T-VER-P-METH-13-04

Mangrove and Seagrass Restoration

Version 01

Sector: 14 –Afforestation and Reforestation

Entry into force on 1 March 2023

1. Methodology Title	Mangrove and Seagrass Restoration
2. Project Type	Reduction, absorption and removal of greenhouse gases from the forestry and agriculture sectors
3. Sector	Afforestation and reforestation
4. Project Outline	Greenhouse gas sequestration activities by increasing carbon stocks from projects related to the restoration of intertidal wetlands, including mangrove forests and sea grasses, that contribute to the increase in aboveground biomass, underground biomass and carbon in the soil. It includes the activities that contribute to the reduction of methane and nitrous oxide emissions in the area from increasing salinity and land use change, and the activities that contribute to the reduction of carbon dioxide emissions by avoiding the loss of soil organic carbon.
5. Applicability	1. The project area has a land use right certificate according to the law. 2. Project activities related to the restoration of wetlands in the tidal zone, including mangrove forests and sea grasses. And must fall into the scope of activities that have at least one of the following characteristics. 2.1 Mangrove plants or sea grass are planted. 2.2 Hydrological conditions are created, restored and/or managed e.g. Improvement of waterways, etc. 2.3 There is sediment supply such as dredging or redirecting sediment from the river to sediment-deficient areas, etc. 2.4 There is a change in salinity such as restoration of the area to cause tidal currents to enter the area, etc. 2.5 Water quality is improved, for example, reducing the amount of nutrients, and water turbidity to restore seagrass beds 3. The characteristics of the area prior to the project start date must meet one of the following conditions: The project proponent must demonstrate the nature of the area that can be examined through, such as laws and regulations,

	management plans, annual reports, annual accounts, and land use planning documents 3.1 The project area is free from other uses that can be moved outside the project area subject to one of the following conditions: (1) The project area is an area that has not been used for at least two years. before starting the project (2) The project area is an area where commercial profits cannot be generated, such as high salinity, low price, etc., however, there must not be logging in the baseline. (3) The project area must not cause degradation of other wetlands due to relocation to create new agricultural areas. 3.2 The project area is under other uses that can be moved outside the project area. Only the baseline greenhouse gas emissions will not be taken into account and will not cause the degradation of other wetlands to create new agricultural areas. 3.3 If the project area is under A utilization for sustenance or household utilization, such as searching for forest products. Such utilization of activities can continue in the project area throughout the credit period but there must be no increase in the volume of such activities. 4. The carbon dioxide reduction in the project area must have a significant difference between the total soil organic carbon from the project implementation and the baseline after 100 years according to the calculation tool *T-VER-P-TOOL-01-10 Methods for Stratification of the Project Area in Mangrove and Seagrass* 5. Activities that change the biomass of trees, such as cutting down trees as part of taking care of the area both in the baseline and from project activities can be done. 6. If there is a mangrove planting activity in the project area with organic soil, water must be brought into the area.

6. Project Conditions	1. Activity on Improved Forest Management (IFM) or it is an activity to reduce greenhouse gas emissions from deforestation and forest degradation. 2. No commercial logging in the baseline. 3. The project area is not below groundwater level (the project area is a submerged area), except for the project that changes the area from open sea to tidal wetland area or improvement of waterways to connect with water storage areas. 4. Project activities must not cause hydrological changes outside the project area. 5. Project activities must not use nitrogen fertilizers such as chemical fertilizers or manure in the project area during the credit period. 6. The project area can combine many areas together. 7. Project activities must be carried out in addition to those already required by law. However, it must not conflict with the laws related to the activities, except for the activities of government agencies, state enterprises and agencies under the supervision of the state.
7. Project starting date	Date of commencement of activities related to the restoration of wetlands according to the specified methodology, such as planting mangrove forests or sea grass, managing hydrological, sediment dredging, etc.
8. Remark	-

Definitions

Baseline	In business-as-usual greenhouse gas emission event
Rewetting	Annual increase in groundwater levels in drained wetlands
Alteration of hydrology	Change in mean elevation of water above ground changes in the frequency or duration of flood water entering an area during high tide.
Tidal wetland restoration	Creation or improvement of hydrology, salinity, water quality, sediment supply or vegetation in degraded or converted intertidal wetlands; including activities that create wetlands on land above sea level rise, activities that convert one wetland type to another, and those that convert open sea areas to wetlands.
Drainage	Areas with natural water levels below the annual average level due to rapid water loss or reduced water volumes resulting from both on- and off-site human activities and construction.
Soil disturbance	Human activities that result in the release of carbon stored in soil organic form into the atmosphere, such as tillage, digging, harrowing, trenching, and drainage.
Small scale project	Greenhouse gas reduction projects that can reduce or store greenhouse gases up to 16,000 tCO_2eq/year.
Large scale project	Greenhouse gas reduction projects that can reduce or store more than 16,000 tCO_2eq/year.
Salinity Average	The average salinity of the wetlands used shows variation in salinity over time of high CH_4 emission
Salinity Low Point	The minimum salinity of the wetlands used shows variation in salinity over time of high CH_4 emission

Organic Soils	Organic soil is soil that has various characteristics as specified by the FAO, which must have the characteristics in items 1 and 2 or items 1 and 3 as follows: (1) having a thickness of 10 centimeters or more Soil thickness < 20 cm. must contain organic carbon of 12% or more. Where soil mixing reaches a depth of 20 cm. (2) In case the soil has never been saturated with water for more than 2-3 days and has >20% by weight of organic carbon in the soil (approximately 35% of organic matter in the soil). (3) In case the soil is saturated with water and (i) (approximately 20% organic matter) here the soil does not contain clay minerals, or (ii) (approximately 30% organic matter content) Where the soil contains 60% or more of clay minerals, or (iii) Moderate soil organic carbon for clay minerals with moderate levels. Area data should be classified according to climatic zones, i.e. temperate and humid tropics. and classified by soil fertility for temperate forest areas organic soil area information may be compiled from the country's official statistical data or the organic soil area of each country reported by the FAO. (http://faostat.fao.org/) Source of information: 2006 IPCC Guidelines (Vol. 4 Chapter 3)
Mineral soil	Soils that do not fall within the definition of organic soils.
Open Water	Areas where the water level is at the ground level, not above the water during low tide.
Mangrove	Wetland with predominantly mangrove vegetation, both shrubs and perennials. It grows in salt water along the coast or in brackish water areas.
Impounded water	Water storage caused by dams or wells

