

VCS Module

VMD0041

Estimation of baseline carbon stock changes and greenhouse gas emissions in ARR project activities on wetland and terrestrial peat and mineral soil (BL-ARR)

Version 1.01

~~9 March 2015~~ 14 February 2017

Sectoral Scope 14

Module developed by:



ERNST MORITZ ARNDT
UNIVERSITÄT GREIFSWALD



Wissen
lockt.
Seit 1456



Revision [to include \(tidal wetland\) restoration and conservation activities \(version 1.1 of this module\)](#)
prepared by Silvestrum Climate Associates and Restore America's Estuaries



Table of Contents

| | | |
|-----|---|---------------------|
| 1 | Sources | 4 |
| 2 | Summary Description of the Module | 4 |
| 3 | Definitions..... | 4 |
| 4 | Applicability Conditions | 4 |
| 5 | Procedures..... | 5 |
| 6 | Data and Parameters | 86 |
| 6.1 | Data and Parameters Available at Validation | 86 |
| 6.2 | Data and Parameters Monitored | 106 |
| 7 | References..... | 117 |

1 SOURCES

This module is one of numerous modules that constitute VCS methodology *VM0007 REDD+ Methodology Framework (REDD+-MF)*.

This module uses the latest versions of the following methodology and module:

- CDM methodology *AR-ACM0003 Afforestation and reforestation of lands except wetlands*
- CDM tool *AR-Tool12 Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities*, and associated tools.
- CDM tool *AR-Tool14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*
- ~~VMD0042 *Estimation of baseline soil carbon stock changes and greenhouse gas emissions in peatland rewetting and conservation project activities (BL-PEAT)*~~

2 SUMMARY DESCRIPTION OF THE MODULE

This module provides procedures for the estimation of net GHG removals under the baseline scenario ($\Delta C_{BSL-ARR}$) in ARR project activities.

3 DEFINITIONS

Definitions are set out in in VCS document *Program Definitions*, and methodology *REDD+-MF*. This module does not set out any further definitions.

4 APPLICABILITY CONDITIONS

This module is applicable under the following conditions:

- The applicability conditions set out in *AR-ACM0003 Afforestation and reforestation of lands except wetlands* must be met.¹
- Applicability conditions included in *AR-ACM0003 Afforestation and reforestation of lands except wetlands* and corresponding tools that exclude project activities on wetlands can be disregarded for the purpose of their use in this module, as accounting procedures for the peat soil are provided in Modules *BL-PEAT* and *BL-TW*.
- Where the ARR project activity is implemented on peatland, the peatland must be degraded in the baseline scenario as identified by the presence of drainage infrastructure (ditches, canals) and associated lowered water tables below the surface. In the case of

¹ In case there is a conflict between the CDM methodology and the VCS rules, the VCS rules must be followed, as set out in VCS *AFOLU guidance, Additional guidance for VCS Afforestation, Reforestation and Revegetation projects using CDM Afforestation/Reforestation Methodologies*, available on the VCS website.

forested peatland, degradation may be identified by the removal or degradation of the tree cover before the project start date.

- Where the ARR project activity is implemented on tidal wetlands, the wetland must be degraded, as defined in REDD+ MF.

~~This module is not applicable under the following condition:~~

- ~~• Project scenarios involving the harvesting of trees are excluded from this module. Therefore, procedures for the estimation of long-term average carbon stocks are not required.~~

5 PROCEDURES

Net GHG removals under the ARR baseline scenario are calculated as:

$$\Delta C_{BSL-ARR} = \Delta C_{BSL-trees/shrubs} + \Delta C_{BSL-herb} + \Delta C_{BSL-deadwood} + \Delta C_{BSL-litter} \quad (1)$$

Where:

$\Delta C_{BSL-ARR}$ Net GHG removals under the ARR baseline scenario up to year t^* (t CO₂e)

$\Delta C_{BSL-trees/shrubs}$ Net GHG removals under the ARR baseline scenario in trees and shrubs up to year t^* (t CO₂e)

$\Delta C_{BSL-herb}$ Net GHG removals under the ARR baseline scenario in herbaceous vegetation up to year t^* (t CO₂e)

$\Delta C_{BSL-deadwood}$ Net GHG removals under the ARR baseline scenario in dead wood up to year t^* (t CO₂e)

