 emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.6.6.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.6.
Purpose of Data	Estimating total expected emissions and removals across all Zones.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total expected baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.6.6.
Value	0
Justification of choice of data or description of	It is conservative to exclude CO_2 removals in the project scenario.

measurement methods and procedures applied	
Purpose of Data	Estimating total expected emissions and removals across all Zones.
Comments	N/A

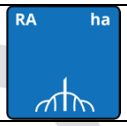
Data/Parameter	
Units	tCO_2e
Description	Total expected project CO_2 emissions from all emission sources across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.6.6.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.6.
Purpose of Data	Estimating total expected emissions and removals across all Zones.
Comments	N/A

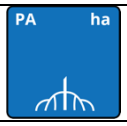
Data/Parameter	
Units	tCO_2e
Description	Total potential CO_2 emissions from the Vegetation and Soil *Carbon Pools* due to leakage across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.6.6.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.6.
Purpose of Data	Estimating total expected emissions and removals across all Zones.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total potential emissions from all emission sources due to leakage across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.6.6.
Value	N/A

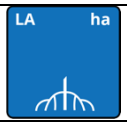
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.6.6.
Purpose of Data	Estimating total expected emissions and removals across all Zones.
Comments	N/A

Data/Parameter	
Units	ha
Description	Area of forest in the Reference Area at the start of the *Verification Period*. To be provided for each Zone.
Equations	16
Source	Land cover maps; Global Mangrove Watch; Global Forest Watch.
Value	N/A.
Justification of choice of data or description of measurement methods and procedures applied	Mapping guidance follows best practice. Global Mangrove Watch is an established global dataset with an estimated mapping accuracy of 87.4% (95th conf. int.: 86.2–88.6%).
Purpose of Data	Activity data generation.
Comments	AA_{RR} in PT002

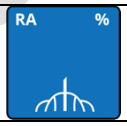
Data/Parameter	
Units	ha
Description	Area of forest deforested in the Reference Area during the *Verification Period*. To be provided for each Zone.
Equations	16
Source	Land cover maps; Global Mangrove Watch; Global Forest Watch.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Mapping guidance follows best practice. Global Mangrove Watch is an established global dataset with an estimated mapping accuracy of 87.4% (95th conf. int.: 86.2–88.6%).
Purpose of Data	Activity data generation.
Comments	AA_{Def} in PT002.

Data/Parameter	
Units	ha
Description	Area of forest deforested in the *Project Area* during the *Verification Period*. To be provided for each Zone in the *Project Area*.
Equations	24-27, 29
Source	Land cover maps; Global Mangrove Watch; Global Forest Watch.
Value	N/A

Justification of choice of data or description of measurement methods and procedures applied	Mapping guidance follows best practice. Global Mangrove Watch is an established global dataset with an estimated mapping accuracy of 87.4% (95th conf. int.: 86.2–88.6%).
Purpose of Data	Activity data generation.
Comments	D_{PA} in PT002.

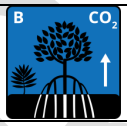
Data/Parameter	
Units	ha
Description	Area of forest deforested in the Leakage Area during the *Verification Period*. To be provided for each Zone in the Leakage Area.
Equations	31-34, 36-39, 44
Source	Land cover maps; Global Mangrove Watch; Global Forest Watch.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	Mapping guidance follows best practice. Global Mangrove Watch is an established global dataset with an estimated mapping accuracy of 87.4% (95th conf. int.: 86.2–88.6%).
Purpose of Data	Activity data generation.
Comments	D_{LA} in PT002.

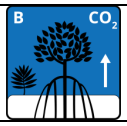
Data/Parameter	
Units	Years
Description	Length of the *Verification Period*.
Equations	16, 24-27, 29, 31-34, 44
Source	See Section 5.8.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.8.
Purpose of Data	Activity data generation.
Comments	D_{LA} in PT002.

Data/Parameter	
Units	ha
Description	Average proportion of the Mangroves in each Zone of the Reference Area that was deforested in each year of the *Verification Period*.
Equations	16-20, 22, 36-39, 46
Source	Land cover maps; Global Mangrove Watch; Global Forest Watch.
Value	N/A.

