Verified Carbon Standard

VCS Module

VMD0004

ESTIMATION OF STOCKS IN THE SOIL ORGANIC CARBON POOL (CP-S)

Version 1.1

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Sectoral Scope 14

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Version 1.1 of this module was prepared by Verra with support from Tim Pearson.

CONTENTS

1 SUMMARY DESCRIPTION OF THE MODULE

This module allows for estimation of carbon stocks in soil organic carbon in the baseline case (for both pre- and post-deforestation stocks) and project case.

2 DEFINITIONS

All terms in the following module are used inline with VCS program definitions.

3 APPLICABILITY CONDITIONS

This module is applicable to non-organic soils under all forest types and age classes.

4 PROCEDURES

4.1 Frequency of measurement for soil organic carbon stocks

Measurements of initial stocks employed in the baseline must take place within ±5 years of the project start date, for simplicity referred to here as stocks at t=0.

Soil organic carbon stock estimates are valid in the baseline (i.e. treated as constant) for 10 years, after which they must be re-estimated from new field measurements (in both the project area and where applicable in the leakage belt). For each stratum, where the re-measured estimate is within the 90% confidence interval of the t=0 estimate, the t=0 stock estimate takes precedence and is re-employed, and where the re-measured estimate is outside (i.e. greater than or less than) the 90% confidence interval of the t=0 estimate, the new stock estimate takes precedence and is used for the subsequent period.

4.2 Part 1: *Ex ante* estimation of pre-deforestation stocks of soil organic carbon

The procedure to be followed in the measurement of soil organic carbon is outlined below. Strata employed for soil organic carbon will conform to the same strata employed for all other included pools. To estimate the carbon stock in soil organic carbon per unit area for sample plot *sp*, stratum *i*:

$$C_{SOC,sp,i} = C_{SOCsample,sp,i} * BD_{sample,sp,i} * Dep_{sample,sp,i} * 100 \quad (1)$$

Where:

$C_{SOC,sp,i}$ = Carbon stock in soil organic carbon for sample plot *sp*, stratum *i*; t C ha^{-1}

$C_{SOCsample,sp,i}$ = Soil organic carbon of the sample in sample plot *sp*, stratum *i*; determined in the laboratory in g C/100 g soil (fine fraction <2 mm)

$BD_{sample,sp,i}$ = Bulk density of fine (<2 mm) fraction of mineral soil in sample plot *sp*, stratum *i*; determined in the laboratory in g fine fraction cm^{-3} total sample volume

$Dep_{sample,sp,i}$ = Depth to which soil sample is collected in sample plot *sp* in stratum *i*; cm

sp = 1, 2, 3, … *Pi* sample plots/points in stratum *i*

i = *1, 2, 3, …M* strata in the project scenario

To estimate the mean carbon stock in soil organic carbon, converted to carbon dioxide equivalents, per unit area for stratum *i*:

$$C_{SOC,i} = \frac{\sum_{sp=1}^{p_i} C_{SOC,sp,i}}{200} * \frac{44}{12} \quad (2)$$

Where:

$C_{SOC,i}$ = Mean carbon stock in soil organic carbon for stratum *i*; t CO_2-e ha^{-1}

$C_{SOC,sp,i}$ = Carbon stock in soil organic carbon for sample plot *sp*, stratum *i*; t C ha^{-1}

sp = *1, 2, 3, … Pi* sample plots/points in stratum *i*

i = *1, 2, 3, …M* strata in the project scenario

$\frac{44}{12}$ = Ratio of molecular weight of CO_2 to carbon, t CO_2-e t C^{-1}

4.3 Part 2: *Ex ante* estimation of post-deforestation stocks of soil organic carbon

Post-deforestation soil carbon stocks are assumed to be the long-term average stocks on the land following deforestation. To estimate this long term average post-deforestation stock of soil organic carbon, the mean soil stock estimated in Part 1 at t=0 is multiplied by the stock change factors, equal to the carbon stock in the altered condition as a proportion of the reference carbon stock as defined in IPCC 2006GL[1]. This method assumes that changes will take place over 20 years and is assumed to equate to the long term average stocks.

