Project Report

Greenhouse Gas Offset Methodology Criteria for Tidal Wetland Conservation

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List of Abbreviations and Acronyms

ACoGS	Avoided Conversion of Grassland and Shrubland
AFOLU	Agriculture, Forestry and Other Land Use
ALM	Agricultural Land Management
APWD	Avoided Planned Wetland Degradation
ARR	Afforestation, Reforestation, Revegetation
AUWD	Avoided Unplanned Wetland Degradation
CEC	Commission for Environmental Cooperation
CO_2	carbon dioxide
CH_4	methane
CIW	Conservation of Intact Wetland
GESTs	Greenhouse Gas Emission Site Type [proxy for deriving peatland GHG emissions, using ground vegetation composition and water level]
GHG	Greenhouse Gas
HCH	hexachlorocyclohexane
IFM	Improve Forest Management
INECC	*Instituto Nacional de Ecología y Cambio Climático* (National Institute of Ecology and Climate Change)
Inegi	*Instituto Nacional de Estadística y Geografía* (National Institute for Statistics and Geography)
IRR	Internal Rate of Return
N_2O	Nitrous oxide
PDT	Peat Depletion Time
RAE	Methodology for Tidal Wetland and Seagrass Restoration
REDD	Reducing Emissions from Deforestation and forest Degradation
RWE	Restoration of Wetland Ecosystems
Semarnat	*Secretaría de Medio Ambiente y Recursos Naturales* (Ministry of the Environment and Natural Resources)
SDT	Soil organic carbon Depletion Time
SOC	Soil organic carbon
VCS	Verified Carbon Standard
VCU	Verified Carbon Unit
WRC	Wetland Restoration and Conservation

Abstract

This document supports the development of a global greenhouse gas (GHG) offset methodology for tidal wetland conservation. The Verified Carbon Standard (VCS) provides a set of requirements which projects must meet before offsets are issued. The requirements for wetlands projects include determining the baseline scenario and anticipated GHG emissions, setting the project boundary, determining additionality, quantifying project GHG emissions and reductions, establishing the permanence of GHG emission reductions, and others.

Tidal wetlands, such as mangroves, salt marshes, and seagrass beds, store globally significant amounts of soil carbon and these ‘blue carbon’ ecosystems remove carbon dioxide from the atmosphere at rates three to ten times greater than forests. No methodologies exist to allow the issuance of carbon offsets for tidal wetland conservation projects. This document recommends specific criteria and procedures to incorporate into the first global tidal wetland conservation GHG offset methodology that would meet the VCS requirements.

Executive Summary

The Commission for Environmental Cooperation (CEC)'s program "North America's Blue Carbon: Assessing the Role of Coastal Habitats in the Continent's Carbon Budget" has the purpose of advancing the conservation and restoration of coastal blue carbon habitat (i.e., salt marshes, mangroves and seagrass meadows). Under this program, a Verified Carbon Standard (VCS)-compliant set of procedures has been developed for project-based greenhouse gas (GHG) accounting for coastal blue carbon habitat conservation. The accounting procedures are suitable for the development of a GHG offset methodology for tidal wetland conservation for North America and other coastal countries.

Generic VCS requirements for methodologies include:

- Setting proper project **boundaries**, defined by the geographic boundary, the temporal boundary (project crediting period), and carbon pools (e.g., soil organic carbon, biomass, necromass) and GHGs (CO_2, CH_4, N_2O) to be included in the accounting
- Setting a **baseline scenario** (the most likely course of action and development over time, in the absence of the proposed project), based on a set of alternative scenarios and criteria for the selection of the most-likely one
- **Additionality**, i.e., the fact that the project would not have happened without the intervention of the carbon market, based on an analysis of barriers to implementation of the project activity
- Quantifying GHG emissions and/or carbon stock changes in both the baseline and the project scenarios and quantifying the GHG emission reductions or removals as the difference between the two—this assessment includes the quantification of leakage emissions, which, if they exist, must be deducted from the result.

VCS requirements specific to wetlands methodologies include:

- Setting additional temporal boundaries based on the assessment of the peat depletion time (PDT) and/or the **soil organic carbon depletion time** (SDT) in the baseline scenario, as it is noted that once depletion of soil organic matter is reached, GHG emissions will stop and a conservation project cannot claim emission reduction beyond this point in time.
- Determining '**permanence'** of project benefits (i.e., that carbon stocks will be maintained over a long period of time) which for wetlands projects includes the assessment of the difference in soil carbon stocks between the baseline and project scenarios at the 100-year time mark.
- Distinguishing carbon stock changes as a result of the on-site accumulation of **allochthonous** soil organic carbon (that is, soil carbon originating outside the project boundary and being deposited in the project area), and **autochthonous** soil organic carbon (soil organic carbon originating or forming in the place where it is accumulated, e.g., from vegetation in the project area) where accumulation of allochthonous soil carbon cannot in all circumstances be accounted towards the carbon benefits of the project.
- Quantification and prediction of carbon loss from the wetland ecosystem and the fate of that carbon; either it is eventually re-buried and therefore protected or it oxidizes and is a GHG emission. Carbon that is lost from the project boundary but not mineralized and emitted cannot be claimed as an emission reduction.
- Assessing a wetlands-specific kind of leakage, being **ecological leakage**, which may occur if the project and adjacent areas are hydrologically connected, e.g., by inducing methane emissions or vegetation dieback outside the project boundary.
- Methodologies must allow for setting a proper geographic boundary that considers projections of expected relative sea-level rise, thus accounting for the potential effect of sea-level rise on

the lateral movement of wetlands during the project crediting period and the potential that the wetlands will migrate beyond the project boundary. It must include procedures to account for any changes in carbon sequestration or GHG emission reductions resulting from lateral movement of wetlands due to sea-level rise, or *coastal squeeze* associated with any structures that prevent wetland landward migration and cause soil erosion.

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Introduction

In 2013, the Commission for Environmental Cooperation (CEC) launched a new project, entitled North America's Blue Carbon: Assessing the Role of Coastal Habitats in the Continent's Carbon Budget, as part of its Operational Plan for 2013–2014, with the purpose of advancing the conservation and restoration of coastal blue carbon habitat (i.e., salt marshes, mangroves and seagrass meadows) by improving data, mapping, and approaches for developing and applying appropriate carbon budgets.

A task of this project is to foster scientific collaboration on blue carbon research, identify research gaps and priorities for future research, and provide recommendations on implications for management of coastal blue carbon habitat. To this end, the CEC supports the development of a scientifically-based methodology to account for net GHG benefits of tidal wetlands conservation activities. The eventual methodology would support coastal managers in conducting conservation projects, resulting in marketable carbon credits.

Drawing on existing resources—such as forest conservation methodologies, draft and approved wetland methodologies, a literature analysis, expert consultation, and discussion—a set of procedures compliant with the Verified Carbon Standard (VCS) was developed for project-based greenhouse gas (GHG) accounting to achieve marketable GHG offset credits for coastal blue carbon habitat conservation. The accounting procedures are suitable for the development of a GHG offset methodology for tidal wetland conservation for North America and other coastal countries.

GHG accounting must allow for the quantification of GHG emission reductions or removals based on scientifically sound assessment of a baseline and a project scenario, taking into account emissions caused by the project outside its boundaries (leakage), and ensuring the permanent nature of emission reductions or removals associated with carbon stock changes (e.g., in wetland soils and biomass). Conservation methodologies emphasize procedures to model the dynamics of the baseline scenario of ongoing wetland degradation and loss, and project the wetland to remain intact in the project case.

Accounting of GHG emissions and removals in coastal wetlands is a relatively new phenomenon. When a sufficient scientific basis for procedures is lacking, as a principle the methodology will exclude—as per its terms of applicability—conditions and situations that cannot be covered, or it will provide conservative procedures that avoid the need for accurate quantification. This may be of particular relevance to CH_4 and N_2O levels, and the fate of carbon when tidal wetland soils erode. Furthermore, based on recent scientific publications (including the IPCC reports), under certain conditions default values for GHG emissions can be set, compliant with the VCS standard and reducing the burden on wetland projects.

This report presents a VCS-compliant set of procedures for project-based GHG accounting that will achieve marketable GHG offset credits for tidal wetland conservation. The criteria will be applicable globally and in both salt and fresh-water conditions, including salt marsh, mangroves, and other tidal systems.