$\Delta C_{BSL-litter}$ Net GHG removals under the ARR baseline scenario in litter up to year t^* (t CO₂e)

Trees and shrubs

GHG emissions and removals under the ARR baseline scenario on mineral soils are estimated using the procedures provided in AR-Tool14 “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”~~AR-ACM0003 Afforestation and reforestation of lands except wetlands and associated tools.~~

~~$\Delta C_{BSL-ARR}$ (net)~~ The net GHG removals under the ARR baseline scenario in trees and shrubs up to time t^* , (t CO₂e) are equal to the summation from $t=1$ to t^* of $\Delta C_{BSL,t}$ (the change in the carbon stock in tree biomass ~~baseline net GHG removals by sinks in year t , t CO₂e)~~ and the change in the carbon stock in shrub biomass in AR-ACM0003~~AR-Tool14 “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”~~, as follows:

$$\Delta C_{BSL-ARR} = \sum_{t=1}^{t^*} (\Delta C_{BSL,t} \text{ ACM0003})$$

$$\Delta C_{BSL-tree/shrubs} = \sum_{t=1}^{t^*} \Delta C_{TREE_BSL,t} + \sum_{t=1}^{t^*} \Delta C_{SHRUB_BSL,t} \quad (2)$$

$$\Delta C_{TREE_BSL,t} = (C_{TREE_BSL,t} - C_{TREE_BSL,(t-T)}) / T \quad (3)$$

$$\Delta C_{SHRUB_BSL,t} = (C_{SHRUB_BSL,t} - C_{SHRUB_BSL,(t-T)}) / T \quad (4)$$

Where:

$\Delta C_{BSL-trees/shrubs}^{DC_{BSL-ARR}}$ Net GHG removals under the ARR baseline scenario in trees and shrubs up to time-year t^* (t CO₂e)

$DC_{BSL,t}^{ACM0003}$ Baseline net GHG removals by sinks in year t (from *AR-ACM0003*) (t CO₂e)
 $\Delta C_{TREE_BSL,t}$ Change in carbon stock in tree biomass in the baseline scenario within the project boundary in year t (from *AR-Tool14*) (t CO₂e)

$\Delta C_{SHRUB_BSL,t}$ Change in carbon stock in shrub biomass in the baseline scenario within the project boundary in year t (from *AR-Tool14*) (t CO₂e)

$C_{TREE_BSL,t}$ Carbon stock in tree biomass in the baseline scenario within the project boundary in year t (from *AR-Tool14*) (t CO₂e)

$C_{SHRUB_BSL,t}$ Carbon stock in shrub biomass in the baseline scenario within the project boundary in year t (from *AR-Tool14*) (t CO₂e)

t 1,2,3..... t^* time elapsed since project start (years)

T Time elapsed between two successive estimations ($T = t_2 - t_1$)

Summation of strata is performed within *AR-Tool14*.

Procedures for the estimation of uncertainty for ARR project activities are provided in *AR-ACM0003 Afforestation and reforestation of lands except wetlands*.

For strata where ARR project activities in the baseline scenario include harvesting, the long-term average of $C_{TREE_BSL,t}$ in *AR-Tool14* “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities” must be calculated as specified in Module *M-ARR*.

Herbaceous vegetation

Where a carbon stock increase in herbaceous vegetation is quantified in the project scenario, carbon stock changes must also be quantified in the baseline scenario; Where a carbon stock decline is quantified in the baseline scenario, carbon stock changes must also be quantified in the project scenario.

Net carbon stock change in herbaceous vegetation in the baseline scenario is estimated using a carbon stock change approach as follows:

$$\Delta C_{BSL-herbs} = \sum_{i=1}^{M_{bsl}} \sum_{t=1}^{t^*} \Delta C_{BSL-herbs,t} \quad (5)$$

$$\Delta C_{BSL-herb,i,t} = (C_{BSL-herb,i,t} - C_{BSL-herb,i(t-T)}) / T \quad (6)$$

Where:

$\Delta C_{BSL-herb}$ Net GHG removals under the ARR baseline scenario in herbaceous vegetation up to year t^* (t CO₂e)

$\Delta C_{BSL-herb,i,t}$ Net carbon stock change in herbaceous vegetation carbon pools in the baseline scenario in stratum i in year t ; t CO₂ yr⁻¹