$$C_{SOC,PD-BSL,i,t} = C_{SOCi,t=0} * F_{LU} * F_{MG} * F_l \quad (3)$$

Where:

$C_{SOC,PD-BSL,i}$ = Mean post-deforestation stock in soil organic carbon in the post deforestation baseline stratum *i*; t CO_2-e ha^{-1}

$C_{SOCi,t=0}$ = Mean carbon stock in soil organic carbon for stratum *i*, at time *t*=0; t CO_2-e ha^{-1}

[1] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf

F_{LU} = Land use factor before or after conversion; dimensionless
F_{MG} = Management factor before or after conversion; dimensionless
F_l = Management factor before or after conversion; dimensionless
i = *1, 2, 3, …M* strata in the project scenario
t = *1, 2, 3, …t** years elapsed since the projected start of the REDD project activity

5 DATA AND PARAMETERS

5.1 Data and Parameters Available at Validation

Data / Parameter	Dep_{sample}
Data unit	cm.
Description	Depth in cm to which soil sample is collected
Equations	1
Source of data	Core dimensions recorded in the field
Value applied	-
Justification of choice of data or description of measurement methods and procedures applied	Depth of sampling for soil organic carbon is centered on the upper soil horizons where root biomass and organic matter inputs are concentrated, depending on soil type and ecosystem, typically between 20 cm and 100 cm. Depth of soil sampling employed in inventories is held constant for the duration of the project.
Purpose of Data	Calculation of baseline and project emissions
Comments	-

Data / Parameter	F_{LU}
Data unit	Dimensionless
Description	Land use factor before or after conversion
Equations	3
Source of data	Stock Change Factors are provided in Tables 5.5, 5.10, and 6.2 of the IPCC 2006GL Volume 4
Value applied	-
Justification of choice of data or description of measurement methods and procedures applied	-

Purpose of Data	Calculation of baseline and project emissions
Comments	Stock Change Factors as defined in IPCC 2006GL are equal to the carbon stock in the altered condition as a proportion of the reference carbon stock. Stock Change Factors must be selected to reflect the circumstances most closely matching those of the project area and baseline scenario, especially regarding climate and post-conversion land-use, taking into account management practices and carbon inputs (e.g. manure).

Data / Parameter	F_{MG}
Data unit	Dimensionless
Description	Management factor before or after conversion
Equations	3
Source of data	Stock Change Factors are provided in Tables 5.5, 5.10, and 6.2 of the IPCC 2006GL Volume 4
Value applied	-
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline and project emissions
Comments	Stock Change Factors as defined in IPCC 2006GL are equal to the carbon stock in the altered condition as a proportion of the reference carbon stock. Stock Change Factors must be selected to reflect the circumstances most closely matching those of the project area and baseline scenario, especially regarding climate and post-conversion land-use, taking into account management practices and carbon inputs (e.g. manure).

Data / Parameter	F_l
Data unit	Dimensionless
Description	Input factor before or after conversion
Equations	3
Source of data	Stock Change Factors are provided in Tables 5.5, 5.10, and 6.2 of the IPCC 2006GL Volume 4
Value applied	-

Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of baseline and project emissions
Comments	Stock Change Factors as defined in IPCC 2006GL are equal to the carbon stock in the altered condition as a proportion of the reference carbon stock. Stock Change Factors must be selected to reflect the circumstances most closely matching those of the project area and baseline scenario, especially regarding climate and post-conversion land-use, taking into account management practices and carbon inputs (e.g. manure).