Wetland	(1) Naturally occurring wetlands in the land (Inland wetlands): creeks, marshes, canals, lagoons, ponds, reservoir, rivers, streams, tributaries, streamlet, canal banks, banks, streams, ponds, lakes, basins, basins, lake, fields, lake, marshland, freshwater swamp forest, bog, waterfall, rapids (2) human-made wetlands, such as dams, reservoirs, rice fields, salt fields, permanent and temporary flooding, agricultural farming, aquaculture farming, or various water canals (3) marine and coastal wetlands (Marine/coastal wetlands) means coastal areas in the area include islands, rocky beaches, sandy beaches, mudflats, mudflats, seashores, rock formations, coral reefs, seagrass, bays, delta, estuaries, swamp forests, mangroves, and forests.
Tidal wetland	Wetlands under the influence of tidal currents (e.g., wet marshes, forests in floodplain areas seagrass and mangrove forests),
Degraded tidal wetland	Wetlands affected by humans or nature cause physical, chemical or biological changes that affect the diversity of life. Decreased soil carbon content or the complexity of the ecosystem's role.
Water table depth	Depth of water in the soil or above the soil relative to the soil surface.
Strat date	The date on which the project developer commences physical activities such as making an agreement to conserve the project area, or cash receipt.
Seagrass meadow	An accumulation of seagrass plants over a mappable area
Allochthonous Soil Organic Carbon	Soil organic carbon originating outside the project area and being deposited in the project area
Autochthonous Soil Organic Carbon	Soil organic carbon originating or forming in the project area (e.g., from local vegetation)

Carbon Preservation Depositional Environment (CPDE)	A type of precipitation environment that affects the amount of organic carbon retained by precipitation. Carbon sequestration is affected by the size of the sediment, water oxygen content, sediment accumulation rates, burial rates, and sediment hydraulic conductivity.
Deltaic Fluidized Mud	One type of Carbon Preservation Depositional Environment (CPDE) caused by sediment accumulation rates Source: More than 0.4 g/cm2 per year in the delta consisting primarily of fluidized (unconsolidated) small sediments. The ground surface may be disturbed by waves or tides. But it can also store organic matter that will precipitate, for example, in the Amazon and Mississippi deltas.
Extreme Accumulation Rate	Carbon Preservation Depositional Environment (CPDE), a kind of sediment accumulation rates Source: more than 1 gram per square centimeter per year This results in the accumulation of sediment that precipitates rapidly and over a long period of time. Ganges-Brahmaputra and Rhone River deltas
Mudflat	A type of tidal wetland with a soft substrate and almost not appear on the surface.
Normal marine	One type of Carbon Preservation Depositional Environment (CPDE) that does not meet the other definitions is deltaic fluidized mud, extreme accumulation rate, oxygen depletion zone or small mountainous river. Normal marine environments typically have low sedimentation rates and oxygen content. in the water mass above ground.
Oxygen (O_2) Depletion Zone	Carbon Preservation Depositional Environment (CPDE), a type of low oxygen content in the aboveground water mass due to limited water circulation or poor water quality results in hypoxic or anaerobic conditions (euxinic and semi-euxinic).

Small Mountainous River	Carbon Preservation Depositional Environment (CPDE), a type in which sediments come from small mountain rivers. They can be found along tectonically active margins and small steep gradients with sediment accumulation rates greater than 0.27 g/cm^2 per year, for example, in rivers in Taiwan, and the Eel River (California).
Document or certificate of land use rights	Documents showing rights to use the land according to the law, such as a land title deed (Nor. Sor 4), a certificate of utilization (Nor Sor 3) or a land use authorization letter from the relevant government agency, etc.

In addition to the definitions contained in this document, Use definitions consistent with definitions in the T-VER, CDM and IPCC Guidelines.

T-VER Methodology for Mangrove and Seagrass Restoration

1. Scope of Project

1.1 Operational characteristics

Implementation of mangrove and seagrass restoration projects are activities that contribute to the carbon storage capacity of the project area. This includes the nature of activities such as creation, restoration and/or management of hydrological conditions, sediment supply change in salinity water quality improvement, mangrove planting or seagrass and/or area management development

1.2 Scope of project

The project developer must specify the project location, its coordinates, locations and details of the area where the project will be carried out in detail, along with presenting a letter showing the land rights according to the law. The scope of the project will not change throughout the life of the project.

2. Selection of carbon sources and greenhouse gases used for calculation

2.1 Source of carbon and greenhouse gases used in calculation

Carbon pools	Selected	Explanation
Aboveground biomass: ABG	Yes	This is the carbon pool subjected to project activity that calculated from tree and sapling biomass stored in stems, branches and leaves for mangrove forests. and calculated from the biomass of leaves and stems of seagrass for seagrass sites.
Belowground biomass: BLG	Yes	This is the carbon pool subjected to project activity that calculated from the biomass of trees and saplings stored in above-ground roots, a underground roots for mangrove forests, and calculated from the

Carbon pools	Selected	Explanation
		biomass of the underground stalks and roots of seagrass for seagrass sites.
Dead wood: DW	Optional	It is a carbon deposit that may occur from project activities calculated from the dry weight of dead wood in the project area.
Litter: LI	No	Litter are circulated in and out of the project area according to the tide. In accordance with conservation principles, the increase in biomass from plant residues will not be assessed.
Soil organic carbon	Yes	It is a carbon deposit that may occur from project activities.

2.2 Source and type of greenhouse gas emission used in calculation

Sources	Greenhouse gas	Selected	Explanation
Emission of methane from soil microorganisms	CH_4	Yes	can be omitted in the baseline and it may be the main source of greenhouse gas emissions in the implementation of projects that cause salinity changes in the area.
Nitrous oxide emissions from the denitrification or nitrification process	N_2O	Yes	can be omitted in the baseline and there may be an increase in greenhouse gas emissions from the implementation of projects that cause changes in the water level in the area.
Burning of woody biomass	CO_2	No	CO_2 emissions from burned biomass assessed from changes in carbon content
	CH_4	Yes	Burning from site preparation and other activities in the management of planted forests must also be taken into account

Sources	Greenhouse gas	Selected	Explanation
			in the calculation of greenhouse gas emissions.
	N_2O	Yes	Burning from site preparation and other activities in the management of planted forests must also be taken into account in the calculation of greenhouse gas emissions.
Use of fossil fuel	CO_2	Yes	It is the main source of greenhouse gas emissions from the use of fuel for machinery or earthmoving engines in large project activities.

3. Identification of baseline scenario and demonstration of additionality

The project developer must prepare information on land use patterns in the project area before project start date in order to determine the baseline scenario that is suitable for the project. by using the calculation tool *T-VER-P-Tool-01-01 Combined tool to identify the baseline scenario and demonstrate additionality in forest project activities*.

4. Stratification

If the total project area is heterogeneous, stratification is required to make the GHG capture assessment more accurate.

- To assess the net GHG removal of the baseline can be stratified by soil type, soil depth, vegetation types and their crown cover, water depth, salinity, type of land use (e.g., open sea areas, canals, bare sand areas, muddy beaches, etc.), or areas where these characteristics have changed.
- For forecasting net GHG removal from activities, can be stratified according to the planning of forest planting and management.
- For assessing net GHG capture from activities (post-project implementation), the stratification is based on afforestation and forest management operations. In case the project is affected by natural or man-made disasters such as rising sea level and coastal

erosion, which will change the trend of carbon storage from biomass or carbon storage in the soil of the project. It is necessary to re-stratification the stratum according to the situation.

