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Protecting the Climate by Saving Forests

REDD Methodological Module

"Estimation of carbon stocks in the long-term wood products pool"

Version – April 2010

I. SCOPE, APPLICABILITY AND PARAMETERS

Scope

This module allows for ex ante estimation of carbon stocks in the long-term wood products pool in the baseline case. Carbon stocks treated here are those stocks remaining in wood products after 100 years; the bulk of emissions associated with timber harvest, processing and waste, and eventual product retirement occur within this timeframe, and this module employs the simplifying assumption that the proportion remaining after 100 years is effectively "permanent[1]."

Applicability

This module is applicable to all cases where wood is harvested for conversion to wood products *for commercial markets*, for all forest types and age classes. This module is applicable in the baseline if the wood products pool is included as part of the project boundary as per applicability criteria in the framework module REDD-MF, specifically::

- -timber harvest occurs prior to or in the process of deforestation, and where timber is destined for commercial markets
- -the wood products pool is determined to be significant (using the X-SIG module).

Parameters

This module produces the following parameter:

Parameter	SI Unit	Description
$C_{WP\,i,t}$	t CO_2-e ha^{-1}	Mean carbon stock in wood products pool (stock remaining in wood products after 100 years) in strata *i* at time *t* post deforestation
$C_{XB,i,t}$	t CO_2-e ha^{-1}	Mean stock of extracted biomass carbon from strata *i* at

[1] The proportion remaining after 100 years is effectively the amount sequestered in the wood products pool throughout the crediting period of any VCS REDD project (maximum crediting period = 100 years).

		time t;

Frequency of update of oxidation factors

The approach outlined in this module employs emission factors (OF, SLF, and WW) derived by Winjum *et al.* 1998. It is anticipated that new research findings may become available in the future (during the project crediting period) further refining these factors, and the use of this module requires that project proponents review research findings every ≤ 10 years to identify further refinements to the emission factors that are empirically-based and peer-reviewed. If new emission factors are discovered, they will replace the factors included in the module, otherwise the factors in the module will remain valid.

II. PROCEDURES

Part 1: Ex ante estimation of carbon stocks in the wood products pool in the baseline

This module estimates carbon stocks in wood products resulting from timber harvest occurring prior to or in the process of deforestation. Accounting for such wood products should only take place at the time of deforestation. This module follows the conceptual framework detailed in Winjum *et al.* 1998[2], applying the simplifying (and conservative) assumption that all extracted biomass not retained in long-term wood products after 100 years is emitted in the year harvested, instead of tracking annual emissions through retirement, burning and decomposition.

All factors are derived from Winjum *et al*. 1998.

If approved timber harvest plans, specifying harvest intensity per strata in terms of volume extracted per ha, are available for the project area use Option 1. If approved harvest plans are not available use Option 2.

Part 1, Option 1: Direct Volume Extraction Estimation

Step 1: Calculate the biomass carbon of the volume extracted by wood product type *ty* at time *t* from within the project boundary:

[2] Winjum, J.K., Brown, S. and Schlamadinger, B. 1998. Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. *Forest Science* 44: 272-284

$$C_{XB,ty,i,t} = \frac{1}{A_i} * \sum_{j=1}^{S_{PS}} (V_{ex,ty,j,i,t} * D_j * CF_j * \frac{44}{12}) \quad (1)$$

Where:

$C_{XB,ty,i,t}$	Mean stock of extracted biomass carbon by class of wood product *ty* from strata *i* at time *t*; t CO_2-e ha^{-1}
A_i	Total area of strata *i*; ha
$V_{ex,ty,j,t}$	Volume of timber extracted from within strata *i* (does not include slash left onsite) by species *j* and wood product class *ty* at time *t*; m^3
D_j	Mean wood density of species *j*; t d.m.m^{-3}
CFj	Carbon fraction of biomass for tree species *j*; t C t^{-1} d.m.
t	*1, 2, 3 … t* years elapsed since the start of the project activity
j	*1, 2, 3 … S* tree species
ty	Wood product class – defined here as sawnwood, wood-based panels, other industrial roundwood, paper and paper board, and other
44/12	Ratio of molecular weight of CO_2 to carbon, t CO_2-e t C^{-1}

Step 2: Calculate the proportion of biomass carbon extracted at time *t* that remains sequestered in long-term wood products after 100 years.

$$C_{WPi,t} = \sum_{s,w,oir,p,o}^{ty} C_{XBty,i,t} * (1 - WW_{ty}) * (1 - SLF_{ty}) * (1 - OF_{ty}) \quad (2)$$

Where:

$C_{WPi,t}$	Carbon stock in wood products pool (stock remaining in wood products after 100 years) in strata *i* at time *t*; t CO_2-e ha^{-1}
$C_{XB,ty,i,t}$	Mean stock of extracted biomass carbon by class of wood product *ty* from strata *i* at time *t*; t CO_2-e ha^{-1}
WW	Wood waste. The fraction immediately emitted through mill inefficiency; dimensionless
SLF	Fraction of wood products that will be emitted to the atmosphere within 5 years of timber harvest; dimensionless
OF	Fraction of wood products that will be emitted to the atmosphere between 5 and 100 years of timber harvest; dimensionless
ty	Wood product class – defined here as sawnwood, wood-based panels, other industrial roundwood, paper and paper board, and other

i	*1, 2, 3, …M* strata
t	*1, 2, 3 … t* years elapsed since the start of the project activity

Part 1, Option 2: Commercial inventory estimation

Step 1: Calculate the biomass carbon of the commercial volume extracted prior to or in the process of deforestation:

$$C_{XBi,t} = C_{AB\_tree,i,t} * \frac{1}{BCEF} * Pcom_i \quad (3)$$

Where:

$C_{XB,i,t}$	Mean stock of extracted biomass carbon from strata *i* at time *t*; t CO_2-e ha^{-1}
$C_{AB\_tree,i,t}$	Mean aboveground biomass carbon stock in stratum *i* at time *t*; t CO_2-e ha^{-1}
BCEF	Biomass conversion and expansion factor for conversion of merchantable volume to total aboveground tree biomass; dimensionless
$Pcom_i$	Commercial volume as a percent of total aboveground volume in stratum *i*; dimensionless
t	*1, 2, 3 … t* years elapsed
i	*1, 2, 3, …M* strata

Step 2: Identify the wood product class(es) (*ty*; defined here as sawnwood, wood-based panels, other industrial roundwood, paper and paper board, and other) that are the anticipated end use of the extracted carbon calculated in Step 1.

Step 3: Calculate the proportion of biomass carbon extracted at time *t* that remains sequestered in long-term wood products after 100 years. This module applies the simplifying (and conservative) assumption that all extracted biomass not retained in long-term wood

products after 100 years is emitted in the year harvested, instead of tracking annual emissions through retirement, burning and decomposition. All factors are derived from Winjum *et al*. 1998.

$$C_{WPi,t} = \sum_{s,w,oir,p,o}^{ty} C_{XBty,i,t} * (1 - WW_{ty}) * (1 - SLF_{ty}) * (1 - OF_{ty}) \quad (4)$$

Where:

$C_{WPi,t}$	Carbon stock in long-term wood products pool (stock remaining in wood products after 100 years) in strata *i* at time *t* post deforestation; t CO_2-e ha^{-1}
$C_{XB,ty,i,t}$	Mean stock of extracted biomass carbon by class of wood product *ty* from strata *i* at time *t*; t CO_2-e ha^{-1}
WW	Wood waste. The fraction immediately emitted through mill inefficiency; dimensionless
SLF	Fraction of wood products that will be emitted to the atmosphere within 5 years of timber harvest; dimensionless
OF	Fraction of wood products that will be emitted to the atmosphere between 5 and 100 years of timber harvest; dimensionless
ty	Wood product class – defined here as sawnwood, wood-based panels, other industrial roundwood, paper and paper board, and other
i	*1, 2, 3, …M* strata
t	*1, 2, 3 … t* years elapsed since the start of the project activity

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

Data / parameter:	*BCEF*
Data unit:	Dimensionless
Used in equations:	1
Description:	Biomass conversion and expansion factor for conversion of commercial wood volume per unit area to total aboveground tree biomass per unit area; note that BCEF as defined here, and in most applications, is not applied on a per stem basis
Source of data:	Equations must have been derived using a wide range of measured variables (commercial wood volume per unit area and total aboveground biomass per unit area) based on datasets that comprise at least 30 trees. Equations must be based on statistically significant regressions and must have an r^2 that is ≥ 0.8. The source of data shall be chosen with priority from higher to lower preference as follows: (a) Existing local forest type-specific; (b) National forest type-specific or eco-region-specific (e.g. from national GHG inventory); (c) Forest type-specific or eco-region-specific from neighboring countries with similar conditions. Sometimes (c) might be preferable to (b); (d) Global forest type or eco-region-specific (e.g. IPCC 2006 INV GLs AFOLU Chapter 4 Table 4.5) The project volume data to which the selected BCEF is applied must conform to the data the BCEF was originally derived from, in particular, it must match forest type, stand structure, minimum DBH, and cover the range of potential independent variable values (commercial volumes) likely to be encountered in the project area.. *Care must be taken to ensure that the selected BCEF does not account for non-commercial species not represented in commercial volume estimates (i.e. is restricted to expanding merchantable volumes to account for only non-merchantable tree components).*
Measurement	