5.2 Data and Parameters Monitored

Data / Parameter:	$C_{SOCsample}$
Data unit:	g C/100 g soil (fine fraction <2 mm)
Description:	Soil organic carbon of the sample in g C/100 g soil
Equations	1
Source of data:	Field sampling and laboratory determination
Description of measurement methods and procedures to be applied:	For soil carbon determination, an aggregate sample (e.g. from 4 systematically-distributed cores) is collected from within a sample plot in the field, thoroughly mixed and sieved through a 2 mm sieve. The prepared sample is analyzed for percent organic carbon using either dry combustion using a controlled-temperature furnace (e.g. LECO CHN-2000, LECO RC-412 multi-carbon analyzer, or equivalent), dichromate oxidation with heating, or Walkley-Black method. Further guidance is provided in the IPCC 2003 GPG-LULUCF and in Nelson, D.W., and L.E. Sommers. 1982. Total carbon, organic carbon, and organic matter. p. 539–580. In A.L. Page et al. (ed.) *Methods of soil Analysis. Part 2*. 2nd ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI. Pearson, T., Walker, S. and Brown, S. 2005. Sourcebook for Land Use, Land-Use Change and Forestry Projects. Winrock International and the World Bank Biocarbon Fund. 57pp. Available at: http://www.winrock.org/Ecosystems/files/Winrock-BioCarbon_Fund_Sourcebook-compressed.pdf
Frequency of monitoring/recording:	Where soil organic carbon is an included pool monitoring must occur at least every ten years for baseline renewal. Where carbon stock enhancement is included and soil organic carbon is an included pool monitoring shall occur at least every five years
QA/QC procedures to be applied:	Standard quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of QA/QCs already applied in national forest monitoring, or available from published handbooks, or form the IPCC GPG LULUCF 2003, is recommended.
Purpose of data:	Calculation of baseline and project emissions

Calculation method:	-
Comments:	Where carbon stock estimation occurs only for determination of the baseline this parameter shall be known ex-ante. Where part of project monitoring, ex-ante soil carbon parameters shall be considered to remain constant.

Data / Parameter:	BD_{sample}
Data unit:	g cm^{-3}
Description:	Bulk density of fine (< 2 mm) fraction of mineral soil per unit volume of sample in g cm-3; bulk density equals the oven dry weight of the fine fraction (< 2 mm) of the soil core divided by the core volume
Equations	1
Source of data:	Field measurements from sample plots or points
Description of measurement methods and procedures to be applied:	For bulk density determination, samples (cores) of known volume are collected in the field and oven dried to a constant weight at 105 °C (for a minimum of 48 hours). The total sample is then weighed, then any coarse rocky fragments (>2 mm) are sieved and weighed separately. The bulk density of the soil core is estimated as: $BD_{sample} = \frac{ODW - RF}{CV}$ Where: BD_{sample} = Bulk density of the < 2mm fraction, in grams per cubic centimeter (g/cm^3) ODW = Oven dry mass total sample in grams CV = Core volume in cm^3 RF = Mass of coarse fragments (> 2 mm) in grams Note that volume includes coarse (>2mm) fragments. Because coarse rocky fragments occupy space in the soil profile in which carbon is not stored, discounting this volume as in traditional bulk density calculations would overestimate soil carbon stocks when applied to a volume that does not distinguish between coarse and fine fractions. Further guidance is provided in the IPCC 2003 GPG-LULUCF and in Nelson, D.W., and L.E. Sommers. 1982. Total carbon, organic carbon, and organic matter. p. 539–580. In A.L. Page et al. (ed.) *Methods of soil Analysis. Part 2.* 2nd ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI. Pearson, T., Walker, S. and Brown, S. 2005. Sourcebook for Land Use, Land-Use Change and Forestry Projects. Winrock International and the World Bank Biocarbon Fund. 57pp. Available at: http://www.winrock.org/Ecosystems/files/Winrock-BioCarbon_Fund_Sourcebook-compressed.pdf
Frequency of monitoring/recording:	Where soil organic carbon is an included pool monitoring must occur at least every ten years for baseline renewal. Where carbon stock enhancement is included and soil organic carbon is an included pool monitoring shall occur at least every five years

QA/QC procedures to be applied:	Standard quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of QA/QCs already applied in national forest monitoring, or available from published handbooks, or form the *IPCC GPG LULUCF 2003*, is recommended.
Purpose of data:	Calculation of baseline and project emissions
Calculation method:	-
Comments:	Where carbon stock estimation occurs only for determination of the baseline this parameter shall be known ex-ante. Where part of project monitoring, ex-ante soil carbon parameters shall be considered to remain constant.

DOCUMENT HISTORY

Version	Date	Comment
v1.0	3 Dec 2010	Initial version
v1.1	27 Nov 2023	• Update to latest VCS methodology template • Removal of references to VM0007