The stratification can be carried out using the calculation tool *T-VER-P-TOOL-01-10 Methods for Stratification of the Project Area in Mangrove and Seagrass*

5. Baseline net GHG removals by sinks

The net GHG removal by sink of the baseline can be calculated as follows:

Equation 1

$$GHG_{BSL\_MSR,t} = \Delta C_{BSL,t} - GHG_{BSL,t}$$

$GHG_{BSL,t}$ = Baseline net greenhouse gas removals by sinks in year t (tCO_2eq)

$\Delta C_{BSL,t}$ = Change in the carbon stocks in baseline in year t (tCO_2eq)

$GHG_{BSL,t}$ = Baseline net greenhouse gas removals by sinks in year t (tCO_2eq)

5.1 Calculation of the change in net GHG removal by sink of the baseline

The net GHG storage change quantification of the baseline is determined from tree biomass. In the case of mangrove forests, biomass in trees is mainly considered, for the biomass in sapling and dead wood will be an alternative. In the case of seagrass, biomass of seagrass is considered as an alternative and consider the amount of change in soil carbon sequestration as an alternative by quantifying the change in GHG removal by sink of the baseline from selected carbon pools in the year t in which the monitoring was performed. can be calculated as follows:

Equation 2

$$\Delta C_{BSL,t} = \Delta C_{BSL\_TREE,t} + \Delta C_{BSL\_SAP,t} + \Delta C_{BSL\_SEAGRASS,t} + \Delta C_{BSL\_DEADWOOD,t} + \Delta SOC_{BSL,t}$$

Where

$\Delta C_{BSL,t}$ = Change in the carbon stocks in the baseline in year t (tCO_2eq)

$\Delta C_{BSL\_TREE,t}$ = Change in the carbon stocks in tree biomass in the baseline in year t (tCO_2eq/y) and calculate according to *T-VER-P-TOOL-01-02 Calculation for carbon stocks and changes in carbon stocks of trees in forest project activities*

$\Delta C_{BSL\_SAP,t}$ = Change in the carbon stocks in sapling in the baseline in year t (optional) (tCO_2eq/y) and calculate according to *T-VER-P-TOOL-01-02 Calculation for carbon stocks and changes in carbon stocks of trees in forest project activities*

$\Delta C_{BSL\_SEAGRASS,t}$ = Change in the carbon stocks in seagrass in the baseline in year t (alternative) (tCO_2eq/y)

$\Delta C_{BSL\_DEADWOOD,t}$ = Change in the carbon stocks in dead wood in the baseline in year t (alternative) (tCO_2eq/y) and calculate according to *T-VER-P-TOOL-01-03 Calculation of carbon stocks and change in carbon stocks in dead wood and litter in forest project activities*

$\Delta SOC_{BSL,t}$ Change in carbon stock in soil organic carbon in the baseline in year t (alternative) (tCO_2eq/y)

t = 1, 2, 3 … years since the project start date

5.1.1 Calculating the change in carbon sequestration of the baseline from seagrass biomass carbon sinks

The amount of change in carbon sequestration of the baseline from seagrass biomass carbon stocks over years t_1 to t_2 can be calculated as follows:

<u>Equation 3</u>

$$\Delta C_{BSL\_SEAGRASS,t} = \sum_i^{M_{bsl}} A_{i,t} \times \left[(C_{BSL\_SEAGRASS,i,t2} - C_{BSL\_SEAGRASS,i,t1})/(t_2 - t_1)\right] \times \frac{44}{12}$$

Where

$\Delta C_{BSL\_SEAGRASS,t}$ Change in the carbon stocks in seagrass in the baseline in year t (alternative) (tCO_2eq/y)

Remark: For tidal wetlands with non-perennial vegetation such as seagrass beds, the yearly increase in biomass is assumed to be equivalent to the loss of biomass from death in that same year.

There was no net change in seagrass biomass. It considers the amount of change in seagrass carbon storage to be zero.

$C_{BSL\_SEAGRASS,i,t}$ = Change in the carbon stocks in seagrass in the baseline in stratum i in year t (tC/rai) with standard values for seagrass *Enhalus acoroides* (Linnaeus f.) as follows (adapted from Stankovic et al., 2018), unless different values are proven:

$$C_{BSL\_SEAGRASS,t} = 0.0790 + 0.0145 \times \%cover \text{ (tC/rai)}$$

Remark: In the case of seagrass planting activities, carbon credits may be requested for the first year of the credit period because the sea grass enters a steady state quickly (steady state)

$A_{i,t}$ = Size of stratum i in year t (rai)

i = Stratum 1, 2, 3,... M_{BSL} in baseline

t = 1, 2, 3 ... year since the project start date

$\frac{44}{12}$ = Molar mass ratio of carbon dioxide to carbon

5.1.2 Baseline quantification of change in soil organic carbon (SOC)

In the event that the baseline has an activity causing the project area to have an increase in soil organic carbon (SOC) Where compared to the soil organic carbon before the project until it reaches a stable state (steady state), the calculation of the change in baseline soil organic carbon Year t must take the change in soil organic carbon from outside the project area. Allochthonous soil organic carbon is subtracted from the total change in soil organic carbon can be calculated as follows:

Equation 4

$$\Delta SOC_{BSL,t} = \sum_{i}^{M_{bsl}} A_{i,t} \times \left[\Delta SOC_{total,i,t} - \Delta SOC_{alloch,i,t}\right] \times \frac{44}{12}$$

Where

$\Delta SOC_{BSL,t}$ = Change in in SOC in the baseline in years t (tCO_2eq/y)

$\Delta SOC_{total,i,t}$ = Total change in in SOC in the baseline in stratum, year t (tC/rai/y). The standard values as shown in Table 1 will be used: Where year t

= year of planting to year t = year of planting + 20 years, unless it is proven that there are other values that are different.

$\Delta SOC_{alloch,i,t}$ = Change in SOC outside the project site in stratum i in year t (tC/rai/y)

$A_{\mathrm{i,t}}$ = The size of the stratum i in year t; rai

i = Stratum 1, 2, 3,... M_{BSL} in baseline

t = 1, 2, 3 ... year since the project start date

Table 1. Standard value for baseline total change in soil carbon sequestration in years t.