1 VCS Requirements for Conservation of Intact Wetlands Methodologies

The VCS, since its launch in 2007, has initiated projects and methodologies for five different project categories: *viz.* Afforestation, Reforestation and Revegetation (ARR), Improved Forest Management (IFM), Avoided Conversion of Grasslands and Shrublands (ACoGS), Reducing Emissions from Deforestation and Forest Degradation (REDD) and Wetlands Restoration and Conservation (WRC). Under WRC, two more categories are recognised, i.e., Restoring Wetlands Ecosystems (RWE) and Conservation of Intact Wetlands (CIW). Not surprisingly, most blue carbon projects will be combinations of two or more of these categories. For example, a mangrove forest, including its soil, may be protected against degradation, while parts of it that are already degraded will be restored. Such an intervention would combine elements of REDD, ARR and WRC. To date, the VCS has approved more than ten Agriculture, Forestry and Other Land Use (AFOLU) methodologies and myriad modules for specific accounting procedures,[1] as well as more than 30 individual projects.[2] Four peatland-related methodologies (three for tropical regions and one for temperate climates) and one tidal wetland methodology for Louisiana are currently under validation by the VCS. The American Carbon Registry (ACR) recently approved a wetlands restoration methodology for the Mississippi Delta.[3]

The VCS has spelled out its requirements for GHG accounting methodologies for AFOLU project activities in the VCS Agriculture, Forestry and Other Land Use (AFOLU) Requirements, v 3.4,[4] which must be used in conjunction with the general VCS Standard (v3.4). Below is a summary of these requirements.

Generic VCS requirements for methodologies include:

- Setting proper project boundaries, defined by the geographic boundary, the temporal boundary (project crediting period), and carbon pools (e.g., soil organic carbon, biomass, necromass) and GHGs (CO_2, CH_4, N_2O) to be included in the accounting.
- Setting a baseline scenario, based on a set of alternative scenarios and criteria for the selection of the most-likely one.
- The project must demonstrate additionality: that is, the project would not have happened without the intervention of the carbon market, based on an analysis of barriers to implementation of the project activity.
- Quantifying GHG emissions and/or carbon stock changes in both the baseline and the project scenarios and quantifying the GHG emission reductions or removals as the difference between the two—this assessment includes the quantification of leakage emissions,[5] which, if they exist, must be deducted from the result.

VCS requirements specific to wetlands methodologies include:

- Setting additional temporal boundaries based on the assessment of the peat depletion time (PDT) and/or the soil organic carbon depletion time (SDT) in the baseline scenario, as it is noted that once depletion of soil organic matter is reached, GHG emissions will stop and a conservation project cannot claim emission reduction beyond this point in time.
- Determining 'permanence' of project benefits which for wetlands projects is not only based on the VCS AFOLU risk assessment (for which a dedicated tool is provided by the VCS), but also on the assessment of the difference in soil carbon stocks between the baseline and project scenarios at the 100-year time mark. The VCS approach is that, in both the baseline and project scenarios, soil organic matter may oxidize but a reduced loss in the project scenario, leading to a significant difference in carbon stock after 100 years, is deemed a permanent gain that can be awarded with carbon credits.

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[1] See <www.v-c-s.org/methodologies/find-a-methodology?title=&tid=14>.

[2] See <https://vcsprojectdatabase2.apx.com/myModule/Interactive.asp?Tab=Projects&a=1&t=1>.

[3] See <http://americancarbonregistry.org/carbon-accounting/restoration-of-degraded-deltaic-wetlands-of-the-mississippi-delta>.

[4] Available at <www.v-c-s.org/program-documents>.

[5] Leakage is defined as any increase in GHG emissions that occurs outside the project boundary (but within the same country), and is measurable and attributable to the project activities. All leakage shall be accounted for, in accordance with Section 2.1.6. The three types of leakage are:

1. Market-effects leakage occurs when projects significantly reduce the production of a commodity causing a change in the supply and market demand equilibrium that results in a shift of production elsewhere to make up for the lost supply.
2. Activity-shifting leakage occurs when the actual agent of deforestation and/or forest or wetland degradation moves to an area outside of the project boundary and continues its deforestation or degradation activities elsewhere.
3. Ecological leakage occurs in WRC projects where a project activity causes changes in GHG emissions or fluxes of GHG emissions from ecosystems that are hydrologically connected to the project area.

- Distinguishing carbon stock changes as a result of the on-site accumulation of **allochthonous** soil organic carbon (that is, soil carbon that originated outside the project boundary and has been deposited within the project area) and **autochthonous** soil organic carbon (soil organic carbon that originated or formed in the place where it then accumulated, e.g., from vegetation within the project area) where accumulation of allochthonous cannot in all circumstances be accounted towards the carbon benefits of the project.
- Quantification and prediction of carbon loss from the wetland ecosystem and the fate of that carbon; either it is eventually re-buried and therefore protected or it oxidizes and is a GHG emission. Carbon that is lost from the project boundary but not mineralized and emitted cannot be claimed as an emission reduction.
- Assessing a wetlands-specific kind of leakage, being ecological leakage, which may occur if the project and adjacent areas are hydrologically connected, e.g., by inducing methane emissions or vegetation dieback outside the project boundary.
- Methodologies must allow for setting a proper geographic boundary that considers projections of projected relative sea-level rise, thus accounting for the potential effect of sea-level rise on the lateral movement of wetlands during the project crediting period and the potential that the wetlands will migrate beyond the project boundary. It must include procedures to account for any changes in carbon sequestration or GHG emission reductions resulting from lateral movement of wetlands due to sea-level rise, or *coastal squeeze* associated with any structures that prevent wetland landward migration and cause soil erosion.

In the next chapter we will propose accounting procedures for tidal wetlands conservation projects compliant with the above VCS requirements and in line with the terms of reference for this report.

2 GHG Accounting Procedures for Tidal Wetland Conservation

2.1 Generic procedures for AFOLU project categories

2.1.1 Project boundaries

The project boundary consists of the geographic boundary, the temporal boundary, the relevant carbon pools, and the relevant GHGs.

Project proponents must define the project boundary at the beginning of a proposed project activity and must provide the geographical coordinates of lands (including subtidal seagrass areas, where relevant) to be included.

Project proponents must determine the project crediting period and the project start date.

2.1.2 Determination of the baseline scenario

In line with VCS requirements, a CIW methodology must distinguish between planned and unplanned conversion of wetlands. In the case of planned conversion, conversion agents or classes of agents must be identified. From historical information, rates of conversion by these agents or agent classes can be estimated and extrapolated. In unplanned deforestation, agents are unlikely to be known and, therefore, a reference area (representative for the project area) must be defined where baseline processes can be assessed and the rate and location of conversion can be quantified. The conversion rate is based on historical information, while the location of conversion is assessed by determining areas likely to be converted in the future.

Procedures for the above approach have been developed for REDD projects and they can be applied for CIW with minimal modifications.

2.1.3 Additionality

Projects must exceed the likeliest "business-as-usual" scenario and demonstrate that GHG emission reductions or removals would not occur without revenue from the sale of VCUs.

Methodologies shall use a standardized method (i.e., 'performance method' or 'activity method') or a (traditional) project method to determine additionality and/or the crediting baseline, and shall state clearly which type of method is used for each.

The VCS provides procedures and rules for testing the additionality of a proposed project (project method) or demonstrating the additionality of a class of project activities in a methodology (standardized method). In essence, these procedures seek answers to the following questions: Was GHG emissions mitigation part of the rationale for project design and implementation? Did the presence of carbon markets provide an incentive to project implementation?

The benefit of a standardized approach is that projects that meet eligibility requirements set forth in the methodology are automatically deemed additional and do not have to undergo further testing. A combination of standardized and project approaches is allowable, where sufficient data may not be available to support a standardized approach for all project activities in a methodology.

Standardized methods are either *performance methods* or *activity methods*. *Performance methods* establish performance benchmark metrics for determining additionality and/or the crediting baseline. Projects that meet or exceed a predetermined level of the metric may be deemed as additional and a predetermined level of the metric may serve as the crediting baseline.

Activity methods predetermine additionality for given classes of project activities by using a positive list. Projects that implement activities on the positive list are automatically deemed additional and do not otherwise need to demonstrate additionality. One of three options (namely, activity penetration, financial viability, or revenue streams) is used to qualify the project activity for the positive list.

- The activity penetration option requires the methodology to demonstrate that the activity penetration rate is less than 5% of the maximum adoption rate.
- The financial viability option requires the methodology to prove that the project activity is less financially or economically attractive than the alternatives to the activity.
- The revenue streams option requires the methodology to demonstrate that the project activity does not have any significant sources of revenue other than the sale of GHG credits.

The rationale supporting the 5% threshold, which is set by the VCS, is that because certain types of project activities are being carried out only a small percentage of how much they could be carried out, the carbon market can provide an incentive to increase the adoption rate.

The draft "Methodology for Tidal Wetland and Seagrass Restoration" applies an activity method for tidal wetland restoration within the United States (excluding seagrass restoration). For seagrass restoration and tidal wetland restoration outside of the United States, the project method is required.

For the CIW methodology, we recommend that the activity method be developed where sufficient data exists. The necessary data sets are: (1) available opportunity for CIW activities—e.g., what is the extent of the areas that can be conserved; and (2) annual rate of adoption of CIW activities—e.g., what is the extent of areas being conserved, compared to the area that could be conserved. If available, these data could be analysed for specific countries, regions, or the globe. For the chosen region of analysis, the annual rate of adoption of CIW activities must be below 5%. A strong option for meeting the VCS WRC requirements would be to demonstrate a low level of activity penetration in one country, or region, such as the United States or North America, and further demonstrate that all other countries will have a lower penetration rate by comparison, e.g., through analysis of public and private investment in conservation, expert opinion, etc.