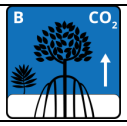
Justification of choice of data or description of measurement methods and procedures applied	Mapping guidance follows best practice. Global Mangrove Watch is an established global dataset with an estimated mapping accuracy of 87.4% (95th conf. int.: 86.2–88.6%).
Purpose of Data	Activity data generation.
Comments	AD_{RR} in PT002

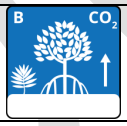
Data/Parameter	
Units	tCO_2e
Description	Actual baseline CO_2 emissions in the aboveground woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	17, 21
Source	See Section 5.9.1.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.1.1.
Purpose of Data	Estimating actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

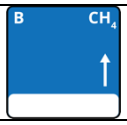
Data/Parameter	
Units	tCO_2e
Description	Actual baseline CO_2 emissions in the aboveground non-woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	18, 21
Source	See Section 5.9.1.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.1.1.
Purpose of Data	Estimating actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

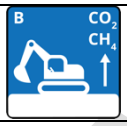
Data/Parameter	
Units	tCO_2e

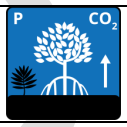
Description	Actual baseline CO_2 emissions in the belowground woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	19, 21
Source	See Section 5.9.1.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.1.1.
Purpose of Data	Estimating actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Actual baseline CO_2 emissions in the soil organic carbon pool in each Zone of the *Project Area* (tCO_2e) for each year of the *Verification Period*.
Equations	20-21
Source	See Section 5.9.1.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.1.1.
Purpose of Data	Estimating actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

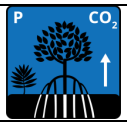
Data/Parameter	
Units	tCO_2e
Description	Total actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	21
Source	See Section 5.9.1.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.1.1.
Purpose of Data	Estimating actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

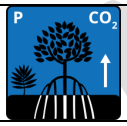
Data/Parameter	
Units	tCO_2e
Description	Total actual baseline emissions due to Soil Methanogenesis in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	22-23
Source	See Section 5.9.1.2.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.1.2.
Purpose of Data	Estimating actual baseline emissions from the *Emission Sources*.
Comments	N/A

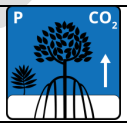
Data/Parameter	
Units	tCO_2e
Description	Total actual baseline emissions from all emission sources in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	23
Source	See Section 5.9.1.2.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.1.2.
Purpose of Data	Estimating actual baseline emissions from the *Emission Sources*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Actual project CO_2 emissions in the aboveground woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	24, 28
Source	See Section 5.9.2.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.2.1.
Purpose of Data	Estimating actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools*.

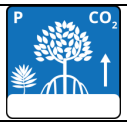
Comments	N/A

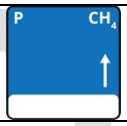
Data/Parameter	
Units	tCO_2e
Description	Actual project CO_2 emissions in the aboveground non-woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	25, 28
Source	See Section 5.9.2.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.2.1.
Purpose of Data	Estimating actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

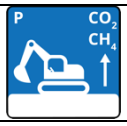
Data/Parameter	
Units	tCO_2e
Description	Actual project CO_2 emissions in the belowground woody biomass *Carbon Pool* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	26, 28
Source	See Section 5.9.2.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.2.1.
Purpose of Data	Estimating actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Actual project CO_2 emissions in the soil organic carbon pool in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	27-28
Source	See Section 5.9.2.1.
Value	N/A
Justification of choice of data or description of	See Section 5.9.2.1.

measurement methods and procedures applied	
Purpose of Data	Estimating actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	28
Source	See Section 5.9.2.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.2.1.
Purpose of Data	Estimating actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual project emissions due to Soil Methanogenesis in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	29-30
Source	See Section 5.9.2.2.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.2.2.
Purpose of Data	Estimating actual project CO_2 emissions from the *Emission Sources*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual project emissions from all emission sources in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	30
Source	See Section 5.9.2.2.
Value	N/A

Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.2.2.
Purpose of Data	Estimating actual project CO_2 emissions from the *Emission Sources*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Actual CO_2 emissions in the aboveground woody biomass *Carbon Pool* in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	31, 35
Source	See Section 5.9.3.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.1.
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Actual CO_2 emissions in the aboveground non-woody biomass *Carbon Pool* in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	32, 35
Source	See Section 5.9.3.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.1.
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e

Description	Actual CO_2 emissions in the belowground biomass *Carbon Pool* in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	33, 35
Source	See Section 5.9.3.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.1.
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Actual project CO_2 emissions in the soil organic carbon pool in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	34-35
Source	See Section 5.9.3.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.1.
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	35, 41
Source	See Section 5.9.3.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.1.
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Expected CO_2 emissions in the aboveground woody biomass *Carbon Pool* in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	36, 40
Source	See Section 5.9.3.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.1.
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Expected CO_2 emissions in the aboveground non-woody biomass *Carbon Pool* in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	37, 40
Source	See Section 5.9.3.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.1.
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Expected CO_2 emissions in the belowground biomass *Carbon Pool* in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	38, 40
Source	See Section 5.9.3.1.
Value	N/A
Justification of choice of data or description of	See Section 5.9.3.1.