Characteristics of project area	$\Delta SOC_{total,i,t}$ (tC/rai/y)
Mangrove forest	
Crown Coverage > 50%	0.2336$^{(1)}$
Crown Coverage 15% to 50%	Proportional estimation of crown cover was used with respect to the above standard values.
Sea grass	
Coverage > 10%	0.0688$^{(2)}$

[1] Source: Chmura et al., 2003

[2] Source: IPCC, 2013

Calculating the change in soil carbon stocks from outside the project area in area i in year t can be calculated as follows:

Equation 5

$$\Delta SOC_{alloch,i,t} = \Delta SOC_{total,i,t} \times (\%C_{alloch}/100)$$

Equation 6

$$\%C_{alloch} = 213.17 \times \%C_{soil}{}^{-1.184}$$

Where

$\Delta SOC_{total,i,t}$ = CO_2 emissions from baseline SOC in area i in year t (tC/rai/y)

$\Delta SOC_{alloch,i,t}$ = Change in SOC from outside the project area i in year t (tC/rai/y)

$\%C_{soil}$ = Percentage of soil organic carbon (%)

$\%C_{alloch}$ = Percentage of soil organic carbon from outside the project area (%) The standard values (Needelman et al., 2018) are as follows, unless different values are proven:

Where the project area is a mangrove forest with non-organic soil characteristics:

$$\%C_{alloch} = 213.17 \times \%C_{soil}{}^{-1.184}$$

Where the project area is a seagrass or an area with organic soil characteristics

$$\%C_{alloch} = 0$$

t = 1, 2, 3 … year since the project start date

5.2 Calculation on the additional GHG emission from baseline

Baseline GHG emissions may be omitted from consideration of baseline GHG emissions from burning fossil fuels and GHG emissions from soils according to conservation rules. The baseline of net greenhouse gas emissions can be calculated as follows

Equation 7

$$GHG_{BSL,t} = GHG_{BSL\_SOIL,t} + GHG_{BSL\_FUEL,t}$$

Where

$GHG_{BSL,t}$ = Additional GHG emission in the baseline in year t (tCO_2eq/y)

$GHG_{BSL\_SOIL,t}$ = GHG emissions from soil in the baseline in year t (tCO_2eq/y)

$GHG_{BSL\_FUEL,t}$ = GHG emissions from fossil fuel consumption in the baseline in year t (tCO_2eq/y)

5.2.1 Calculation of the baseline greenhouse gas emissions from soil

The baseline emissions from the soil can be omitted unless it is a project that has implemented activities on carbon dioxide emissions reduction, Where compared to the baseline. The baseline GHG emissions from the soil can be calculated as follows:

Equation 8

$$GHG_{BSL\_SOIL,t} = CO_{2\_BSL\_SOIL,t} + CH_{4\_BSL\_SOIL,t} + N_2O_{\_BSL\_SOIL,t}$$

Where

$GHG_{BSL\_SOIL,t}$ = GHG emissions from soil in the baseline in year t (tCO_2eq/y)

$CO_{2\_BSL\_SOIL,t}$ = CO_2 emissions from soil in the baseline in year t (tCO_2eq/y)

$CH_{4\_BSL\_SOIL,t}$ = CH_4 emissions from soil in the baseline in year t (tCO_2eq/y)

$N_2O_{\_BSL\_SOIL,t}$ = N_2O emissions from soil in the baseline in year t (tCO_2eq/y)

t = 1, 2, 3 … years since the project start date

5.2.1.1 Calculation of the baseline carbon dioxide emission from soil

Baseline emissions of CO_2 from soil in year t can be generated from 3 types of project sites: drained area and eroded areas. The amount of CO_2 emissions from the soil from the project can be calculated as follows:

Equation 9

$$CO_{2\_BSL\_SOIL,t} = CO_{2\_BSL\_SOIL\_excav,t} + CO_{2\_BSL\_SOIL\_drain,t} + CO_{2\_BSL\_SOIL\_erode,t}$$

Where

$CO_{2\_BSL\_SOIL,t}$ = CO_2 emission from soil in the baseline in year t ($tCO_2eq/rai/y$)

$CO_{2\_BSL\_SOIL\_excav,t}$ = CO_2 emission from soil in the baseline in year t from the area with excavation ($tCO_2eq/rai/y$)

$CO_{2\_BSL\_SOIL\_drain,t}$ = CO_2 emission from soil in the baseline in year t from the area with water drainage ($tCO_2eq/rai/y$)

$CO_{2\_BSL\_SOIL\_erode,t}$ = CO_2 emission from soil in the baseline in year t from the area of with land erosion ($tCO_2eq/rai/y$)

t = 1, 2, 3 … year since the project start date

Activities associated with excavation (such as filling or dredging for leveling) that result in the loss of carbon stored in water-saturated soils. (water-logged) to unsaturated soil (aerobic), depending on the type of soil. The baseline CO_2 emissions from the area that was excavated in year t are calculated for the first year of excavation CO_2 emissions only. The baseline emissions of CO_2 from the soil from the excavated area can be calculated as follows:

Equation 10

$$CO_{2\_BSL\_SOIL\_excav,t} = \sum_{i}^{M_{bsl}} \left(A_{excav\_i,t} \times SO_{before}\right) \times \frac{44}{12}$$

Where

$CO_{2\_BSL\_SOIL\_excav,t}$ = CO_2 emission from soil in the baseline in year t from the area with excavation (tCO_2eq/rai/y)

$A_{excav\_i,t}$ = Size of land excavated in stratum i in year t (rai)

SO_{before} = Soil carbon content before soil disturbance (tC/rai) using the standard values as in Table 2 at a depth of 1 meter, unless proven to be different.

i = Stratum 1, 2, 3,… M_{BSL} in baseline

t = 1, 2, 3 … year since the project start date

$\frac{44}{12}$ = Molar mass ratio of carbon dioxide to carbon

Table 2. Standard values for carbon content in the soil before soil disturbance

Characteristics of project area	SO_{before} (tC/rai)
Mangrove forest	
organic soil	75.36
non-organic soil	45.76
organic soil combined with non-organic soil	61.76
Seagrass	17.28

Source: IPCC, 2013

Drainage may cause soil to dry out, depleting soil carbon. If there is full drainage (e.g., the water level is changed to be 1 meter below the soil surface), the assessment of CO_2 emissions amount of baseline from drained area in year t; Where t = the project start year to t = year with complete loss of organic carbon in the soil (consider from SO_{before}/EF_{drain}) unless different values are proven to exist. The baseline soil CO_2 emissions from the drained area can be calculated as follows:

Equation 11

$$CO_{2\_BSL\_SOIL\_drain,t} = \sum_{i}^{M_{bsl}}\left(A_{drain\_i,t} \times EF_{drain}\right) \times \frac{44}{12}$$

Where

$CO_{2\_BSL\_SOIL\_drain,t}$ = CO_2 emission from soil in the baseline in year t from the area with water drainage (tCO$_2$eq/rai/y)

$A_{drain\_i,t}$ = The size of the drained area in stratum i in year t (rai)