$C_{BSL-herb,i,t}$ Carbon stock in herbaceous vegetation in the baseline scenario in stratum i in year t ; t CO₂

i 1, 2, 3 ... M_{BSL} strata in the baseline scenario

t 1, 2, 3 ... t^* years elapsed since the project start date

T Time elapsed between two successive estimations ($T = t_2 - t_1$)

Dead wood and litter

The net GHG removals under the ARR baseline scenario in dead wood and litter are equal to the summation from $t=1$ to t^* of the change in the carbon stock in dead wood and the change in the carbon stock in litter in *AR-Tool12 "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities"*, as follows:

$$\Delta C_{BSL-deadwood} = \sum_{t=1}^{t^*} \Delta C_{DW_BSL,t} \quad (7)$$

$$\Delta C_{DW_BSL,t} = (C_{DW_BSL,t} - C_{DW_BSL,(t-T)}) / T \quad (8)$$

$$\Delta C_{BSL-litter} = \sum_{t=1}^{t^*} \Delta C_{LI_BSL,t} \quad (9)$$

$$\Delta C_{LI_BSL,t} = (C_{LI_BSL,t} - C_{LI_BSL,(t-T)}) / T \quad (10)$$

Where:

$\Delta C_{BSL-deadwood}$ Net GHG removals under the ARR baseline scenario in dead wood up to year t^* (t CO₂e)

$\Delta C_{BSL-litter}$ Net GHG removals under the ARR baseline scenario in litter up to year t^* (t CO₂e)

$\Delta C_{DW_BSL,t}$ Change in carbon stock in dead wood within the project boundary in year t (from *AR-Tool12*) (t CO₂e)

$\Delta C_{LI_BSL,t}$ Change in carbon stock in litter within the project boundary in year t (from *AR-Tool12*) (t CO₂e)

$C_{DW_BSL,t}$ Carbon stock in dead wood in the baseline scenario within the project boundary in year t (from *AR-Tool12*) (t CO₂e)

$C_{LI, BSL, t}$ Carbon stock in litter in the baseline scenario within the project boundary in year t (from *AR-Tool12*) (t CO₂e)

t 1,2,3... t^* time elapsed since project start (years)

T Time elapsed between two successive estimations ($T = t_2 - t_1$)

Summation of strata is performed within *AR-Tool12*.

ARR on wetlands

For tidal wetlands, a default factor for carbon stock in herbaceous vegetation of 11 t CO₂ ha⁻¹ may be applied for strata with 100 percent herbaceous cover. For areas with a vegetation cover <100 percent, a 1:1 relationship between vegetation cover and carbon stock must be applied. The default factor may be claimed only for the first year of the project crediting period, as herbaceous biomass quickly reaches a steady state. Vegetation cover must be determined by commonly used techniques in field biology. Procedures for measuring carbon stocks in herbaceous vegetation are provided in Module *M-ARR*.

ARR project activities on peatland must develop a baseline considering peat as the soil carbon pool and incorporating the resulting emission estimates to the calculation of emissions and carbon stock changes of the ARR project activity. Net GHG emissions under the ARR baseline scenario on peat soils must be estimated using the following:

Non-soil pools (such as aboveground biomass and wood products) must be determined using *AR-ACM0003*. The estimation of carbon stock changes in the soil components and below-ground biomass must not be included.

Soil pools must be determined using module *BL-PEAT*.

Where:

$DC_{BSL-ARR}$ Net GHG removal under the ARR baseline scenario up to time t^* (t CO₂e)

$DC_{BSL, t_{ACM0003}}$ Baseline net GHG removals by sinks in year t (t CO₂e)

$GHG_{BSL-WRC}$ Net GHG emissions in the WRC baseline scenario up to year t^* (t CO₂e)

t 1,2,3..... t^* time since project start (years)

6 DATA AND PARAMETERS

6.1 Data and Parameters Available at Validation

| | |
|------------------|--|
| Data / Parameter | $C_{TREE, BSL, t}$ $DC_{BSL, t_{ACM0003}}$ |
|------------------|--|

| | |
|--|---|
| Data unit | t CO ₂ e |
| Description | Carbon stock in tree biomass in the baseline scenario within the project boundary in year t Baseline net GHG removals by sinks in year t |
| Equations | 1, 23 |
| Source of data | AR-Tool14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities AR-ACM0003 |
| Value applied | N/A |
| Justification of choice of data or description of measurement methods and procedures applied | AR-Tool14 AR-ACM0003 is approved by the UNFCCC's CDM |
| Purpose of Data | Calculation of baseline emissions |
| Comments | N/A |