Where a performance method cannot be applied, due to insufficient evidence, projects must apply the project method, for which the VCS provides a tool. A project-level additionality test involves four steps:

1. Identification of alternative baseline scenarios—these tests must be performed against a set of alternative scenarios or the most likely baseline scenarios. There must be consistency between the determination of these scenarios and the determination of additionality of a project activity. This is why the VCS has adopted a combined tool for assessing baselines and additionality.
2. Regulatory surplus test—all scenarios must be in compliance with all mandatory applicable legal and regulatory requirements, unless those requirements are systematically not enforced and non-compliance is widespread. These legal requirements may involve the use of a specific technology, meeting a certain standard of performance, or managing operations according to a certain set of criteria or practices. The VCS does not consider mandatory those agreements without an enforcement mechanism, proposed laws or regulations, or general government policies.
3. Common practice test—A common practice analysis tests the extent to which similar activities have already diffused in the geographical area of the proposed project activity. Other registered AFOLU project activities must not be included in this analysis. Considerations must be limited to the period beginning 10 years prior to the project start date (VCS). Projects that are "first-of-its-kind" are not considered to be common practice.
4. Implementation barriers test—If the proposed project passes the tests for regulatory surplus and common practice, barriers to its implementation must be identified. Note that the baseline scenario is always considered to be a scenario without barriers to its implementation. Wording and categorization differ amongst standards, but barriers can be financial, technological, ecological, social or institutional barriers. The project must be faced with at least one of these barriers.

   In terms of financial barriers, if an investment test is used, one must determine whether the proposed project activity, without the revenue from the sale of GHG credits is economically or financially less attractive than the baseline scenario. If it is concluded that the proposed project produces no financial benefits other than carbon-related income then the project is deemed additional. If one of the other land use scenarios has the better indicator (e.g., higher IRR), or if the project has a less favorable indicator (e.g., lower IRR) than a benchmark, then the project cannot be considered as financially attractive and is deemed additional.

   Alternative investment barriers may be identified instead, such as lack of access to grants, debt funding or credit.

   There is a multitude of possible technological, ecological, social or institutional barriers, such as unfavorable environmental or institutional conditions or local traditions, lack of capacity, skill, consensus or infrastructure. The VCS tool provides the most extensive list of possible barriers that can be considered.

2.1.4 Accounting for carbon stock changes in biomass and soil

CO_2 emissions may be determined using carbon stock changes in carbon pools (for any carbon pool, *viz.* soil, biomass, litter, dead wood) as a proxy. If the determination of stocks is not feasible (e.g., in deep peatlands or in highly variable systems such as certain tidal wetlands) alternative methods need to be employed (see Section 2.2.5). For carbon stock changes two methods exist:

a. Gain-loss method: $\Delta C_t = \Delta C_{G,t} - \Delta C_{L,t}$

which subtracts the losses from the gains;

and

b. Stock difference method: $\Delta C_t = (C_t — C_{(t-T)}) / T$

which takes the difference between two points in time, where:

ΔC_t Change in carbon stock in year t; t C $ha^{-1}yr^{-1}$

$\Delta C_{G,t}$ Average annual increase in carbon stock (gain) in year t; t C $ha^{-1}yr^{-1}$

$\Delta C_{L,t}$ Average annual decrease in carbon stock (loss) in year t; t C $ha^{-1}yr^{-1}$

C_t Carbon stock in year t; t C ha^{-1}

t 1, 2, 3 … t^* years elapsed since the start of the project activity

T Number of years between times t and t_{-1}

The stock change approach has been used in various approved methodologies and can be applied in a CIW methodology for the assessment of both the baseline and the project scenario.

2.1.5 Accounting for emissions from fossil fuel use

In certain cases the fossil fuel combustion from transport and machinery in the project scenario must be accounted for. Where machinery use for earthmoving activities may be significant in WRC project activities as compared to the baseline, emissions shall be accounted for. Fossil fuel combustion from transport and machinery use in rewetting of drained peatland and conservation of peatland project activities need not be accounted for.

Emissions from the use of vehicles and mechanical equipment can be estimated using the procedures provided in A/R CDM methodological tool “Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities.”

2.1.6 Leakage

The VCS AFOLU requirements state that where the project results in activity shifting of forest products, the applicable requirements for leakage in REDD project activities shall be followed, accounting for both activity-shifting and/or market effects leakage. As in REDD, CIW distinguishes between avoiding planned or unplanned degradation.

In Avoided Planned Wetland Degradation (APWD) projects, activity-shifting leakage shall be quantified by directly monitoring the activities of the land conversion agent (e.g., deforestation agent or agent causing other forms of wetland degradation) identified in the baseline scenario. However, if the specific land conversion agent can be identified and it can be demonstrated that the management plans and/or land-use designations of the land conversion agent in other lands have not materially changed as a result of the project, leakage need not be considered. Where the specific land conversion agent cannot be identified, leakage shall be quantified based upon the difference between historic rates and project rates of wetland degradation as caused by the class of land conversion agent identified as most likely to be present within the region.

In Avoiding Unplanned Wetland Degradation (AUWD) projects, the potential for leakage shall be identified by addressing the socio-economic factors that drive wetland degradation. Leakage shall be calculated by monitoring wetland areas surrounding the project and other wetland areas within the country susceptible to leakage from activities found within the project area.

Since the requirements for leakage assessment in REDD and CIW are very similar, VCS-approved REDD methodologies can be used that provide procedures to account for leakage from shifting activities and market effects. Here follows a summary of leakage procedures in REDD methodology module VM0007.[6]

2.1.6.1 Activity-shifting leakage

The procedures distinguish projects that have an identified agent and those with only a class of agent. Where the agent is known, the methodology calculates the rate of deforestation (read: ‘conversion’ for CIW) by the agent across all actual and potential landholdings and subtracts the project (avoided) deforestation. Anything that exceeds this rate is leakage. For the class of agent, standard leakage

[6] Partly derived from Guidance Document for the Use of Avoided Deforestation Partners VCS REDD Modular Methodology <www.climatefocus.com>.

factors are used, based on the productivity of the project lands (and, therefore, the relative area of new lands needed to replace the project hectares).

The methods are divided between those for local agents and those for agents immigrating into the project region. It is assumed that a leakage belt around the project will capture deforestation by displaced local agents. For immigrants, however, it is possible that displacement will occur to an area far distant from the project. The methodology calculates the likelihood of immigration still occurring to the project region (looking at the project region as a proportion of suitable area for immigration in the country) and assumes a conservative emission for all immigrants that will not be captured in the leakage belt. Concerning the size of leakage belt and the level of effort in analysis of available area for unplanned deforestation, the methodology provides various options to weigh up the costs and benefits of the thoroughness of this analysis.

There is a risk that baseline activities will be displaced onto peatland, producing emissions that far outweigh the avoided emissions achieved by the project. To avoid this situation, procedures are in place accounting for such emissions, under the notion that if such emissions would be large the project design might be considered flawed.

2.1.6.2 Market effects leakage

Leakage deduction factors are directly from market effects defaults developed by the VCS. Market effects leakage is only applicable if timber is harvested during the process of deforestation timber (read: ‘goods produced on degraded wetland’ for CIW) in the baseline and/or fuel wood or charcoal was in the baseline harvested for commercial markets (sales more than 50km from the project area). If potential leakage is insignificant then market effects leakage need not be considered for the remainder of the baseline period.

2.2 Procedures specific to the CIW project category

2.2.1 Introduction

In this chapter we outline GHG accounting procedures specific to blue carbon conservation activities. In order to set the scene, we describe the typical scenarios covered by the procedures.

The principles used when developing the procedures are that they must be scientifically credible (and when science is insufficient for simple or generic procedures, we propose conservative alternatives that may reduce the volume of emission reductions that can be claimed, or put the onus on the project to justify the conservative use of methods), feasible to implement, and provide flexibility. Flexibility is created by allowing for the use of published data, default values, emission factors, field-collected data, proxies, models, and historical data or chronosequences, depending on the project’s circumstances.

2.2.2 Scenarios covered by the proposed procedures

Blue carbon interventions account for greenhouse gasses in two ways: carbon sequestration (taking up CO_2 from the atmosphere) and conservation (avoiding the release of greenhouse gasses to the atmosphere). That means, a carbon project can sequester carbon by creating carbon sinks in the form of a growing vegetation (e.g., by restoring a mangrove forest or a tidal marsh vegetation) or by enhancing carbon storage in soils and sediments (e.g., by inducing plant litter production and creating the necessary hydrological conditions), or it can protect the wetland ecosystem against degradation (e.g., caused by the removal of the vegetation or the loss and/or oxidation of wetland soil carbon).

The spectrum of blue carbon activities includes:

- Conservation / Avoided Emissions—Protection of at risk wetlands, improved water management on drained wetlands, sediment recharge on drowning coastal wetlands, creation of accommodation space for wetlands migrating with sea-level rise.