EF_{drain} = CO_2 emission from soil in drained areas (tC/rai/y) with the following standard values applied (IPCC, 2013), unless proven otherwise. different
$EF_{drain} = 1.264$ (tC/rai/y)

i = Stratum 1, 2, 3,… M_{BSL} in baseline

t = 1, 2, 3 … year since the project start date

$\frac{44}{12}$ = Molar mass ratio of carbon dioxide to carbon

Baseline of CO_2 emissions from eroded areas in year t; Where year t = project start year to year t = 5 – erosion start year before project start. The baseline soil CO_2 emissions from the eroded area can be calculated as follows:

Equation 12

$$CO_{2\_BSL\_SOIL\_erode,t} = \sum_{i}^{M_{bsl}}\left(A_{erode\_i,t} \times SO_{before} \times \%C_{BSL\_EMITTED,i,t}/100\right) \times \frac{44}{12}$$

Where

$CO_{2\_BSL\_SOIL\_erode,t}$ = CO_2 emission from soil in the baseline in year t from the area of with land erosion (tCO$_2$eq/rai/y)

$A_{erode\_i,t}$ = The size of the eroded area in stratum i in year t (rai)

SO_{before} = Tonnes of carbon per rai before soil disturbance, using the standard values as in Table 2, at a depth of 1 meter will be used, unless different values can be proven.

$\%C_{BSL\_EMITTED,i,t}$ = Soil organic carbon loss from baseline erosion in area i in year t (%) using standard values as Table 3 unless different values are proven.

i = Stratum 1, 2, 3,... M_{BSL} in baseline

t = 1, 2, 3 ... year since the project start date

$\frac{44}{12}$ = Molar mass ratio of carbon dioxide to carbon

Table 3. Standard value for loss of organic carbon in the soil from erosion (%)

Characteristics of project area and carbon stocks environment	$C\%_{BSL\_EMITTED,i,t}$
If the land is eroded and connected to the estuary	
- Normal Marine or Deltaic fluidized muds	80%
- Normal Marine and sediment deposition rate (sediment accumulation rate) less than 0.002 grams per square centimeter per year	98.5%
- O_2 depletion	53%
- Extreme accumulation rates	49%
In case the land is eroded and not connected to the estuary and the open sea	0%
- The baseline is more eroded than the project	100%
- The baseline is less eroded than the project	

Source: Blair and Aller, 2012

5.2.1.2 Calculation of the baseline methane emission from soil

Mangrove restoration and/or managing hydrological conditions that causes the transition from an oxygenated (aerobic) state to an anaerobic one. This leads to an increase in the release potential of CH_4, especially in low salinity environments. Therefore, the amount of CH_4 gas emissions will increase Where salinity decreases.

CH_4 emissions can be ignored according to conservation rules for the baseline. If project proponents can demonstrate that the conditions for CH_4 emissions in baseline and project implementation are not different or an insignificant decrease. The amount of CH_4 released from the soil caused by changes in salinity in the area. can be calculated as follows:

Equation 13

$$CH_{4\_BSL\_SOIL,t} = \sum_i^{M_{bsl}} \left(A_{i,t} \times EF_{CH4} \right) \times \mathrm{GWP_{CH4}}$$

$CH_{4\_BSL\_SOIL,t}$ = CH_4 emission from soil in the baseline in year t (tCO_2eq/y)

$A_{i,t}$ = Size of stratum area i in year t (rai)

EF_{CH4} = CH_4 emission from soil in the baseline (tCH_4/rai/y) with the following standard values applied (IPCC, 2013), unless different values are proven;

For areas with average salinity or lowest salinity > 18 ppt

$$EF_{CH4} = 0$$

For areas with average salinity or lowest salinity < 18 ppt

$$EF_{CH4} = 0.030992 \ \mathrm{tCH_4/rai/y}$$

GWP_{CH4} = The global warming potential of methane gas

i = Stratum 1, 2, 3,… M_{BSL} in baseline

t = 1, 2, 3 … year since the project start date

5.2.1.3 Calculation of the baseline nitrous oxide emission from soil

Nitrous oxide (N_2O) emissions can be ignored according to conservation rules for the baseline. If project proponents can demonstrate that the conditions for N_2O emissions in baseline and project implementation are not different. or an insignificant decrease. The change in the water level in the area results in the emission of greenhouse gas N_2O which can be calculated as follows:

Equation 14

$$N_2O_{\_BSL\_SOIL,t} = \sum_i^{M_{bsl}} \left(A_{i,t} \times EF_{N2O} \right) \ x \ GWP_{N2O}$$

$N_2O_{\_BSL\_SOIL,t}$ = N_2O emission from soil in baseline in year t (tCO_2eq/y)

$A_{i,t}$ = The size of stratum i in year t (rai)

EF_{N2O} = N_2O emission from soil in baseline (tN_2O/rai/y) using the standard values as in Table 4, unless different values are proven.
GWP_{N2O} = The global warming potential of nitrous oxide gas
i = Stratum 1, 2, 3 ...M_{BSL} in baseline
t = 1, 2, 3 ... year since the project start date

Table 4. Standard value for N2O emissions from soil

Characteristics of project area	EF_{N2O} (tN_2O/rai/y)
Mangrove forest	
Average salinity or minimum salinity >18 ppt	0.00007792
Average salinity or minimum salinity between 5 and 18 ppt.	0.00012064
Average salinity or minimum salinity < 5 ppt	0.00013824
Seagrass	
Average salinity or minimum salinity >18 ppt	0.00002512
Average salinity or minimum salinity between 5 and 18 ppt.	0.0000528
Average salinity or minimum salinity < 5 ppt	0.0000848

Source: Smith et al., 1983

5.2.2 Calculation of greenhouse gas emissions from fossil fuel use

Greenhouse gas emissions from the combustion of fossil fuels from the use of machines in various activities related to planting and planting forest management, such as preparing or managing land by using machinery, etc. For small projects, GHG emissions from fossil fuel consumption from project activities do not have to be calculated.

For the following activities, they are not required to assess the amount of greenhouse gas emissions, including

1) Cutting herbaceous plants and shrubs.
2) Degradation of plant remains and roots
3) in the project area and transportation resulting from project activities.

The amount of greenhouse gas emissions from such activities are considered having insignificant effect on the amount of GHG captured from project activities. Therefore, the amount of greenhouse gas emissions from such activities are set to zero.

The amount of greenhouse gas emissions from baseline fossil fuel use may be ignored by conservation rules, and can be calculated as follows:

Equation 15

$$GHG_{BSL\_FUEL,t} = \sum\left(FC_i \times (NCV_i \times 10^{-6}) \times EF_{CO2_i}\right) \times 10^{-3}$$

Where

$GHG_{BSL\_FUEL,t}$ = GHG emission from fossil fuel use in the baseline in year t (tCO_2eq/y)

FC_i = Quantity of fossil fuel use type *i* for the operation project i (units)

NCV_i = Net Calorific Value of type i fuel consumption (MJ/units)

EF_{CO2_i} = GHG emission from fossil fuel burning type i ($kgCO_2/TJ$)

Developers will need to forecast changes in the area over a 100-year period, which may affect baseline emissions of greenhouse gases, such as sea level rise, according to the calculation tool *T-VER-P-TOOL-01-10 Methods for Stratification of the Project Area in Mangrove and Seagrass* and other factors that may cause changes in the area, such as assessing the trend of land use and land development in the future. This includes the change of the surrounding area that may affect changes in the hydrology of the project site (e.g. water barriers or sediment loads), invasion of exotic plants, the entry of any other vegetation from neighboring areas or from human activities (e.g. gardening) and climate change. Such factors may affect greenhouse gas emissions of the area in the future within 100 years of the project area. You can use historical data of at least 20 years prior to the start of the project from the two nearest stations. It is information for making predictions.