| | |
|--|---|
| Data / Parameter | C_{SHRUB_BSL,t} |
| Data unit | t CO₂e |
| Description | Carbon stock in shrub biomass in the baseline scenario within the project boundary in year t |
| Equations | 4 |
| Source of data | AR-Tool14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities |
| Value applied | N/A |
| Justification of choice of data or description of measurement methods and procedures applied | AR-Tool14 is approved by the UNFCCC's CDM |
| Purpose of Data | Calculation of baseline emissions |
| Comments | N/A |

| | |
|----------------------------------|---|
| Data / Parameter | C_{BSL-herb,i,t} |
| Data unit | t CO₂e |
| Description | Carbon stock in herbaceous vegetation in the baseline scenario in stratum i in year t |
| Equations | 5 |
| Source of data | Default value or from own measurements (using Module M-ARR) |

| | |
|---|---|
| <u>Value applied</u> | <u>11 t CO₂ ha⁻¹ may be applied for strata with 100 percent herbaceous cover. For areas with a vegetation cover <100 percent, a 1:1 relationship between vegetation cover and carbon stock must be applied.</u> |
| <u>Justification of choice of data or description of measurement methods and procedures applied</u> | <u>Calculated from peak aboveground biomass data from 20 sites, as summarized in Mitsch and Gosselink 2007. The median of these studies is 1.3 kg dry matter m⁻². This was converted to the default factor value as follows: 1.3 × 0.45 × 0.5 × 44/12. The factor 0.45 converts organic matter mass to carbon mass; the factor 0.5 is a factor that averages annual peak biomass (factor = 1) and annual minimum biomass (factor = 0, assuming ephemeral aboveground biomass and complete litter decomposition).</u> |
| <u>Purpose of Data</u> | <u>Calculation of baseline emissions</u> |
| <u>Comments</u> | <u>N/A</u> |
| | |

| | |
|---|---|
| <u>Data / Parameter</u> | <u>GHG_{BSL-WRC}</u> |
| <u>Data unit</u> | <u>tCO₂e</u> |
| <u>Description</u> | <u>Net GHG emissions in the WRC baseline scenario up to year t*</u> |
| <u>Equations</u> | <u>2</u> |
| <u>Source of data</u> | <u>Module BL-PEAT</u> |
| <u>Value applied</u> | <u>N/A</u> |
| <u>Justification of choice of data or description of measurement methods and procedures applied</u> | <u>See module BL-PEAT</u> |
| <u>Purpose of Data</u> | <u>Calculation of baseline emissions</u> |
| <u>Comments</u> | <u>N/A</u> |

| | |
|-------------------------|--|
| <u>Data / Parameter</u> | <u>$C_{DW_BSL,t}$</u> |
| <u>Data unit</u> | <u>t CO₂e</u> |
| <u>Description</u> | <u>Carbon stock in dead wood in the baseline scenario within the project boundary in year t</u> |
| <u>Equations</u> | <u>8</u> |
| <u>Source of data</u> | <u>AR-Tool12 Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities</u> |
| <u>Value applied</u> | <u>N/A</u> |

| | |
|--|---|
| Justification of choice of data or description of measurement methods and procedures applied | AR-Tool12 is approved by the UNFCCC's CDM |
| Purpose of Data | Calculation of baseline emissions |
| Comments | N/A |

| | |
|--|---|
| Data / Parameter | C_{LI,BSL,t} |
| Data unit | t CO₂e |
| Description | Carbon stock in litter in the baseline scenario within the project boundary in year <i>t</i> |
| Equations | 10 |
| Source of data | AR-Tool12 Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities |
| Value applied | N/A |
| Justification of choice of data or description of measurement methods and procedures applied | AR-Tool12 is approved by the UNFCCC's CDM |
| Purpose of Data | Calculation of baseline emissions |
| Comments | N/A |

6.2 Data and Parameters Monitored

None.

7 REFERENCES

[Mitsch, W.J., and J.G. Gosselink. 2007. *Wetlands*. 4th ed. John Wiley & Sons, Inc., Hoboken, NJ.](#)

DOCUMENT HISTORY

| Version | Date | Comment |
|---------|--------------|-----------------|
| v1.0 | 9 March 2015 | Initial version |