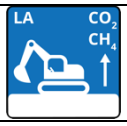
measurement methods and procedures applied	
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Expected project CO_2 emissions in the soil organic carbon pool in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	39-40
Source	See Section 5.9.3.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.1.
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

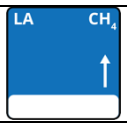
Data/Parameter	
Units	tCO_2e
Description	Total expected project CO_2 emissions from the Vegetation and Soil *Carbon Pools* in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	40-41
Source	See Section 5.9.3.1.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.1.
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual CO_2 emissions from the Vegetation and Soil *Carbon Pools* due to leakage in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	41

Source	See Section 5.9.3.2.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.2.
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

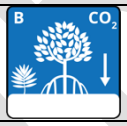
Data/Parameter	
Units	tCO_2e
Description	Total actual emissions from all emission sources in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	42, 45, 48
Source	See Section 5.9.3.3.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.3.
Purpose of Data	Estimating actual leakage emissions from the Vegetation and Soil *Carbon Pools*.
Comments	N/A

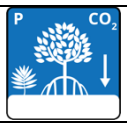
Data/Parameter	
Units	tCO_2e
Description	Total expected emissions from emission sources that would have occurred in each Zone of the Leakage Area during each year of the *Verification Period*.
Equations	43, 47, 48
Source	See Section 5.9.3.3.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.3.
Purpose of Data	Estimating actual leakage emissions from emission sources.
Comments	N/A

Data/Parameter	
Units	tCO_2e

Description	Actual emissions due to Soil Methanogenesis in each Zone of the Leakage Area for each year of the *Verification Period*.
Equations	44-45
Source	See Section 5.9.3.3.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.3.
Purpose of Data	Estimating actual leakage emissions from emission sources.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Expected emissions from Soil Methanogenesis that would have occurred in each Zone of the Leakage Area during each year of the *Verification Period*.
Equations	46-47
Source	See Section 5.9.3.3.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.3.3.
Purpose of Data	Estimating actual leakage emissions from emission sources.
Comments	N/A

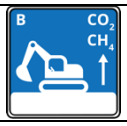
Data/Parameter	
Units	tCO_2e
Description	Total actual baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.9.4.
Value	0
Justification of choice of data or description of measurement methods and procedures applied	The applicability conditions of this module exclude projects that may lead to baseline CO_2 removals.
Purpose of Data	Estimating actual baseline CO_2 removals.
Comments	N/A

Data/Parameter	

Units	tCO_2e
Description	Total actual project CO_2 removals in the Vegetation and Soil *Carbon Pools* in each Zone of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.9.4.
Value	0
Justification of choice of data or description of measurement methods and procedures applied	It is conservative to exclude CO_2 removals in the project scenario.
Purpose of Data	Estimating actual project CO_2 removals.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual baseline CO_2 emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.9.5.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.5.
Purpose of Data	Estimating total actual emissions and removals across all Zones.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.9.5.
Value	0
Justification of choice of data or description of measurement methods and procedures applied	The applicability conditions of this module exclude projects that may lead to baseline CO_2 removals.
Purpose of Data	Estimating total actual emissions and removals across all Zones.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual baseline CO_2 emissions from all emission sources across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.9.5.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.5.
Purpose of Data	Estimating total actual emissions and removals across all Zones.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual project CO_2 emissions from the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.9.5.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.5.
Purpose of Data	Estimating total actual emissions and removals across all Zones.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual baseline CO_2 removals in the Vegetation and Soil *Carbon Pools* across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.9.5.
Value	0
Justification of choice of data or description of measurement methods and procedures applied	It is conservative to exclude CO_2 removals in the project scenario.
Purpose of Data	Estimating total actual emissions and removals across all Zones.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual project CO_2 emissions from all emission sources across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.9.5.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.5.
Purpose of Data	Estimating actual expected emissions and removals across all Zones.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual CO_2 emissions from the Vegetation and Soil *Carbon Pools* due to leakage across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.9.5.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.5.
Purpose of Data	Estimating total actual emissions and removals across all Zones.
Comments	N/A

Data/Parameter	
Units	tCO_2e
Description	Total actual emissions from all emission sources due to leakage across all Zones of the *Project Area* for each year of the *Verification Period*.
Equations	N/A
Source	See Section 5.9.5.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.9.5.
Purpose of Data	Estimating total actual emissions and removals across all Zones.