6. Calculation of net GHG removal from project operations

Calculation of net GHG removal from project operations can be calculated as follows:

Equation 16

$$GHG_{PROJ\_MSR,t} = \Delta C_{PROJ,t} - GHG_{PROJ,t}$$

$GHG_{PROJ\_MSR,t}$ = GHG removal in the project activities in year t (tCO_2eq)

$\Delta C_{PROJ,t}$ = Change in carbon stock in the project from selected carbon pools in year t (tCO_2eq)

$GHG_{PROJ,t}$ = Additional greenhouse gas emissions from project activities in year t (tCO_2eq)

The amount of change in carbon stock from project activities is determined by the tree biomass. In the case of mangrove forests, tree biomass is mainly considered for the biomass in the sapling. The biomass in dead wood is optional. In the case of seagrass, seagrass biomass is considered optional. and consider the change in soil carbon as optional. It can be calculated by following Equation 2 to 6, replacing the BSL subscript with PROJ.

Regarding the net greenhouse gas emissions from project implementation, the GHG emission from soil will be considered in case of changes in salinity or water level, fossil fuel combustion in case of mechanized earthmoving in large-scale projects, including the greenhouse gas emissions from the combustion of biomass. The net greenhouse gas emissions from project implementation can be calculated as follows:

Equation 17

$$GHG_{PROJ,t} = GHG_{PROJ\_SOIL,t} + GHG_{PROJ\_FUEL,t} + GHG_{PROJ\_BURN,t}$$

$GHG_{PROJ,t}$ = Net GHG emission from project operations in year t (tCO_2eq/y)

$GHG_{PROJ\_SOIL,t}$ = Net GHG emissions from the soil from project implementation in year t (tCO_2eq/y) can be calculated by using the *Equation 8 to 14 by replacing the subscript BSL with PROJ*

$GHG_{PROJ\_FUEL,t}$ = GHG from the use of fossil fuels, net from project operations in year t (tCO_2eq/y) implemented *Equation 15 by replacing the BSL subscript with PROJ.*

$GHG_{PROJ\_BURN,t}$ = GHG emissions from burning biomass from project activities in year t (tCO_2eq/y) can be carried out by using the calculation tool *T-VER-P-TOOL-01-05 Calculation for non-CO2 greenhouse gas emissions from burning of biomass in forest project activities*

t = 1, 2, 3 … year since the project start date

Project proponents may refrain from considering CH_4 and N_2O emissions if CH_4 and N_2O emissions do not differ between baseline and from project implementation.

Project developers will need to forecast changes in the area over a 100-year period, which may have the same effect on project implementation GHG emissions as in the baseline.

7. Calculation of greenhouse gas emissions outside the project area

The calculation of greenhouse gas emissions outside the project area is required if the implementation of the project activities is aligned with the nature of the project activities under the project's terms and conditions. The carbon emissions from the leakage is set to zero.

8. Calculation of net GHG removal from project implementation

Net GHG removal from project implementation can be calculated as follows

Equation 18

$$GHG_{MSR} = \sum_{t=1}^{t=n}(GHG_{PROJ\_MSR,t} - GHG_{BSL\_MSR,t} - GHG_{LK,t})$$

Where

GHG_{MSR} = Net GHG removal from project implementation during the 1st year to year n (tCO_2eq)

$\Delta C_{PROJ\_MSR,t}$ = Net GHG removal from project implementation in year t (tCO_2eq)

$\Delta C_{BSL\_MSR,t}$ = GHG removal in the baseline in year t (tCO_2eq)

$GHG_{LK,t}$ = GHG emissions outside project boundaries (tCO_2eq/y)

t = 1, 2, 3 … n year since the project start date

However, for projects that want to reduce greenhouse gas emissions in the baseline (reductions of baseline GHG emissions) or projects that are expected to be impacted by rising seawater, they will be affected by the amount of carbon storage in tree biomass and soil organic carbon. Maximum amount of net GHG capture from project implementation ($GHG_{MSR-MAX}$) is equal to the net GHG storage obtained from project operation at t = 100 years after project operation ($GHG_{MSR-100}$).

9. Uncertainty Analysis

The project developer must demonstrate the cumulative uncertainty calculation for the project from the uncertainty arising from the calculation of GHG emissions and carbon change in the deposit both from baseline and from project operations according to conservation principle. The methodology defined uncertainty as 10% with 90% confidence interval. The project developer can assess the uncertainty according to the calculation tools used or theoretically. If the project's cumulative uncertainty is greater than 10%, the resulting value must be adjusted against the amount of change in carbon deposits both from baseline and from project operations according to the ratio in Annex.

10. Monitoring Procedure

10.1 Monitoring Plan

The Project Monitoring Plan provides the collection of data needed to quantify changes of carbon stocks from selected carbon pools from project activities and outside the project area.

10.2 Monitoring of project implementation

Information for project monitoring is included in the Project Design Document (PDD) with the parameters to be monitored, including measurement methods and frequency of measurements according to TGO requirements.

In this regard, there must be a monitoring of the project activities to ensure that they are carried out in accordance with the nature and conditions specified by the methodology. The following conditions must be consistently met:

1.) No project activity burning organic soil is found.
2.) No project activity using nitrogen fertilizers is found.