- Restoration and creation of wetlands—Breach of levees and reconnecting tides, lowering of water levels in impounded wetlands, raising soil surface with dredged material, increases in sediment supply by removing dams, restoring salinity conditions (reducing methane emissions), improving water quality, revegetation.

Concerning the carbon angle, the entire spectrum of blue carbon project activities has been captured by one of the leading voluntary market standards, the VCS. Incorporating both sequestration and conservation, the VCS, under its AFOLU standard,[7] includes five different project categories, *viz.* Afforestation, Reforestation and Revegetation (ARR), Improved Forest Management (IFM), Avoided Conversion of Grasslands and Shrublands (ACoGS), Reducing Emissions from Deforestation and forest Degradation (REDD) and Wetlands Restoration and Conservation (WRC). Under WRC, then, two more categories are recognised: Restoring Wetlands Ecosystems (RWE) and Conservation of Intact Wetlands (CIW). Not surprisingly, most blue carbon projects will be combinations of two or more of these categories. For example, a mangrove forest, including its soil, may be protected against degradation while already degraded parts of it will be restored. Such an intervention would combine elements of REDD, ARR and WRC. Further examples are given in Table 1.

[7] See <www.v-c-s.org/program-documents>.

Table 1. Blue carbon interventions and project categories recognised in the VCS AFOLU requirements

Baseline Scenario		Project Activity	VCS AFOLU category	Typical baseline scenarios*
Pre-project condition	Land Use			
Degraded wetland (including, drained, impounded, and with interrupted sediment supply)	Non-forest (including aquacultures, shrublands and grasslands)	Restoring wetlands#	RWE	
		Restoring wetlands# and revegetation or conversion to forest	RWE+ARR	
		Restoring wetlands# and conversion to wetland agriculture (including paludiculture)	RWE+ALM	
		Restoring wetlands# and avoided conversion of grassland or shrubland	RWE+ACoGS	
	Forest	Restoring wetlands#	RWE	
	Forest with deforestation/ degradation	Restoring wetlands# and avoided deforestation	RWE+REDD	
	Forest managed for wood products	Restoring wetlands# and improved forest management	RWE+IFM	
Non-wetland or open water	Non-forest	Creation of wetland conditions and afforestation, reforestation or revegetation	RWE+ARR	
	Open water or impounded wetland	Creation or restoration of conditions for afforestation, reforestation or revegetation	RWE+ARR	
Intact wetland	Non-forest (including shrubland and grassland)	Avoided drainage and/or interrupted sediment supply	CIW	Drainage of soils (e.g., for settlement, agriculture)

		Avoided conversion to open/ impounded water (including excavation to create fish ponds)**	CIW	Drainage of wetland due to impairment to hydrology Conversion to open water due to impairment to sediment supply Excavation of soils and placement in aerobic conditions (e.g., excavation of soils for levee building or removal of material to lower a surface or to clear organic soils such as for aquaculture pond construction, dredge channel cutting) Impounded water resulting in increased CH_4 emissions and/or reduced soil carbon stock accumulation Drowning due to sea-level rise (e.g., 'thin layer spraying') Nutrient loading resulting in loss of seagrass or marsh vegetation cover***
		Avoided drainage and/or interrupted sediment supply and avoided conversion of grasslands and shrublands	CIW+ACoGS	All of the above, when leading to loss of grassland or shrubland

	Forest	Avoided drainage and/or interrupted sediment supply	CIW	All of the above, when occurring of forested wetland
		Avoided conversion to open/ impounded water	CIW	
	Forest with deforestation/ degradation	Avoided drainage and/or interrupted sediment supply and avoided deforestation/degradation	CIW+REDD	All of the above, when leading to loss of forest
		Avoided conversion to open/ impounded water and avoided deforestation/degradation	CIW+REDD	
	Forest managed for wood products	Avoided drainage and/or interrupted sediment supply and improved forest management	CIW+IFM	All of the above, when associated with poor forest management

Source: See <www.v-c-s.org/program-documents>.
Notes: * The column "Typical baseline scenarios" has been added to the original VCS table.
** The division between this and "Avoided drainage and/or interrupted sediment supply" is not logical, because interrupted sediment supply may also lead to conversion to open water. The list under "Typical baseline scenarios" applies to a merged class identified as "Avoided drainage and/or interrupted sediment supply and/or excavation."
*** Open water is defined as non-vegetated wetland.
[#] This involves:
<u>Restoring Wetland Ecosystems (RWE)</u>: Activities that reduce GHG emissions or increase carbon sequestration in a degraded wetland through restoration activities. Such activities include enhancing, creating and/or managing hydrological conditions, sediment supply, salinity characteristics, water quality and/or native plant communities.
<u>Conservation of Intact Wetlands (CIW)</u>: Activities that reduce GHG emissions by avoiding degradation and/or the conversion of wetlands that are intact or partially altered while still maintaining their natural functions, including hydrological conditions, sediment supply, salinity characteristics, water quality and/or native plant communities.
The VCS AFOLU requirements specify various project activities together with specific conditions that need to be met for eligibility under the program.

2.2.3 Soil organic carbon Depletion Time

The Soil organic carbon Depletion Time (SDT) is one of the aspects of temporal project boundaries specific to wetlands. Projects that claim the reduction of baseline GHG emissions through conservation must estimate the SDT.

The SDT is the time it would have taken for the soil organic carbon to be lost due to oxidation or to reach a steady state where no further losses occur. No GHG emissions reductions may be claimed for a given area of wetland for longer than the SDT. The procedure for determining the SDT shall conservatively consider soil organic carbon content and oxidation rate within the project boundary and SDT estimation may be based on the relationship between water table depth and soil organic carbon content in the project area. Where wetland soils are subject to sedimentation or erosion, the procedure for determining the SDT shall conservatively account for the associated gain or loss of soil organic carbon. This assessment is not mandatory in cases where soil organic carbon content may average *de minimis* levels.

Associated with SDT is PDT (Peat Depletion Time). PDT is the time it would have taken for the peat to be completely lost due to oxidation or other causes, or for the depth of the peat to reach a level where no further oxidation or other losses occur. No GHG emission reductions may be claimed for a given area of peatland for longer than the PDT. The procedure for determining the PDT shall conservatively consider peat depth and oxidation rate within the project boundary and PDT may be estimated based on the relationship between water table depth, subsidence (e.g., using peat loss and water table depth relationships established in scientific literature), and peat depth in the project area.

Procedures for SDT and PDT have been developed for the methodology 'Methodology for Tidal Wetland and Seagrass Restoration' (RAE)[8] and can be summarized as follows.

$t_{SDT\text{-}BSL} = C_{min,t0} / Rate_{Closs\text{-}BSL}$

which calculates how long it takes for a certain amount of carbon at project start to vanish, given a loss rate, where:

$t_{SDT\text{-}BSL}$	Soil organic carbon Depletion Time in the baseline scenario in years elapsed since the project start; yr
$C_{min,t0}$	Average organic carbon content in mineral soil at project start; t C ha^{-1}
$Rate_{Closs\text{-}BSL}$	Rate of soil organic carbon (SOC) loss due to oxidation in the baseline scenario; t C ha^{-1} yr^{-1}

$t_{PDT\text{-}BSL} = Depth_{peat,t0} / Rate_{peatloss\text{-}BSL}$

which calculates how long it takes for a certain amount of carbon at project start to vanish, based on the depth of the peat at project start and a loss rate of peat, where:

$t_{PDT\text{-}BSL}$	Peat Depletion Time in the baseline scenario in years elapsed since the project start; yr
$Depth_{peat,t0}$	Average peat depth above the drainage limit at project start; m
$Rate_{peatloss\text{-}BSL}$	Rate of peat loss due to subsidence and fire in the baseline scenario; m yr^{-1}

No amendments are required for a conservation methodology.

[8] Under validation, see <www.v-c-s.org/methodologies/in-development>.

2.2.4 Permanence of carbon stock conservation

For projects quantifying CO_2 emission reductions, areas within the project boundary which do not achieve a significant difference (≥5%) in cumulative carbon loss over a period of 100 years beyond the project start date are not eligible for carbon crediting, based on the reduction of baseline emissions, and these areas must be mapped.

The maximum eligible quantity of GHG emission reductions from soil is limited to the difference between the remaining soil organic carbon stock in the project and baseline scenarios after 100 years (total stock approach), or the difference in cumulative soil organic carbon loss in both scenarios over a period of 100 years since the project start date (stock loss approach). The assessment must be executed *ex ante* using conservative parameters.

Procedures for the quantification of the maximum eligible quantity of GHG emission reductions from soil have been developed for the methodology ‘Methodology for Tidal Wetland and Seagrass Restoration’ (RAE)[9] and can be summarized as follows.

Total stock approach: The difference between soil organic carbon stock in the project scenario and baseline scenario at t = 100 is estimated as:

$$C_{WPS\text{-}BSL,t100} = (C_{WPS,t100} \text{ x } A_{WPS}) — (C_{BSL,t100} \times A_{BSL})$$

which calculates the difference between soil organic carbon stock in the project scenario and baseline scenario from carbon stock per unit area and the area of the project.