procedures (if any):	
Any comment:	Alternatively, BCEF, where not directly available, can be calculated as wood density (t dry mass m^{-3} green volume) * BEF (Biomass Expansion Factor = ratio of aboveground biomass to biomass of the commercial volume). If using BCEFs developed outside the project country (cases (c) and (d) above under Source of data), it is necessary to validate the applicability of BCEFs used. Validation is performed by: 1. Limited Measurements • Select at least 20 plots in the project area covering a wide range of commercial volumes. • Obtain tree measurements (e.g. dbh, height to a 10 cm diameter top) from which to calculate commercial volume and total biomass. • Calculate commercial volume per unit area (e.g. using Smalian's formula) and total biomass per unit area (using the biomass equation(s) selected for application in CP-AB) for each plot • Calculate BCEF for each plot (biomass (t) / commercial volume (m^3) • Graph the plot-level estimates of BCEF versus commercial volume along with the BCEF equation (predicted) to be validated. If the estimated BCEFs of the measured plots are distributed both above and below the predicted value the BCEF equation may be used. The BCEF equation may also be used if the measured plots have a BCEF consistently lower than that predicted. If graphing the BCEF of the measured plots indicates a systematic bias to overestimation of BCEF (>75% of the plots above the predicted value) then another BCEF equation must be selected or developed anew.

Data / parameter:	CF
Data unit:	t C t-1 d.m.
Used in equations:	4
Description:	Carbon fraction of dry matter in t C t-1 d.m.
Source of data:	Species- or family-specific values from the literature (e.g. IPCC 2006 INV

	GLs AFOLU Chapter 4 Table 4.3) shall be used if available, otherwise default value of 0.47 t C t-1 d.m. can be used.
Measurement procedures (if any):	
Any comment:	Where new species are encountered in the course of monitoring, new carbon fraction values must be sourced from the literature or otherwise use the default value.

Data / parameter:	*D*
Data unit:	t d.m. m^{-3}
Used in equations:	4
Description:	Basic wood density in t d.m. m^{-3}
Source of data:	The source of data shall be chosen with priority from higher to lower preference as follows: (a) National species-specific or group of species-specific (e.g. from National GHG inventory); (b) Species-specific or group of species-specific from neighboring countries with similar conditions. Sometimes (b) may be preferable to (a); (c) Global species-specific or group of species-specific (e.g. IPCC 2006 INV GLs AFOLU Chapter 4 Tables 4.13 and 4.14). Species-specific wood densities may not always be available, and may be difficult to apply with certainty in the typically species rich forests of the humid tropics, hence it is acceptable practice to use wood densities developed for forest types or plant families or species groups.
Measurement procedures (if any):	N/A
Any comment:	Where using wood densities developed outside of the project country (cases (b) and (c) above under Source of data), wood densities must be validated with either limited destructive sampling or direct measurement of wood hardness (e.g. with a Pilodyn wood tester) in the field and correlating with wood density. Samples or measurements should be from 20-30 trees. For validation of mean forest type or species group wood densities, representation of species in the sample should be proportional to their occurrence in terms of basal area or volume in the project area (not abundance or stem density). Samples should provide representation across the length of the tree. Wood samples are cut in discs and thickness and diameter measured to

	calculate green volume. Samples are oven dried (70o C) to a constant weight in the laboratory, and density calculated as dry weight (g) per unit green volume (cm3). If the density of the samples/measurements (or mean density in the case of forest type or species group means) is within ±10% of the selected density values, then the selected density values may be used. Otherwise, a new density value must be developed with more extensive sampling, using the validation samples as a base. Where new species are encountered in the course of monitoring, new wood density values must be sourced from the literature and validated, if necessary, as per requirements and procedures above.

IV. DATA AND PARAMETERS MONITORED

Data / parameter:	A_i
Data unit:	ha
Used in equations:	3
Description:	Total area of stratum *i* in ha
Source of data:	
Measurement procedures (if any):	
Any comment:	

Data / parameter:	$Pcom_i$
Data unit:	Dimensionless
Used in equations:	1
Description:	Commercial volume as a percent of total aboveground volume in stratum *i*.
Source of data:	The source of data shall be chosen with priority from higher to lower preference as follows: (a) Direct forest inventory of the project area, distinguishing commercially viable stocks on the basis of species and tree size, referencing local expert knowledge or a participatory rural assessment

	(PRA) of harvest practices and markets; (b) Forest inventory from a proxy area in the same region, representing the same forest type and age class, distinguishing commercially viable stocks on the basis of species and tree size, referencing local expert knowledge of harvest practices and markets National and forest type-specific or eco-region-specific (e.g. from National GHG inventory).
Measurement procedures (if any):	This parameter is updated at baseline renewal when aboveground biomass is re-inventoried as per module CP-AB (every < 10 years).
Any comment:	Note that application of the commercial percentage of total volume introduces the simplifying assumption (and conservative, as it is only used in the ex ante baseline calculations) that all commercial stocks are extracted (i.e. perfect efficiency).

