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REDD Methodological Module

"Estimation of carbon stocks in the soil organic carbon pool"

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I. SCOPE, APPLICABILITY AND PARAMETERS

Scope

This module allows for estimating carbon stocks in soil organic carbon. Stocks are assumed to be stable prior to deforestation.

Emissions from soil organic carbon due to deforestation are treated in the baseline modules, referencing stocks calculated here.

Applicability

This module is applicable to non-organic soils under all forest types and age classes with stable or increasing stocks in the with-project case.

Parameters

This module produces the following parameters:

Parameter	SI Unit	Description
$C_{SOC,i,t=0}$	t CO_2-e ha^{-1}	Initial carbon stock in soil organic carbon in stratum *i*
$C_{SOC,BSLi,t}$	t CO_2-e ha^{-1}	Baseline post-deforestation carbon stock in soil organic carbon in stratum *i* at time *t*

II. PROCEDURES

Estimation of initial stocks of soil organic carbon

The procedure to be followed in the measurement of soil organic carbon is outlined below. To estimate the carbon stock in soil organic carbon per unit area for sample plot *sp*, stratum *i*, at time *t=0*:

$$C_{SOCsp,i,t=0} = C_{SOCsample,sp,i,t=0} * BD_{sample,sp,i,t=0} * Dep_{sample,sp,i,t=0} * 100 \quad (1)$$

where:

$C_{SOCsp,i,t=0}$	Carbon stock in soil organic carbon for sample plot *sp*, stratum *i,* at time *t=0*; t C ha^{-1}
$C_{SOCsample,sp,i,t=0}$	Soil organic carbon of the sample in sample plot *sp*, stratum *i,* at time *t=0*; determined in the laboratory in g C/100 g soil (fine fraction <2 mm)
$BD_{sample,sp,i,t=0}$	Bulk density of fine (<2 mm) fraction of mineral soil in sample plot *sp*, stratum *i,* at time *t* =0; determined in the laboratory in g fine fraction cm^{-3} total sample volume
$Dep_{sample,sp,i,t=0}$	Depth to which soil sample is collected in sample plot *sp* in stratum *i* at time *t=0*; cm
sp	*1, 2, 3 …* P_i sample plots in stratum *i*
i	*1, 2, 3 … M* strata
t=0	*0* years elapsed since the start of the project activity

To estimate the mean carbon stock in soil organic carbon, converted to carbon dioxide equivalents, per unit area for stratum *i*, at time *t=0*:

$$C_{SOCi,t=0} = \frac{\sum_{sp=1}^{P_i} C_{SOCsp,i,t=0}}{P_i} * \frac{44}{12} \quad (2)$$

Where:

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

$C_{SOCsp,i,t=0}$	Carbon stock in soil organic carbon for sample plot *sp*, stratum *i,* at time *t=0*; t C ha^{-1}
sp	*1, 2, 3 … P_i* sample plots in stratum *i*
i	*1, 2, 3 … M* strata
t=0	*0* years elapsed since the start of the project activity
44/12	Ratio of molecular weight of CO_2 to carbon, t CO_2-e t C^{-1}

Baseline

Two options are provided for estimating post-deforestation soil organic carbon stocks in the baseline scenario ($C_{SOC,BSLi,t}$):

1) Apply appropriate IPCC Stock Change Factor to estimate post-deforestation stock from mean carbon stock in soil organic carbon at time *t=0* ($C_{SOC,t=0}$) or;
2) Estimate mean stock of soil organic carbon from a representative proxy site

Option 1: Apply IPCC Stock Change Factor to calculate post-deforestation stock from mean stock at time t=0

To estimate post-deforestation stock of soil organic carbon, mean stock estimated at t=0 is multiplied by the Stock Change Factor, equal to the carbon stock in the altered condition as a proportion of the reference carbon stock as defined in IPCC 2006GL;

$$C_{SOCBSL\,i,t} = C_{SOCi,t=0} * SCF \quad (3)$$

Where:

$C_{SOC,BSLi,t}$	Mean post-deforestation stock in soil organic carbon in the baseline for stratum *i,* at time *t*; t CO_2-e ha^{-1}
$C_{SOC,i,t=0}$	Mean carbon stock in soil organic carbon for stratum *i,* at time *t=0*; t CO_2-e ha^{-1}
SCF	Stock Change Factor; dimensionless
i	*1, 2, 3* … *M* strata
t	*1, 2, 3* … years elapsed in the baseline

Options 2: Estimate mean stock of soil organic carbon from a representative proxy site

Post-deforestation stocks are treated as a constant value reflecting the ultimate stocks of the designated replacement land use, and are sampled from proxy sites and calculated in the same way as initial (t=0) stocks. Proxy sample sites must represent the land use, site conditions and management practices identified as the most likely conversion use in the baseline, and documentation must be provided to the satisfaction of the verifier establishing that the lands are representative.

Sample measurements must be from equivalent masses of soil, not volumes, due to changes in bulk density that occur with landuse conversion.

Proxy sites should only differ from the project area with respect to landuse. All other factors (soil type, climate, hydrology, etc.) should be kept constant in as much as possible. Sites in close proximity to each other often meet this requirement. As well, the current land use or

management on each should have been in place for as long a period as possible (preferably > 20 years) to ensure that sites that are no longer in transition and are presumably in equilibrium.

III. DATA AND PARAMETERS NOT MONITORED (DEFAULT OR POSSIBLY MEASURED ONE TIME)

Data / parameter:	$C_{SOCsample}$
Data unit:	g C/100 g soil (fine fraction <2 mm)
Used in equations:	1
Description:	Soil organic carbon of the sample
Source of data:	Field sampling and laboratory determination
Measurement procedures (if any):	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
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / parameter:	BD_{sample}
Data unit:	g cm^{-3}
Used in equations:	1
Description:	Bulk density of fine (< 2 mm) fraction of mineral soil per unit volume of sample; bulk density equals the oven dry weight of the fine fraction (< 2 mm) of the soil core divided by the core volume
Source of data:	Field sampling and laboratory determination
Measurement procedures (if any):	For bulk density determination, samples (cores) of known volume are collected in the field and oven dried to a constant weight at 105 ^{o}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
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / parameter:	Dep_{sample}
Data unit:	cm
Used in equations:	1
Description:	Depth to which soil sample is collected
Source of data:	Core dimensions recorded in the field
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / parameter:	*SCF*
Data unit:	Dimensionless
Used in equations:	3
Description:	Stock Change Factor
Source of data:	Stock Change Factors are provided in Tables 5.5, 5.10, and 6.2 of the IPCC 2006GL Volume 4

Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	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).
Any comment:	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.