Stock loss approach: The assessment may also be based on cumulative soil organic carbon loss up to t = 100 as follows:

$$C_{WPS\text{-}BSL,t100} = (C_{loss\text{-}BSL,t100} \times A_{BSL}) — (C_{loss\text{-}WPS,t100} \times A_{WPS})$$

which calculates the difference between soil organic carbon stock in the project scenario and baseline scenario from the difference in loss rates in the baseline and the project scenario, where:

$C_{WPS\text{-}BSL,t100}$ Difference between soil organic carbon stock in the project scenario and baseline scenario at t = 100; t C ha^{-1}

$C_{WPS,t100}$ Soil organic carbon stock in the project scenario at t = 100; t C ha^{-1}

$C_{BSL,t100}$ Soil organic carbon stock in the baseline scenario at t = 100; t C ha^{-1}

A_{WPS} Area of project stratum; ha

A_{BSL} Area of baseline stratum; ha

$C_{loss\text{-}BSL,t100}$ Cumulative soil organic carbon loss in the baseline scenario at t = 100; t C ha^{-1}

$C_{loss\text{-}WPS,t100}$ Cumulative soil organic carbon loss in the project scenario at t = 100; t C ha^{-1}

t_{100} 100 years after the project start date

A further elaboration of the parameters in the equations is provided in the RAE restoration methodology. No amendments are required for a conservation methodology.

[9] *ibid*.

2.2.5 GHG emissions from wetlands soil

2.2.5.1 General

The net GHG emissions from soil in both the baseline and project scenario are estimated as:

$$GHG_{soil,t} = A_t \times (GHG_{soil\text{-}CO2,t} - Deduction_{alloch} + GHG_{soil\text{-}CH4,t} + GHG_{soil\text{-}N2O,t})$$

which calculates the GHG emission from the soil by a summation of emissions of CO_2 (corrected for the share of allochthonous carbon in the soil), CH_4 and N_2O, where:

$GHG_{soil,t}$	GHG emissions from the soil organic carbon (SOC) pool in year *t*; t CO_2e yr^{-1}
$GHG_{soil\text{-}CO2,t}$	CO_2 emissions from the SOC pool in year *t*; t CO_2e ha^{-1} yr^{-1}
$Deduction_{alloch}$[10]	Deduction from CO_2 emissions from the SOC pool to account for the percentage of the carbon stock that is derived from allochthonous soil organic carbon; t CO_2e ha^{-1} yr^{-1}
$GHG_{soil\text{-}CH4,t}$	CH_4 emissions from the SOC pool in year *t*; t CO_2e ha^{-1} yr^{-1}
$GHG_{soil\text{-}N2O,t}$	N_2O emissions from the SOC pool in year *t*; t CO_2e ha^{-1} yr^{-1}
A_t	Area of project in year *t*; ha
t	1, 2, 3, … *t** years elapsed since the project start date

A model may be used to generate a rate for GHG emissions in the same or similar systems as those in the project area. The project may apply deterministic models (models as defined in the *VCS Standard*) to derive values of GHG emissions. Modeled GHG emissions and removals must have been validated with direct measurements from a system with the same or similar water table depth and dynamics, salinity, tidal hydrology, sediment supply and plant community type.

Peer-reviewed, published data may also be used to generate values for the average rate of GHG emissions in the same or similar systems as those in the project area. These 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 GHG emissions.

The most recently published IPCC emission factors[11] may be used for non-tidal wetland and seagrass systems in the absence of data suitable for using the published-value approach.

2.2.5.2 CO_2 emissions from soil

CO_2 emissions must be estimated in the baseline scenario. Projects may use published values, models, historical data or chronosequences, or emission factors.

CO_2 emissions must be estimated in the project scenario. Projects may use proxies, field-collected data, published values, default factors, or models.

CO_2 emissions may be estimated using proxies such as carbon stock change, soil subsidence, water table and vegetation composition, as:

$$GHG_{soil\text{-}CO2,t} = f\ (\text{GHG emission proxy})$$

[10] In some cases, allochthonous soil organic carbon may accumulate on the project site where this carbon may be accounted in the baseline towards the benefit of the project. Procedures for the estimation of a compensation factor for allochthonous soil organic carbon are provided.

[11] 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. See <www.ipcc-nggip.iges.or.jp/home/wetlands.html>.

Various methodologies exist[12] that spell out the procedures for this approach.

For non-seagrass tidal wetland systems, a general default factor may be used:

$GHG_{soil\text{-}CO2,t}$ = -1.4[13] t C ha^{-1} yr^{-1} × 44/12

This default factor may only be applied to areas with a crown cover of at least 50%. By contrast, for areas with a crown cover of less than 15%, this value can be assumed to be insignificant and accounted as zero.

Soil coring may be used to measure soil organic carbon stock. It is estimated by determining the organic carbon accumulated above a consistent reference plane in the cores and then dividing by the years since the date of the reference plane (for the baseline scenario) or the start of project activities (for the project scenario). The reference plane must be established using a marker horizon (most commonly using feldspar),[14] a strongly contrasting soil layer (such as the boundary between organic and mineral soil materials), an installed reference plane (such as the shallow marker in a surface elevation table),[15] a layer identified biogeochemically (such as through radionuclide, heavy metal, or biological tracers),[16] a layer with soil organic carbon indistinguishable from the baseline SOC concentration,[17] or other accepted technologies. The material located above the reference plane must be analyzed for total carbon and bulk density.

The rate of organic soil carbon loss due to oxidation in the baseline scenario from mineral soils may be estimated using either historical data collected from the project site or chronosequence data collected at similar sites.

Published values and models may be used to estimate CO_2 emissions as described in Section 2.2.5.1.

The most recently published IPCC Emission Factors may be used for non-tidal wetland and seagrass systems in the absence of data suitable for using the published value approach.

A deduction from the estimate of the CO_2 emissions may be used to account for the percentage of those emissions that are derived from allochthonous soil organic carbon. A deduction must not be used if the approach used above to estimate CO_2 emissions directly estimates autochthonous CO_2 emissions or otherwise accounts for allochthonous carbon. This deduction may be conservatively set to zero for the baseline. Procedures for this deduction have been developed for the methodology, “Methodology for Tidal Wetland and Seagrass Restoration” (RAE).[18]

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[12] See e.g., Baseline and Monitoring Methodology for the Rewetting of Drained Peatlands used for Peat Extraction, Forestry or Agriculture based on GESTs; Methodology for Tidal Wetland and Seagrass Restoration (both at <www.v-c-s.org>).

[13] The median rate (Poffenbarger et al. 2011) from the literature synthesis of Chmura et al. 2001 was used as a default factor. The synthesis included studies worldwide, including marshes and mangroves. The median was used as the best estimate of central tendency because the data were not normally distributed.

[14] Cahoon & Turner 1989.

[15] Cahoon *et al.* 2002.

[16] DeLaune *et al.* 1978.

[17] Greinier *et al.* in press.

[18] Under validation, see <www.v-c-s.org/methodologies/in-development>.

Table 2. Potential for CO_2 removals and/or oxidation in typical baseline scenarios

Typical baseline scenario	**CO_2 removals in baseline**	**CO_2 oxidation in baseline**
Drainage of soils (e.g., for settlement, agriculture)	Yes	Yes
Drainage of wetland due to impairment to hydrology	Yes, if still vegetated	Yes
Conversion to open water due to impairment to sediment supply	No	Eroded material only
Excavation of soils and placement in aerobic conditions (e.g., excavation of soils for levee building or removal of material to lower a surface or to clear organic soils such as for aquaculture pond construction, dredge channel cutting)	Yes, if still vegetated	Yes
Impounded water resulting in increased CH_4 emissions and/or reduced soil carbon stock accumulation	Yes, if still vegetated	No (assuming negligible eroded material)
Drowning due to sea-level rise (e.g., 'thin layer spraying')	No	Eroded material only
Nutrient loading resulting in loss of seagrass or marsh vegetation cover*	No (assuming all cover lost)	Eroded material only

Note: * Open water is defined as non-vegetated wetland.

2.2.5.3 CH_4 emissions from soil

CH_4 emissions in the baseline scenario may be conservatively set to zero. Baseline CH_4 emissions may be estimated using published values, models, or emission factors.

CH_4 must be estimated in the project scenario. Projects may use proxies, field-collected data, published values, default factors, or models.

Where relevant, CH_4 emissions from organic soil may be estimated using proxies such as water table and vegetation composition, as:

$GHG_{soil\text{-}CH4,t} = f$ (GHG emission proxy) × $VCS_{CH4\text{-}GWP}$

($VCS_{CH4\text{-}GWP}$: Current VCS value for global warming potential of CH_4; dimensionless)

The default factor[19] of $GHG_{soil\text{-}CH4,i,t}$ may be used for tidal wetland systems. Where the salinity average or salinity low point is >18 ppt, projects may apply a default emission of

$GHG_{soil\text{-}CH4,t} = 0.011 \text{ t } CH_4 \text{ ha}^{-1} \text{ yr}^{-1} \times VCS_{CH4\text{-}GWP}$

Where the salinity average or salinity low point is ≥20, projects may apply a default emission of

$GHG_{soil\text{-}CH4,i,t} = 0.0056 \text{ t } CH_4 \text{ ha}^{-1} \text{ yr}^{-1} \times VCS_{CH4\text{-}GWP}$

Procedures for measuring the salinity average or salinity low point are available from the literature.