Comments	N/A

Data/Parameter	
Units	Unitless
Description	The actual effectiveness of project activities in reducing emissions from Mangrove deforestation, expressed as a proportion of baseline scenario emissions that were likely avoided as a result of project activities (0-1, with 0 being completely ineffective and 1 being completely effective).
Equations	49
Source	Justified estimation.
Value	Between 0-1
Justification of choice of data or description of measurement methods and procedures applied	Projects must clearly explain and justify the assumptions.
Purpose of Data	Estimating project effectiveness in preventing GHG emissions.
Comments	F in PT002

7 References

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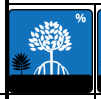
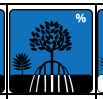
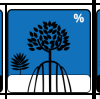
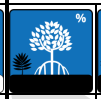
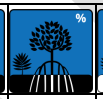
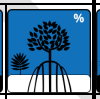
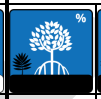
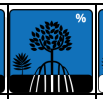
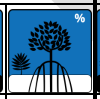
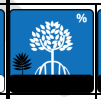
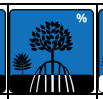
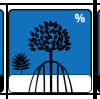
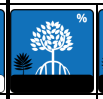
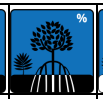
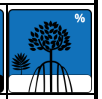
Annex One

The default values for the percentage of the carbon stocks in the aboveground woody biomass, belowground biomass and soil organic carbon pools that is lost following Mangrove deforestation due to the drivers listed in Section 5.1, according to the marine province[27]. These values are adapted from Adame et al., 2021[28], who in turn reference Sasmito et al., 2019[29].

Marine Province	Agriculture/ Aquaculture			Clearing for wood/charcoal			Erosion			Extreme climate			Settlement		
															
Agulhas	0.83	0.83	0.52	0.70	0.70	0.21	1	1	1	0.31	0.31	0.14	1	1	0.66
Andaman	0.90	0.90	0.27	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
Bay of Bengal	0.83	0.83	0.52	0.70	0.70	0.33	1	1	1	0.31	0.31	0.14	1	1	0.66
East Central Australian Shelf	0.83	0.83	0.52	0.70	0.70	0.33	1	1	1	0.31	0.31	0.14	1	1	0.66
East Coral Triangle	0.83	0.83	0.52	0.70	0.70	0.33	1	1	1	0.31	0.31	0.14	1	1	0.66
Gulf of Guinea	0.83	0.83	0.52	0.70	0.70	0.33	1	1	1	0.31	0.31	0.14	1	1	0.66
North Brazil Shelf	0.97	0.97	0.67	0.70	0.70	0.33	1	1	1	0.31	0.31	0.14	1	1	0.66
Northeast Australian Shelf	0.83	0.83	0.52	0.70	0.70	0.33	1	1	1	0.31	0.31	0.14	1	1	0.66
North New Zealand	0.83	0.83	0.52	1.00	1.00	0.33	1	1	1	0.31	0.31	0.14	1	1	0.66

[27] Marine Ecoregions of the World https://academic.oup.com/bioscience/article-abstract/57/7/573/238419?redirectedFrom=PDF. This tool can be used to establish which marine province(s) the project is in: https://planvivo.shinyapps.io/bluecarbontool/

[27] https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.15571#gcb15571-bib-0015

[28] https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.15571#gcb15571-bib-0015

[29] https://onlinelibrary.wiley.com/doi/10.1111/gcb.14774

Northwest Australian Shelf	0.83	0.83	0.52	0.70	0.70	0.33	1	1	1	0.31	0.31	0.14	1	1	0.66
Red Sea and Gulf of Aden	0.83	0.83	0.52	0.70	0.70	0.33	1	1	1	0.31	0.31	0.14	1	1	0.66
Sahul Shelf	0.90	0.90	0.27	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
Somali/Arabian	0.83	0.83	0.52	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
South China Sea	0.83	0.83	0.52	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
Southeast Australian Shelf	0.83	0.83	0.52	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
Southern New Zealand	0.83	0.83	0.52	1.00	1.00	0.60	1	1	1	0.31	0.31	0.14	1	1	0.66
Southwest Australian Shelf	0.83	0.83	0.52	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
Sunda Shelf	0.90	0.90	0.27	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
Tropical East Pacific	0.83	0.83	0.52	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
Tropical Northwestern Atlantic	0.76	0.76	0.46	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
Warm Temperate Northeast Pacific	0.83	0.83	0.52	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
Warm Temperate Southwestern Atlantic	0.97	0.97	0.67	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
West African Transition	0.83	0.83	0.52	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
West and South Indian Shelf	1.00	1.00	0.45	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
West Central Australian Shelf	0.83	0.83	0.52	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
Western Coral Triangle	0.90	0.90	0.27	0.88	0.88	0.45	1	1	1	0.31	0.31	0.14	1	1	0.66
Western Indian Ocean	0.83	0.83	0.52	0.70	0.70	0.21	1	1	1	0.31	0.31	0.14	1	1	0.66