VCS Module

VMD0011

ESTIMATION OF EMISSIONS FROM MARKET-EFFECTS (LK-ME)

Version 1.2

27 November 2023

Sectoral Scope 14

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Version 1.2 of this module was prepared by Verra with support from Tim Pearson.

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1 SOURCES

This module uses the latest versions of the following modules:

- *VMD0005 Estimation of carbon stocks in the long-term wood products pool (CP-W)*
- *VMD0016 Methods for stratification of the project area (X-STR)*

2 SUMMARY DESCRIPTION OF THE MODULE

This module allows for estimating GHG emissions caused by the market-effects leakage related to extraction of wood for timber, fuelwood or charcoal in the baseline for carbon projects. As per the VCS *AFOLU Requirements* consideration of international market leakage is not required.

This module provides procedures to determine the net greenhouse gas emissions due to market-effects leakage (ΔC_{LK-ME})

3 DEFINITIONS

In addition to the definitions set out in the *VCS Program Definitions* and methodology *REDD-MF*, the following definitions apply to this methodology:

Commercial Markets
Sale of products to end users and public and private companies with sales conducted distant (>50km) from the project area

Commercial Species
Tree species used for the generation of timber products, fuelwood and charcoal in commercial markets (as defined above). Sources of this information may include official national statistics as well as market surveys from recognized sources, peer-reviewed articles or surveys carried out by the project proponent using statistically sound approaches.

Market Leakage Forests
Areas of forest within the country where the REDD+ project activities are carried out where deforestation due to market effects may be displaced as a consequence of a substantial and permanent reduction of wood harvest levels resulting from the implementation of such REDD+ project activities

Merchantable Biomass

Total gross biomass (including bark) of a tree 40 cm DBH or larger from a 30 cm stump to a minimum 10 cm top of the central stem

4 APPLICABILITY CONDITIONS

This module is applicable for calculating market-effects leakage from projects that are anticipated to reduce levels of wood harvest substantially and permanently. When project activities result in reductions in wood harvest, it is likely that production could shift to other areas of the country to compensate for the reduction, including activity shifting to forested peatland that is drained as a consequence of project implementation. This tool shall be used in countries where wood harvest happens on forested peatland regardless of the absence of peatland within the project boundary.

5 PROCEDURES

Total leakage due to market effects is equal to the sum of market-effects leakage through decreased timber harvest and decreased harvest for fuelwood/charcoal production.

$$\Delta C_{LK-ME} = LK_{MarketEffects,timber} + LK_{MarketEffects,FW/C} + LK_{MarketEffects,Peat} \quad (1)$$

Where:

ΔC_{LK-ME}	=	Net greenhouse gas emissions due to market-effects leakage (t CO_2e)
$LK_{MarketEffects,timber}$	=	Total GHG emissions due to market-effects leakage through decreased timber harvest (t CO_2e)
$LK_{MarketEffects,FW/C}$	=	Total GHG emissions due to market-effects leakage through decreased harvest of fuelwood and charcoal sold into regional and/or national markets (t CO_2e)
$LK_{MarketEffects,Peat}$	=	Total GHG emissions due to market-effects leakage through decreased timber, fuelwood and charcoal harvest resulting in increased peatland drainage (t CO-e)

Section 5.1 below details calculations necessary for estimating market-effects leakage caused by decreased timber harvest and Section 2 details calculations necessary for estimating market-effects leakage caused by decreased harvest of fuelwood or charcoal for sale to regional or national markets. Section 3 provides guidance on how to estimate market-effects leakage due to peatland drainage associated with these harvesting activities.

5.1 Market-Effects Leakage Through Decreased Timber Harvest

Leakage due to market effects is equal to the baseline emissions from logging multiplied by a leakage factor and, where applicable, by a leakage management factor:

$$LK_{MarketEffects,timber} = \sum_{i=1}^{M} (LF_{ME} \times LK_{MAF} \times AL_{T,i}) \quad (2)$$

Where:

$\mathrm{LK_{MarketEffects,timber}}$	=	Total GHG emissions due to market-effects leakage through decreased timber harvest (t CO_2e)
$\mathrm{LF_{ME}}$	=	Leakage factor for market-effects calculations (dimensionless)
$\mathrm{LK_{MAF}}$	=	Leakage management adjustment factor (dimensionless)
$\mathrm{AL_{T,i}}$	=	Summed emissions from timber harvest in stratum i in the baseline case potentially displaced through implementation of the project (t CO_2e)
i	=	*1, 2, 3, …M* strata (dimensionless)

The amount of leakage is determined by where harvesting would likely be displaced to. If in the forests to which displacement would occur a lower proportion of forest biomass in commercial species is in merchantable material than in project area, then in order to extract a given volume higher emissions should be expected as more trees will need to be cut to supply the same volume. In contrast if a higher proportion of the total biomass of commercial species is merchantable in the displacement forest than in the project forests, then a smaller area would have to be harvested and lower emissions would result.