Project proponents may not use the default value of 0.11 for the baseline and 0.0056 for the project scenario to create a difference and claim an emission reduction. The use of the default value is intended for projects that protect salinity levels that inhibit CH_4 emissions.

[19] Taken from Poffenbarger *et al.*, 2011.

Field-collected data used to estimate CH_4 emissions may be made with either a closed chamber technique or a chamber-less technique such as eddy covariance flux using accepted methodologies.

Published values and models may be used to estimate CH_4 emissions as described in Section 2.2.5.1.

The most recently published IPCC Emission Factors may be used for non-tidal wetland systems in the absence of data suitable for using the published value approach. Tier 1 values may be used, but must be applied conservatively including accounting for local salinity and vegetative cover conditions.

Table 3. Potential for CH_4 emissions in typical baseline scenarios

Typical baseline scenario	**CH_4 emissions in baseline**
Clearing wetlands of vegetation (e.g., forest wood extraction, clearance for aquaculture)	Yes, e.g., for wetland land uses such as aquaculture
Drainage of soils (e.g., settlement, agriculture)	No
Excavation of soils and placement in aerobic conditions (e.g., excavation of soils for levee building or removal of material to lower a surface or to clear organic soils such as for aquaculture pond construction, dredge channel cutting)	Yes, emissions from areas of soil excavation
Impaired drainage resulting in increased CH_4 emissions and/or reduced soil carbon stock accumulation	Yes
Nutrient loading resulting in loss of vegetation cover	Yes, in shallow open water
Degradation of wetland due to impairment to hydrology or sediment supply	Yes
Conserve against sea-level rise (e.g., thin lift dredge material placement)	Yes, in shallow open water

2.2.5.4 N_2O emissions from soil

N_2O emissions may be conservatively excluded in the baseline scenario. Baseline N_2O emissions may be estimated using published values, default values (for open water scenarios), models, or emission factors. See Table 4.

N_2O must be estimated in the project scenario. Projects may use proxies, field-collected data, published values, default factors, or models.

Where relevant, N_2O emissions may be estimated using proxies such as water table and vegetation composition, as:

$GHG_{soil\text{-}N2O,t} = f$ (N_2O emission proxy) $\times VCS_{N2O\text{-}GWP}$

($VCS_{N2O\text{-}GWP}$: VCS global warming potential for N_2O; dimensionless)

Table 4. Potential for N_2O emissions in typical baseline scenarios

Typical baseline scenario	**N_2O emissions in baseline**
Drainage of soils (e.g., for settlement, agriculture)	Yes, particularly for agriculture
Drainage of wetland due to impairment to hydrology	Yes, default value for open water
Conversion to open water due to impairment to sediment supply	Yes, default value for open water
Excavation of soils and placement in aerobic conditions (e.g., excavation of soils for levee building or removal of material to lower a surface or to clear organic soils such as for aquaculture pond construction, dredge channel cutting)	Yes, default value for open water, emission factors for aquaculture?
Impounded water resulting in increased CH_4 emissions and/or reduced soil carbon stock accumulation	Yes, default value for open water
Drowning due to sea-level rise (e.g., 'thin layer spraying')	Yes, default value for open water
Nutrient loading resulting in loss of seagrass or marsh vegetation cover	Yes, default value for open water

The following default factors[20] of $GHG_{BSL\text{-}soil\text{-}N2O,i,t}$ may be used in the absence of data suitable for using the published value approach for the systems listed below except when the project area receives direct hydrologic inputs from a point or non-point source of nitrogen such as wastewater effluent or an intensively nitrogen-fertilized system or runoff.

Open water systems where the salinity average or salinity low point is >18 ppt:

$GHG_{soil\text{-}N2O,t}$ = 0.00015 t N_2O ha^{-1} yr^{-1} × $VCS_{N2O\text{-}GWP}$

Open water systems where the salinity average or salinity low point is >5 ppt:

$GHG_{soil\text{-}N2O,t}$ = 0.00030 t N_2O ha^{-1} yr^{-1} × $VCS_{N2O\text{-}GWP}$

Other open water systems:

$GHG_{soil\text{-}N2O,t}$ = 0.00045 t N_2O ha^{-1} yr^{-1} × $VCS_{N2O\text{-}GWP}$

Non-seagrass wetland systems where the salinity average or salinity low point is >18 ppt:

$GHG_{soil\text{-}N2O,t}$ = 0.00049 t N_2O ha^{-1} yr^{-1} × $VCS_{N2O\text{-}GWP}$

Non-seagrass wetland systems where the salinity average or salinity low point is >5 ppt:

$GHG_{soil\text{-}N2O,t}$ = 0.00070 t N_2O ha^{-1} yr^{-1} × $VCS_{N2O\text{-}GWP}$

Other non-seagrass wetland systems:

$GHG_{soil\text{-}N2O,t}$ = 0.00076 t N_2O ha^{-1} yr^{-1} × $VCS_{N2O\text{-}GWP}$

Field-collected data used to estimate N_2O emissions may be made with either a closed chamber technique or a chamber-less technique such as eddy covariance flux using accepted methodologies.

Published values and models may be used to estimate N_2O emissions as described in Section 2.2.5.1.

[20] Taken from Smith *et al.*, 1983.

The most recently published IPCC Emission Factors may be used in the absence of data suitable for using the published value approach. Tier 1 values may be used, but must be applied conservatively including accounting for local salinity and vegetative cover conditions.

2.2.6 Effects of sea-level rise

2.2.6.1 Wetland carbon balance

The consequences of submergence of project area due to sea-level rise are:

1) Carbon stocks from aboveground biomass are lost to oxidation, and
2) Depending upon geomorphic setting, soil carbon stocks may be held intact or be eroded and transported beyond the project boundary.

For consequence 1), if biomass is submerged, it is assumed that this carbon is immediately and entirely returned to the atmosphere. For such strata:

$$\Delta C_{BSL\text{-}biomass,t} = 44/12 \times (C_{BSL\text{-}biomass,t} — C_{BSL\text{-}biomass,(t\text{-}T)}) / T$$

For the year of submergence:

$$C_{BSL\text{-}biomass,i,t} = 0$$

where:

$\Delta C_{BSL\text{-}biomass,t}$	Net carbon stock changes in biomass carbon pools in the baseline scenario in year t; t C yr^{-1}
$C_{BSL\text{-}biomass,t}$	Carbon stock in biomass in the baseline scenario in year t; t C ha^{-1}
t	1, 2, 3, … t* years elapsed since the project start date
T	Time elapsed between two successive estimations (T=t_2—t_1)

The gradual loss of vegetation in a project area due to submergence can be captured by detailed stratification into areas with and areas without vegetation.

If conversion to open water is expected before the end of the project-crediting period, the long-term average carbon stock must be determined by averaging the stock over the length of the project-crediting period. This long-term average is the maximum for $\Delta C_{BSL\text{-}biomass}$ that may be used for the calculation of the net CO_2 equivalent emissions in the project scenario up to the moment of verification. Examples of how to calculate the long-term average carbon stock are provided in VCS AFOLU *Guidance Example for Calculating the Long-Term Average Carbon Stock for ARR Projects with Harvesting*.

For consequence 2), the project may apply models to assess time and rate of drowning of the project area. For areas that drown out while the area of ponds increases, the loss of SOC can be assumed to be insignificant.

In areas with wave action, sediment will erode and carbon will be removed. It is one of the great challenges for the development of a conservation methodology to determine how much of this carbon will oxidize and how much will be re-sedimented and stored.

