REDD Methodological Module

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

Version - April 2010

I. SCOPE, APPLICABILITY AND PARAMETERS

Scope

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

Applicability

This module is applicable to non-organic soils under all forest types and age classes. This module is applicable if the soil organic carbon pool is included as part of the project boundary as per applicability criteria in the framework module REDD-MF, specifically:

- Soil organic carbon shall be included if stocks are greater, or are increasing at a greater rate, in the baseline than in the project scenario. Ex ante determination that stocks are greater in the baseline than in the project scenario can be made on the basis of IPCC 2006GL Relative Stock Change Factors (F_{LU}, F_{MG}, and F_I)[1] – if the average combined stock change factor for the baseline (area-weighted by post conversion landuse) is greater than or equal to 1, then soil organic carbon must be included, otherwise it can be conservatively omitted, and
- Soil organic carbon shall be included if determined to be significant (using the X-SIG module).

Parameters

This module produces the following parameters:

Parameter	SI Unit	Description
$C_{SOC,i,t}$	t CO_2-e ha^{-1}	Mean carbon stock in soil organic carbon in stratum *i* at

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

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

II. PROCEDURES

Frequency of measurement for soil organic carbon stocks

Measurements of initial stocks employed in the baseline must take place within 5 years prior to 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. For each strata, 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.

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*, at time *t*:

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

where:

$C_{SOCsp,i,t}$	Carbon stock in soil organic carbon for sample plot *sp*, stratum *i,* at time *t*; t C ha^{-1}
$C_{SOCsample,sp,i,t}$	Soil organic carbon of the sample in sample plot *sp*, stratum *i,* at time *t*; determined in the laboratory in g C/100 g soil (fine fraction <2 mm)

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

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

sp *1, 2, 3 … P_i* sample plots in stratum *i*

i *1, 2, 3 … M* strata

t *0, 1, 2, 3 …* 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*:

$= \quad =1 \qquad *4412$ (2)

Where:

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

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

sp *1, 2, 3 … P_i* sample plots in stratum *i*

i *1, 2, 3 … M* strata

t *0, 1, 2, 3 …* 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}

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 2006GL2. This method assumes that changes will take place over 20 years and is assumed to equate to the long term average stocks.

$$= * \quad (3)$$

Where:

$C_{SOC,PD\text{-}BSLi,t}$	Mean post-deforestation stock in soil organic carbon in the post deforestation baseline 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}
F_{LU}	land use factor before or after conversion; dimensionless
F_{MG}	management factor before or after conversion; dimensionless
F_I	input factor before or after conversion; dimensionless
i	*1, 2, 3 … M* strata
t	*1, 2, 3 …* years elapsed in the baseline

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

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

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

Data / parameter:	F_{LU}
Data unit:	Dimensionless
Used in equations:	3
Description:	Land use factor before or after conversion
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.

Data / parameter:	F_{MG}
Data unit:	Dimensionless
Used in equations:	3
Description:	Management factor before or after conversion
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.

Data / parameter:	F_I
Data unit:	Dimensionless
Used in equations:	3
Description:	Input factor before or after conversion
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.

IV. DATA AND PARAMETERS MONITORED

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 in g C/100 g soil
Monitoring interval:	Not more than 10 years
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
QA/QC procedures:	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.
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 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
Monitoring interval:	Not more than 10 years
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
QA/QC procedures:	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.
Any comment:	