11. Relevant parameters

11.1 Parameters not required monitoring

Parameters	$C_{PROJ\_SEAGRASS,t}$
Unit	tC/rai
Definition	The amount of carbon content from seagrass of the project implementation at time t

Source of information	Option 1: Standard values for the seaweed Enhalus acoroides (Linnaeus f.) were used as follows: Standard values for the seaweed Enhalus acoroides (Linnaeus f.) were used as follows. (adapted from Stankovic et al., 2018) $$C_{PROJ\_SEAGRASS,t} = 0.0790 + 0.0145 \times \%cover$$ Option 2: Obtained from research published in academic papers that are recognized and can be identified as appropriate for the project area. Option 3: Collecting samples from the project area to develop values as determined by TGO.
Remark	

<table>
<tr><td>Parameters</td><td>$\Delta SOC_{total,i,t}$</td></tr>
<tr><td>Unit</td><td>tCO_2eq/rai/y</td></tr>
<tr><td>Definition</td><td>The amount of change in total soil carbon stock of baseline in year t</td></tr>
<tr><td>Source of information</td><td>Option 1: The baseline total change in soil carbon sequestration in years t was used.
<table>
<tr><th>Characteristics of project area</th><th>$\Delta SOC_{total,i,t}$ (tonnes per rai per year)</th></tr>
<tr><td>Mangrove forest
Canopy coverage > 50%
15% to 50% canopy coverage</td><td>0.2336(1)
Use the estimation in the range of the above standard values.</td></tr>
<tr><td>Seagrass
Coverage > 10%</td><td>0.0688(2)</td></tr>
<tr><td colspan="2">[1] Source: Chmura et al., 2003
[2] Source: IPCC, 2013</td></tr>
</table>
Option 2: Values obtained from research published in academic papers that are recognized and can be identified as appropriate for the project area.
option samples from the project area to develop values as determined by the TGO.</td></tr>
<tr><td>Remark</td><td></td></tr>
</table>

Parameters	SO_{before}

<table>
<tr><td>Unit</td><td>tC/rai</td></tr>
<tr><td>Definition</td><td>The amount of carbon content in soil before soil disturbance</td></tr>
<tr><td>Source of information</td><td>Option 1: Use the standard value for the carbon content in the soil before soil disturbance at a depth level of 1 meter
<table>
<tr><td>Characteristics of project area</td><td>SO_{before} (tC/rai)</td></tr>
<tr><td>Mangrove forest</td><td></td></tr>
<tr><td>organic soil</td><td>75.36</td></tr>
<tr><td>non-organic soil</td><td>45.76</td></tr>
<tr><td>organic soil combined with non-organic soil</td><td>61.76</td></tr>
<tr><td>Seagrass</td><td>17.28</td></tr>
<tr><td colspan="2">Source: IPCC, 2013</td></tr>
</table>
Option 2: Values obtained from research published in academic papers that are recognized and can be identified as appropriate for the project area.
Option 3: Collecting samples from the project area to develop values as determined by the TGO.</td></tr>
<tr><td>Remark</td><td></td></tr>
</table>

Parameters	EF_{drain}
Unit	tC/rai/year
Definition	The baseline soil CO_2 emissions from the drained area.
Source of information	Option 1: Use the following standard values (IPCC, 2013) $EF_{drain} = 1.264$ (tC/rai/year) Option 2: Values obtained from research published in academic papers that are recognized and can be identified as appropriate for the project area. Option 3: Collecting samples from the project area to develop values as determined by the TGO.
Remark	

Parameters	$\%C_{BSL\_EMITTED,i,t}$
Unit	%
Definition	Organic carbon loss due to oxidation, as a percentage of C mass

<table>
<tr><td></td><td>present in in-situ soil material in the baseline scenario in stratum i in year t</td></tr>
<tr><td>Source of information</td><td>Option 1: Use the following standard values.
<table>
<tr><th>Characteristics of project area and carbon deposition environment</th><th>$C\%_{BSL\_EMITTED,i,t}$</th></tr>
<tr><td>If the land is eroded and connected to the estuary</td><td>80%</td></tr>
<tr><td>- Normal Marine or Deltaic fluidized muds</td><td></td></tr>
<tr><td>- Normal Marine type and sediment accumulation rate less than 0.002 g/cm2 per year.</td><td>98.5%</td></tr>
<tr><td>- O2 depletion form</td><td>53%</td></tr>
<tr><td>- Extreme accumulation rates</td><td>49%</td></tr>
<tr><td>In case the land is eroded and not connected to the estuary and the open sea</td><td></td></tr>
<tr><td>- The baseline has more erosion than the project implementation.</td><td>0%
100%</td></tr>
<tr><td>- The baseline is less eroded than the project.</td><td></td></tr>
<tr><td colspan="2"><i>Source: Blair and Aller, 2012</i></td></tr>
</table>
Option 2: Values obtained from research published in academic papers that are recognized and can be identified as appropriate for the project area.
Option 3: Collecting samples from the project area to develop values as determined by the TGO.</td></tr>
<tr><td>Remark</td><td></td></tr>
</table>

Parameters	EF_{CH4}
Unit	tCH_4/rai/yaer
Definition	The amount of CH_4 emission from soil of baseline
Source of information	Option 1: Use the following standard values. (IPCC, 2013) for areas with mean or minimum salinity < 18 ppt, unless different values are proven; $EF_{CH4} = 0.030992$ tonnes of methane per rai per year

	Option : Values obtained from research published in academic papers that are recognized and can be identified as appropriate for the project area. Option 3: Collecting samples from the project area to develop values as determined by the TGO.
Remark	

<table>
<tr><td>Parameters</td><td>EF_{N2O}</td></tr>
<tr><td>Unit</td><td>tonnes of nitrous oxide per rai per year</td></tr>
<tr><td>Definition</td><td>The amount of carbon content in soil before soil disturbance</td></tr>
<tr><td>Source of information</td><td>Option 1: Use the following standard values.
<table>
<tr><th>Characteristics of project area</th><th>EF_{N2O}</th></tr>
<tr><td>Mangrove forest
- Average salinity or minimum salinity >18 ppt
- Average salinity or minimum salinity between 5 and 18 ppt.
- Average salinity or minimum salinity < 5 ppt</td><td>0.00007792
0.00012064
0.00013824</td></tr>
<tr><td>Seagrass
- Average salinity or minimum salinity >18 ppt
- Average salinity or minimum salinity between 5 and 18 ppt.
- Average salinity or minimum salinity < 5 ppt</td><td>0.00002512
0.0000528
0.0000848</td></tr>
<tr><td colspan="2">Source: Smith et al., 1983</td></tr>
</table>
Option 2: Values obtained from research published in academic papers that are recognized and can be identified as appropriate for the project area.
Option 3: Collecting samples from the project area to develop values as determined by the TGO.</td></tr>
<tr><td>Remark</td><td></td></tr>
</table>

Parameters	NCV_i
Unit	megajoules per unit
Definition	Net calorific value of type i fossil energy

Source of information	Option 1 The net calorific value of fossil fuels specified in the invoice from the fuel supplier. Option 2 from monitoring Ooption 3 Thailand Energy Statistics Report Department of Alternative Energy Development and Efficiency ministry of energy
Remark	

Parameters	$EF_{CO_2,i}$
Unit	kg carbon dioxide/terajoules
Definition	Greenhouse gas emissions from the combustion of type i fossil fuels
Source of information	Table 1.4 2006 IPCC Guidelines for National GHG Inventories
Remark	-

For other parameters that do not need monitoring, they appear in the corresponding calculation tool.