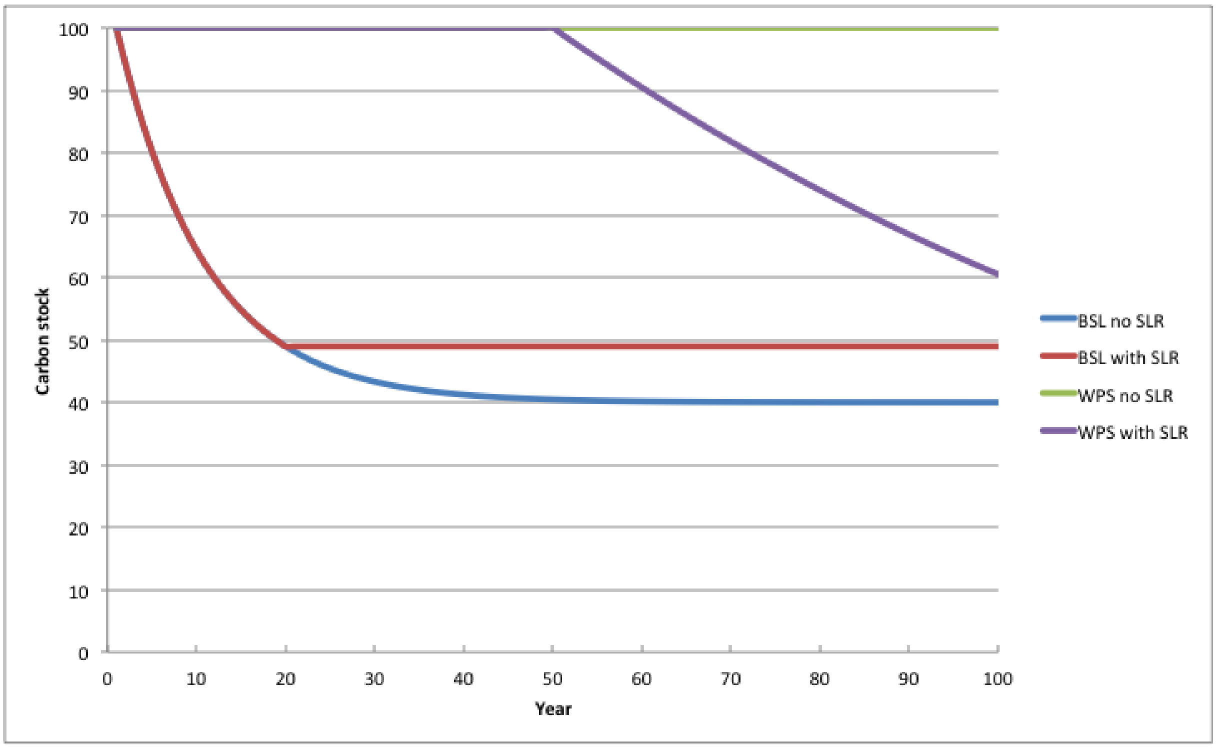
For the project case, one may conservatively assume that all carbon is oxidized. However, for the baseline assuming that all carbon is oxidized (and consequently claim all carbon conserved) is not conservative.

Therefore, the assumption that all carbon is oxidized creates a conflict and, moreover, a conservation project would be over-credited.

In contrast with the project case, for the baseline one can conservatively assume that no carbon is oxidized. Whether this overburdens the conservation project depends on a number of factors. These include the point in time when submergence and erosion sets off (which may be different for the baseline and project scenario), the amount of carbon that erodes upon submergence (this also may be different for the baseline and project scenario) and the oxidation rate of eroded soil organic matter. In the most conservative approach, the oxidation constant is 0 for the baseline and 1 for the project scenario.

In a well-designed conservation project, the resilience to sea-level rise is likely to increase, resulting in submergence that occurs later in time and erosion that is slower than in the baseline scenario. For example, in a hypothetical case (without reference to any existing case or situation) where 60% of the carbon stock is excavated in baseline activities, the rate of erosion is 5% and 1% annually for the baseline and project, respectively, erosion begins after 20 and 50 years for baseline and project, respectively, and the decay constant of in situ soil organic matter is set to 0.1, the conservation activity is set to reduce emissions by 11% of the original carbon stock (Figure 1), despite the unfavorable difference in oxidation rates between baseline and project scenario. With a more favorable difference (with a rate of greater than 0 for the baseline and smaller than 1 for the project case) the results would improve considerably, and, therefore, project proponents shall be allowed to justify a narrower spread between the baseline and project oxidation rates based on appropriate scientific research.

Figure 1. Hypothetical comparison of baseline and project scenario showing how excavation rate, erosion rate and oxidation constant interact



2.2.6.2 Geographic project boundary

In the determination of geographical project boundaries, project proponents must consider expected relative sea-level rise and the potential for expanding the project area landward to account for wetland migration, inundation and erosion.

For both the baseline and project scenarios, the project proponent must provide a projection of relative sea-level rise within the project area based on IPCC forecasts or peer-reviewed literature applicable to the region. In addition, the project proponent may also utilize expert judgment. Global average sea-level rise scenarios are not suitable for determining changes in wetlands boundaries. Therefore, if used, IPCC most-likely global sea-level rise scenarios must be appropriately downscaled to regional conditions, including vertical land movements such as subsidence.

Whether degraded in a baseline scenario or protected or restored in a project scenario, the assessment of potential wetland migration, inundation, and erosion with projected sea-level rise must account for topographical slope, land use and management, sediment supply and tidal range. The assessment may use literature relevant to the project area, expert judgment, or both.

The potential for tidal wetlands to migrate horizontally must consider the topography of the adjacent land and any migration barriers that may exist. In general, concave up-slopes may cause 'coastal squeeze', while straight or convex up-gradients are more likely to provide the space required for lateral movement.

The potential for tidal wetlands to rise vertically with sea-level rise is sensitive to suspended sediment loads in the system. A sediment load of >300 mg per liter has been found to balance high-end IPCC scenarios for sea-level rise (Orr *et al*. 2003, Stralsburg *et al*. 2011); project proponents may use this as a sediment load threshold above which wetlands are not predicted to be submerged, however, lateral erosion must still be accounted for. The assessment may use lower threshold values for sediment load if justified. The vulnerability of tidal wetlands to sea-level rise and conversion to open water is also related to tidal range. In general, the most vulnerable tidal wetlands are those in areas with a small tidal range, those with elevations low in the tidal frame, and those in locations with low suspended sediment loads.

Alternatively, in a project scenario, the project proponent may conservatively assume that part of the wetland within the project area erodes and does not migrate. In a baseline scenario, the project proponent may conservatively assume that part of the project area drowns, with reduced emissions as a consequence.

The projection of wetland boundaries within the project area must be presented in maps delineating these boundaries from the project start date until the end of the project crediting period, with intervals appropriate to the rate of change due to sea-level rise, and at $t = 100$.

2.2.7 Ecological leakage

Ecological leakage occurs in WRC projects where a project activity causes changes in GHG emissions or fluxes of GHG emissions from ecosystems that are hydrologically connected to the project area. Monitoring and quantifying ecological leakage may be an onerous burden on WRC projects and, if simplifications in the assessment cannot be found, the accounting protocol may include applicability criteria that render ecological leakage inexistent or not significant.

This can be achieved by determining that hydrological connectivity with adjacent areas is insignificant (i.e., causing no significant alteration of mean annual water table depths in such areas). Conservation projects have the intention to keep the natural hydrology of the project area intact, and therefore are unlikely to cause the abovementioned changes.

Therefore, ecological leakage in CIW projects equals 0

3 Summary

This document provides an approach to developing a GHG offset methodology for tidal wetland conservation, which is consistent with the requirements of the VCS. A conservation methodology could provide financial incentives for the conservation of mangroves, salt marsh, and other tidal wetlands in developing countries and elsewhere.

4 Annex: Recommendations for Incorporating the "Greenhouse Gas Offset Methodology Criteria for Tidal Wetland Conservation" into Future Methodologies

Under the Verified Carbon Standard (VCS) standard no methodologies exist to allow the issuance of carbon offsets for tidal wetland conservation projects. The VCS has so far approved four forest conservation methodologies, of which two have a broad scope: VM0007 REDD Methodology Modules and VM0009 Methodology for Avoided Deforestation.

The VCS will eventually consider consolidating methodologies. It is likely that it will opt for a modular approach, such as established by the Clean Development Mechanism (CDM) for Afforestation/Reforestation (A/R) project activities. Under the VCS requirements, a modular methodology includes its basic functional structure in a Framework, and accompanying, pre-defined modules and tools that perform specific functions. A modular methodology for Reducing Emissions from Deforestation and Degradation (REDD) already exists (VM0007), which has recently been upgraded to include peatland accounting procedures. VM0007 now also incorporates afforestation, reforestation, and revegetation (ARR) procedures, which makes it suitable for restoration activities as well and it can therefore accommodate projects that cover, with a landscape approach, both conservation and restoration work. It constitutes a complete REDD+ baseline and monitoring methodology.

Expanding this modular methodology would prepare the proposed Conservation of Intact Wetland (CIW) procedures for simple application in future methodologies.

Modules include:

Carbon Pool Modules:

- CP-AB "VMD0001 Estimation of carbon stocks in the above- and below-ground biomass in live tree and non-tree pools"
- CP-D "VMD0002 Estimation of carbon stocks in the dead-wood pool"
- CP-L "VMD0003 Estimation of carbon stocks in the litter pool"
- CP-S "VMD0004 Estimation of carbon stocks in the soil organic carbon pool (mineral soils)"
- CP-W g"VMD0005 Estimation of carbon stocks in the long-term wood products pool"

Baseline Modules:

- BL-PL "VMD0006 Estimation of baseline carbon stock changes and greenhouse gas emissions from planned deforestation and planned degradation"
- BL-UP "VMD0007 Estimation of baseline carbon stock changes and greenhouse gas emissions from unplanned deforestation"
- BL-DFW "VMD0008 Estimation of baseline emission from forest degradation caused by extraction of wood for fuel"
- BL-ARR "VMD00xx[21] Estimation of baseline carbon stock changes and greenhouse gas emissions in ARR project activities on peat and mineral soil"
- BL-PEAT "VMD00xx Estimation of baseline soil carbon stock changes and greenhouse gas emissions in peatland rewetting and conservation project activities"

[21] 'xx' signifies that these modules are still in the process of validation and a final number will be obtained upon VCS approval.