Data / parameter:	$V_{ex,i}$
Data unit:	m^3
Used in equations:	3
Description:	The volume of timber in m^3 extracted from within the stratum (does not include slash left onsite), reported by wood product class and preferably species.
Source of data:	Timber harvest records and/or estimates derived from field measurements or remote assessments with aerial photography or satellite imagery.
Measurement procedures (if any):	
Any comment:	Note that this volume does not include logging slash left onsite. Data compilers should also make sure that extracted volumes reported are gross volumes removed (i.e. reported volume does not already discount for estimated wood waste, as is often the practice in harvest records). Assignment of volume extracted to wood product class(es), must be substantiated on the basis of participatory rural appraisal (PRA) findings (also used to assess potential for degradation in module M-FCC) or records of timber sales. Assignment of volume extracted to species, must be substantiated on the basis of either PRA findings, harvest records, or a commercial inventory.

Data / parameter:	*OF*

Data unit:	Dimensionless
Used in equations:	2,4
Description:	OF = Fraction of wood products that will be emitted to the atmosphere between 5 and 100 years after production; Winjum *et al*. 1998 gives annual oxidation fractions for each class of wood products split by forest region (boreal, temperate and tropical). This methodology projects these fractions over 95 years to give the additional proportion (*OF* value) that is oxidized between the 5th and 100th years after initial harvest:

Wood Product Class	***OF***		
	Boreal	**Temperate**	**Tropical**
Sawnwood	0.36	0.60	0.84
Woodbase panels	0.60	0.84	0.97
Other industrial roundwood	0.84	0.97	0.99
Paper and paperboard	0.36	0.60	0.99

Source of data:	The source of data is the published paper of Winjum *et al*. 1998[3]
Measurement procedures (if any):	
Any comment:	Parameter values to be updated if new empirically-based peer-reviewed findings become available. Every 10 years,

Data / parameter:	*SLF*
Data unit:	Dimensionless
Used in equations:	2,4
Description:	SLF = Fraction of wood products that will be emitted to the atmosphere within 5 years of production

[3] Winjum, J.K., Brown, S. and Schlamadinger, B. 1998. Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. *Forest Science* 44: 272-284

<table>
<tr><td></td><td>Winjum et al. 1998 give the following proportions for wood products with short-term (<5 yr) uses after which they are retired and oxidized (applicable internationally):

Sawnwood 0.2
Woodbase panels 0.1
Other industrial roundwood 0.3
Paper and Paperboard 0.4

The methodology makes the assumption that all other classes of wood products, and where wood product class ty is unknown, are 100% oxidized within 5 years.

Therefore SLF, by wood product class, is equal to:

<table>
<tr><th>Wood Product Class</th><th>SLF</th></tr>
<tr><td>Sawnwood</td><td>0.2</td></tr>
<tr><td>Woodbase panels</td><td>0.1</td></tr>
<tr><td>Other industrial roundwood</td><td>0.3</td></tr>
<tr><td>Paper and paperboard</td><td>0.4</td></tr>
<tr><td>Other classes of wood products</td><td>1.0</td></tr>
</table>
</td></tr>
<tr><td>Source of data:</td><td>The source of data is the published paper of Winjum et al. 1998[4]</td></tr>
<tr><td>Measurement procedures (if any):</td><td></td></tr>
<tr><td>Any comment:</td><td>Parameter values to be updated if new empirically-based peer-reviewed findings become available.</td></tr>
</table>

Data / parameter:	*WW*
Data unit:	dimensionless
Used in equations:	2,4
Description:	WW = Fraction of extracted biomass effectively emitted to the atmosphere during production

[4] Winjum, J.K., Brown, S. and Schlamadinger, B. 1998. Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. *Forest Science* 44: 272-284

	Winjum *et al*. 1998 indicate that the proportion of extracted biomass that is oxidized (burning or decaying) from the production of commodities to be equal to 19% for developed countries, 24% for developing countries. *WW* is therefore equal to $C_{XB,ty}$ multiplied by 0.19 for developed countries and 0.24 for developing countries.
Source of data:	The source of data is the published paper of Winjum *et al*. 1998[5]
Measurement procedures (if any):	
Any comment:	Parameter values to be updated if new empirically-based peer-reviewed findings become available.

[5] Winjum, J.K., Brown, S. and Schlamadinger, B. 1998. Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. *Forest Science* 44: 272-284