11.2 Parameters required monitoring

Parameters	$A_{i,t}$, $A_{excav\_i,t}$, $A_{erode\_i,t}$, $A_{drain\_i,t}$
Unit	rai
Definition	Area size/area with excavation/area with drainage/area with erosion/area with greenhouse gas emissions in area i in year t
Source of information	Monitoring report
Monitoring method	- Area exploration - Satellite Imagery or Aerial Photography
Monitoring Frequency	Following a cycle of follow-up assessments for certification
Remark	-

Parameters	$\Delta C_{PROJ\_TREE,t}$
Unit	tCO$_2$eq/y

Definition	The amount of change in carbon sequestration of trees grown during project implementation in year t
Source of information	Monitoring report
Monitoring method	*T-VER-P-TOOL-01-02 Calculation for carbon stocks and changes in carbon stocks of trees in forest project activities*
Monitoring Frequency	Following a cycle of follow-up assessments for certification
Remark	-

Parameters	$\Delta C_{PROJ\_SAP,t}$
Unit	tCO2eq/y
Definition	The amount of change in carbon sequestration of sapling during project implementation in year t
Source of information	Monitoring report
Monitoring method	*T-VER-P-TOOL-01-02 Calculation for carbon stocks and changes in carbon stocks of trees in forest project activities*
Monitoring Frequency	Following a cycle of follow-up assessments for certification
Remark	Optional carbon deposit

Parameters	$\%cover$
Unit	%
Definition	Vegetation cover
Source of information	Monitoring report
Monitoring method	Area exploration
Monitoring Frequency	Following a cycle of follow-up assessments for certification
Remark	-

Parameters	$\%C_{SOIL}$
Unit	%
Definition	Percentage of organic carbon in the soil
Source of information	Collect samples in the field and measure them in the lab.
Monitoring method	Samples are collected in the field and measured in the laboratory by loss on ignition (LOI) or by using an elemental analyzer.
Monitoring Frequency	Following a cycle of follow-up assessments for certification
Remark	-

Parameters	FC_i
Unit	Fuel unit
Definition	Consumption of fossil fuel type *i* in case of project implementation in year t
Source of information	measurement report
Monitoring method	Option 1: In case of purchasing or disbursing fuel by using all the fuel at once no spare. Follow up on invoices or disbursement records showing fuel consumption. Option 2: In case of having a fuel storage container and disbursing from the storage container. To measure the mass or volume of fuel used and continuously record fuel consumption.
Monitoring Frequency	continuous monitoring by recording at least monthly
Remark	-

Parameters	$\mathrm{NER}_{\mathrm{REDD+ERROR}}$
Unit	%
Definition	Cumulative uncertainty for any REDD+ project to year t.
Source of information	-
Monitoring method	-

Monitoring Frequency	-
Remark	-

Parameters	GWP_{CH4}
Unit	tCO_2eq / tCH_4
Definition	Global warming potential of methane
Source of information	Use data from the Climate Change Assessment Report prepared by Intergovernmental Panel on Climate Change of IPCC announced by TGO
Monitoring method	<u>**For the preparation of project design document**</u> - Use the latest GWP_{CH4} value announced by TGO <u>**For GHG emission reduction monitoring**</u> – Use GWP_{N2O} value announced by TGO for GHG amount assessment during crediting period to quantify GHG emission and for certification

Parameters	GWP_{N2O}
Unit	tCO_2eq / tN_2O
Definition	Global warming potential of nitrous oxide
Source of information	Use data from the Climate Change Assessment Report prepared by Intergovernmental Panel on Climate Change of IPCC announced by TGO
Monitoring method	<u>**For the preparation of project design document**</u> - Use the latest GWP_{N20} value announced by TGO <u>**For GHG emission reduction monitoring**</u> – Use GWP_{N2O} value announced by TGO for GHG amount assessment during crediting period to quantify GHG emission and for certification

For other parameters that do not need monitoring, they appear in the corresponding calculation tool.

12. Reference

1) 2003 IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry
2) 2006 IPCC Guidelines
3) 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands
4) Blair, N.E., and Aller, R.C. 2012. The Fate of Terrestrial Organic Carbon in the Marine Environment. Annual Review of Marine Science 4(1): 401–423.
5) CDM tool AR-Tool14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities
6) CDM tool AR-Tool02 Combined tool to identify the baseline scenario and demonstrate additionality for A/R CDM project activities
7) CDM tool AR-Tool03 Calculation of the number of sample plots for measurements within A/R CDM project activities
8) CDM tool AR-Tool04 Tool for testing significance of GHG emissions in A/R CDM project activities
9) CDM tool AR-Tool05 Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities
10) Chmura, GL, SC Anisfeld, DR Cahoon, and JC Lynch 2003. Global carbon sequestration in tidal, saline wetland soils. Global biogeochemical cycles 17: 1111-1123. doi:10.1029/2002GB001917
11) Needelman, BA, IM Emmer, S Emmett-Mattox, S Crooks, JP Megonigal, D Myers, MPJ Oreska, and K McGlathery 2018. The science and policy of the verified carbon standard methodology for tidal wetland and seagrass restoration. Estuaries and Coasts 41(8): 2159-2171
12) Smith, CJ, RD DeLaune, and WH Patrick Jr 1983. Nitrous oxide emission from Gulf Coast wetlands. Geochimica et Cosmochimica Acta, 47: 1805-1814.
13) Stankovic, M., Tantipisanuh, N., Rattanachot, E., and Prathep, A. 2018. Model-based approach for estimating biomass and organic carbon in tropical seagrass ecosystems. Marine Ecology Progress Series. 596.
14) VCS Methodology VM0033 Methodology for tidal wetland and seagrass restoration
15) VCS module VMD0016 Methods for stratification of the project area
16) VCS module VMD0019 Methods to Project Future Conditions
17) VCS Module VMD0017 Estimation of Uncertainty for REDD+ Project Activities
18) VCS module VMD0052 Demonstration of Additionality of Tidal Wetland Restoration and Conservation Project Activities

Annex

Annex 1 Using uncertainty discounts

Calculation results with high uncertainty can be used further Where such an assessment is conservative. This appendix provides steps for applying uncertainty discounts to make the assessment of the parameter under conservation principle (e.g., the carbon content of the tree).

Where the uncertainty in the mean of the Assessment of the Parameters is more than 10%, the mean will be adjusted up or down from the percentage of uncertainty as follows:

Uncertainty discount factors

Uncertainty: U	Discount (percentage of uncertainty)	Application
U ≤ 10%	0%	<u>Example</u> Mean biomass = 60 ± 9 tonnes dry weight/rai Uncertainty = 9/60 x 100 = 15% Discount = 25% x 9 = 2.25 tonnes dry weight/rai The discount calculation is based on conservation principles as follows: baseline = 60+2.25 = 62.25 tonnes dry weight/rai Project execution = 60-2.25 = 57.75 dry tonnes/rai
10<U≤15	25%	
15<U≤20	50%	
20<U≤30	75%	
U>30	100%	

Document information

Version	Amendment	Entry into force	Description
01	--	1 March 2023	-