Leakage Modules:

- LK-ASP "VMD0009 Estimation of emissions from activity shifting for avoided planned deforestation and planned degradation"
- LK-ASU "VMD0010 Estimation of emissions from activity shifting for avoided unplanned deforestation"
- LK-ME "VMD0011 Estimation of emissions from market-effects"
- LK-DFW "VMD0012 Estimation of emissions from displacement of fuelwood extraction"
- LK-ARR "VMD00xx Estimation of emissions from displacement of pre-project agricultural activities"
- LK-ECO "VMD00xx Estimation of emissions from ecological leakage"

Emissions Modules (applicable to baseline, project scenario and leakage):

- E–BPB "VMD0013 Estimation of greenhouse gas emissions from biomass and peat burning"
- E-FFC "VMD0014 Estimation of emissions from fossil fuel combustion"
- E-NA "Estimation of direct N_2O emissions from nitrogen application"—latest CDM-EB approved version

Monitoring Modules:

- M-REDD "VMD0015 Methods for monitoring of greenhouse gas emissions and removals in REDD project activities"
- M-ARR "VMD00xx Methods for monitoring greenhouse gas emissions and removals in ARR project activities on peat and mineral soil"
- M-PEAT "VMD00xx Methods for monitoring of soil carbon stock changes and greenhouse gas emissions and removals in peatland rewetting and conservation project activities"

Miscellaneous Modules:

- X-STR "VMD0016 Methods for stratification of the project area"
- X-UNC "VMD0017 Estimation of uncertainty for REDD+ project activities"

Tools:

- T-SIG "Tool for testing significance of GHG emissions in A/R CDM project activities"—latest CDM-EB approved version
- T-ADD"Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities"—latest CDM-EB approved version
- T-BAR "Tool for AFOLU non-permanence risk analysis and buffer determination"—latest VCS-approved version

The Methodology Framework includes a decision tree (below) and applicability conditions, allowing project proponents to assess if the methodology is suitable. We tentatively expanded this decision tree for use in a CIW context.

The decision tree below (Table A-1) shows how to assess whether or not a project is eligible under the Afforestation, Reforestation, and Revegetation (ARR) modules. If the project is eligible and has coastal or peatland degraded habitat, Table A-2 shows how to add the Wetlands Restoration and Conservation (WRC) modules, depending on what types of activities/habitats are included in the project. Table A-3 presents the current modules within the structure of the modular methodology. Once the combination of required ARR and WRC modules is determined, Table A-3 shows how those modules would be combined.

Table A-1. Decision Tree for the VCS Afforestation, Reforestation, and Revegetation (ARR) modular methodology, expanded for use in a Conservation of Intact Wetland (CIW) context

<table>
<tr><td colspan="4">Is the forest land expected to be converted to non-forest land in the baseline case, or expected to be subject to authorized conversion to a managed tree plantation in the baseline case?</td></tr>
<tr><td colspan="2">YES*</td><td colspan="2">NO</td></tr>
<tr><td colspan="2">Is the land legally authorized and documented for conversion to non-forest or a managed tree plantation?</td><td colspan="2">Is the forest in the baseline expected to be degraded by fuelwood extraction or charcoal production?</td></tr>
<tr><td>YES**</td><td>NO</td><td>YES</td><td>NO</td></tr>
<tr><td>Avoiding planned deforestation/planned degradation</td><td>Avoiding unplanned deforestation</td><td>Avoiding forest degradation</td><td>Proposed project is not a VCS REDD*** activity currently covered by the Framework</td></tr>
<tr><td colspan="4">Is part of the land non-forest land or with degraded forest?</td></tr>
<tr><td colspan="2">YES</td><td colspan="2">NO</td></tr>
<tr><td colspan="2">Suitable for ARR</td><td colspan="2">No additional activity</td></tr>
</table>

Notes: * If the answer is "yes," evidence must be provided, based on the application of the appropriate baseline module (*BL-PL* for APD and *BL-UP* for AUDD).
** If the answer is "yes," evidence must be provided, based on the application of the *BL-PL* module. Project proponents are required to show legal permissibility to deforest, suitability of project area for conversion and intent to deforest.
*** If degradation is occurring through legal or sanctioned timber production, then this is an eligible IFM activity.

If the project area includes coastal wetlands or peatland already degraded (for peatlands, this would imply drained) or that would be degraded in the baseline case, project proponents must combine the project activities identified above with the WRC category, as shown in Table A-2.

Table A-2. Wetlands Restoration and Conservation (WRC) modules to be added for Conservation of Intact Wetland (CIW) projects according to project activities/habitats

Baseline scenario		Project activity	Combined categories@
Pre-project condition	**Land Use**		
Drained peatland/ Degraded wetland	Non-forest with degradation	Wetland restoration# and conversion to forest/revegetation	RWE+ARR
		Wetland restoration	RWE
	Forest with deforestation/degradation	Wetland restoration and avoided deforestation	RWE+REDD
Undrained peatland/ Intact wetland	Non-forest with degradation	Avoiding drainage and/or interrupted sediment supply Avoiding conversion to open water or impounded wetland Avoiding degradation of seagrass beds	CIW*
	Forest with deforestation/degradation	Avoiding drainage and/or interrupted sediment supply and avoided deforestation Avoiding conversion to open water or impounded wetland and avoiding deforestation	CIW*+REDD

Notes: @ See Table A-3 for how modules are to be combined.
Includes wetlands creation (see VCS AFOLU requirements).
* Includes Avoiding Unplanned Wetland Degradation (AUWD) and Avoiding Planned Wetland Degradation (APWD).

The modules listed above can be relatively easily amended to include additional CIW functionality, and new modules can be proposed as well. One could propose to update modules BL-PEAT, M-PEAT (and rename to BL-WRC and M-WRC) and X-STR to include new procedures. Leakage modules can be amended to include procedures for tidal wetlands restoration and conservation. A standardized approach for additionality can be covered in the Methodology Framework. Table A-3 shows how they would fit the modular structure. For categories marked “***”, new modules could be proposed.

Table A-3. List of modules/tools and determination of when module/tool use is mandatory or optional

		Avoiding Unplanned Deforestation/ Degradation	Avoiding Planned Deforestation	Avoiding Degradation (Fuelwood / Charcoal)	ARR	REDD or ARR on wetland
Always Mandatory	***REDD-MF***	M	M	M	M	M
	M-REDD	M	M	M	-	←
	M-ARR	-	-	-	M	←
	M-WRC	-	-	-	-	M
	T-ADD	M	M	M	M	M
	T-BAR	M	M	M	M	M
	X-UNC	M	M	M	M	M
	X-STR	M	M	M	X***	M
Baselines	***BL-UP***	M	-	-	-	←
	BL-PL	-	M	-	-	←
	BL-DFW	-	-	M	-	←
	BL-ARR	-	-	-	M	←
	BL-WRC	-	-	-	-	M
Leakage	***LK-ASU***	M	-	-	-	←
	LK-ASP	-	M	-	-	←
	LK-DFW	-	-	M	-	←
	LK-ARR	-	-	-	M	←
	LK-ECO	-	-	-	-	M
	LK-ME	(m)[1]	(m)[1]	(m)[2]	-	←
Pools*	**CP-AB**	M	M	M	X***	←
	CP-D	(m)[3]	(m)[3]	(m)[3]	X***	X****
	CP-L	O	O	O	X***	X****

	CP-S	O	O	O	X***	X****
	CP-W	(m)[1]	(m)[1]	-	-	←
Emissions*	**E-BPB**	M	M	M	X**	M
	E-FFC	O	O	O	-	←
	E-NA	(m)[4]	O	O	-	X

Notes: ← See instructions under REDD and ARR categories

Modules in italics contain specific CIW procedures.

M Modules marked with an M are fully mandatory: the indicated modules and tools must be used

O Modules marked with an O are fully optional: the indicated pools and sources can be included or excluded as decided by the project but if included in the baseline they must also be included in the project scenario

X Modules marked with an X are excluded

(m)[1] Mandatory where the process of deforestation involves timber harvesting for commercial markets

(m)[2] Mandatory where fuelwood or charcoal is harvested for commercial markets

(m)[3] Mandatory if this carbon pool is greater in baseline (post-deforestation/degradation) than project scenario and significant; otherwise can be conservatively omitted

(m)[4] Mandatory where leakage prevention activities include increases in the use of fertilizers

* VCS requirements and the tool *T-SIG* must be used to justify the omission of carbon pools and emission sources

** Procedures provided in *M-ARR*

*** Procedures provided in *BL-ARR* and *M-ARR*

**** Procedures provided in *BL-WRC* and *M-WRC*

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