Each project thus must calculate within each stratum the proportion of total biomass in commercial species that is merchantable (PMP_i). This must then be compared to mean proportion of total biomass that is merchantable for each forest type (PML_{FT}).

Table 1 sets out the deduction factors that must be used.

Table 1: Deduction factors

Deduction Factors for $\boldsymbol{LF_{ME}}$	
$\boldsymbol{PML_{FT}}$ is equal (± 15%) to $\boldsymbol{PMP_i}$	LF_{ME} = 0.4
$\boldsymbol{PML_{FT}}$ is > 15% less than $\boldsymbol{PMP_i}$	LF_{ME} = 0.7
$\boldsymbol{PML_{FT}}$ is > 15%) greater than $\boldsymbol{PMP_i}$	LF_{ME} = 0.2

Where:

PML_{FT}	=	Mean merchantable biomass as a proportion of total aboveground tree biomass for each forest type (%)
PMP_i	=	Merchantable biomass as a proportion of total aboveground tree biomass for stratum i within the project boundary (%)
LF_{ME}	=	Leakage factor for market-effects calculations (dimensionless)

Where the project proponent is able to clearly demonstrate based on, for example, official data from the government or peer-reviewed literature, that market leakage will only happen out of the country, then market leakage shall be set as zero.

Moreover, if leakage management activities are established within areas under the control of the project proponent in order to minimize the displacement of land use activities to areas outside the project area by maintaining the production of total biomass in commercial species that is merchantable, a leakage management adjustment factor (LK_{MAF}) may be applied. The leakage management adjustment factor discounts the value of $LK_{CP-ME,c,i}$ in a proportion equal to the annual volume of biomass in commercial species that is merchantable produced by the leakage management areas with respect to the total annual volume that would have been produced in the project area in the absence of the project, as follows:

$$LK_{MAF} = 1 - \left(PRODMB_{LMA,t} / PRODMB_{BL,t}\right) \quad (3)$$

Where:

LK_{MAF}	=	Leakage management adjustment factor (dimensionless)
$PRODMB_{LMA,t}$	=	Production biomass in commercial species that is merchantable in year t in leakage management areas (t per year)
$PRODMB_{BL,t}$	=	Production of biomass in commercial species that is merchantable in year t in the baseline case (t per year)
t	=	*1, 2, 3, …* $t*$ time elapsed since the start of the project activity (years)

If the leakage management areas produce an amount equal or higher than the expected baseline production of biomass in commercial species that is merchantable, leakage shall be assumed to be zero. In order to apply this factor, project proponents need to demonstrate the production of the volume biomass in commercial species that is merchantable used to estimate this deduction, as well as evidence that such biomass has reached the relevant regional/national markets. Any increase in GHG emissions associated with the leakage management activities shall be accounted for, unless deemed de minimis or conservatively excluded.

The next step is to estimate the emissions associated with the displaced logging activity. This is based on the total volume that would have been logged in the baseline in the project area across strata and time periods:

$$AL_{T,i} = \sum_{t=1}^{t} \left(C_{BSL,XBT,i,t}\right) \quad (4)$$

Where:

$AL_{T,i}$	=	Summed emissions from timber harvest in stratum *i* in the baseline case laced through implementation of carbon project (t CO_2e)
$C_{BSL,XBT,i,t}$	=	Carbon emission due to displaced timber harvests in the baseline scenario in stratum *i* in year *t* (t CO_2e)
i	=	*1, 2, 3, …M* strata in the project scenario
t	=	*1, 2, 3, …* $t*$ time elapsed since the start of the project activity (years)

The carbon emission due to the displaced logging has two components: the biomass carbon of the extracted timber (see also module *CP-W* which uses the same equation) and the biomass carbon in the forest damaged in the process of timber extraction:

$$C_{BSL,XBT,i,t} = \left(\left(V_{BSL,XE,i,t} \times D_{mn} \times CF\right) + \left(V_{BSL,XE,i,,t} \times LDF\right) + \left(V_{BSL,XE,i,,t} \times LIF\right)\right) \times \frac{44}{12} \quad (5)$$

Where:

$C_{BSL,XBT,i,t}$ = Carbon emission due to timber harvests in the baseline scenario in stratum *i* in year *t* (t CO_2e)
$V_{BSL,XE,i,t}$ = Volume of timber projected to be extracted from within the project boundary during the baseline in stratum *i* in year *t* (m^3)
D_{mn} = Mean wood density of commercially harvested species (t d.m.m^{-3})
CF = Carbon fraction of biomass for commercially harvested species *j* (t C t d.m.$^{-1}$)
LDF = Logging damage factor (t C m^{-3})
LIF = Logging infrastructure factor (t C m^{-3})
i = *1, 2, 3, …M* strata
t = *1, 2, 3, …* t^* time elapsed since the start of the project activity (years)

The logging damage factor (LDF) is a representation of the quantity of emissions that will ultimately arise per unit of extracted timber (m^3). These emissions arise from the non-commercial portion of the felled tree (the branches and stump) and trees incidentally killed during tree felling. The default values given here comes from the slope of the regression equation between carbon damaged and volume extracted based on 774 logging gaps measured by Winrock International in Bolivia, Belize, the Republic of Congo, Brazil and Indonesia (Appendix 1), and 134 logging gaps in Mexico.

The logging infrastructure factor (LIF) is a representation of the quantity of emissions that will ultimately arise per unit of timber (m^3) from roads, skid trails and logging decks. The conservative default value is the upper confidence interval of the average emission from analyses conducted across 1,473 hectares in the Republic of Congo and 366 hectares in Brazil (Appendix I).

5.2 Market-Effects Leakage Through Decreased Harvest of Fuelwood and Charcoal Sold into Regional and/or National Markets

Leakage due to market effects is equal to the emissions from fuelwood or charcoal harvests that are displaced outside the project area multiplied by a leakage factor and, where applicable, by a leakage management factor:

$$LK_{MarketEffects,FW/C} = \sum_{i=1}^{M} \left(LF_{ME} \times LKFC_{MAF} \times AL_{FW/C,i}\right) \quad (6)$$

Where:

$\mathrm{LK}_{\mathrm{MarketEffects,FW/C}}$ = Total GHG emissions due to market-effects leakage through decreased harvest of fuelwood and charcoal sold into regional and/or national markets (t CO_2-e)
$\mathrm{LF}_{\mathrm{ME}}$ = Leakage factor for market effects calculations (dimensionless)
$\mathrm{LKFC}_{\mathrm{MAF}}$ = Fuelwood/charcoal leakage management adjustment factor (dimensionless)

$AL_{FW/C,i}$ = Summed emissions from fuelwood/charcoal harvests in stratum *i* in the baseline case potentially displaced through implementation of carbon (t CO_2e)

The leakage factor is determined by considering where in the country harvest of fuelwood/charcoal might be increased as a result of the decreased supply of the products caused by the project. As very few species would be considered unsuitable for fuelwood and charcoal, and the infrastructure associated with fuelwood or charcoal is greatly less significant than for timber extraction, it is not considered that the proportion of biomass in commercial species will have relevance. Thus LF_{ME} is set at the level where mean merchantable biomass as a proportion of total aboveground tree biomass is considered equal in the project area to areas where harvesting will be displaced (ie, LF_{ME} = 0.4 for fuel wood/charcoal in all circumstances).

Where project proponents are able to clearly demonstrate based on eg, official data from the government or peer-reviewed literature, that fuelwood/charcoal market leakage will only happen out of the country, then fuelwood/charcoal market leakage shall be set as zero.

Moreover, if leakage management activities are established within areas under the control of the project proponents in order to minimize the displacement of land use activities to areas outside the project area by maintaining the production of fuelwood/charcoal, a fuelwood/charcoal leakage management adjustment factor ($LKFC_{MAF}$*)* may be applied. This factor discounts the value of $LK_{MarketEffects,FW/C}$ in a proportion equal to the annual volume of fuelwood/charcoal provided by the leakage management areas with respect to the total annual volume of fuelwood/charcoal that would have been produced in the project area in the absence of the project, as follows:

$$LKFC_{MAF} = 1 - \left(PRODFC_{LMA,t} / PRODFC_{BL,t}\right) \tag{7}$$

Where:

$LKFC_{MAF}$	=	Fuelwood/charcoal leakage management adjustment factor (dimensionless)
$PRODFC_{LMA,t}$	=	Production of fuelwood/charcoal in year *t* in leakage management areas (t per year)
$PRODFC_{BL,t}$	=	Production of fuelwood/charcoal in year *t* in the baseline case (t per year)
t	=	*1, 2, 3, …* $t*$ time elapsed since the start of the project activity (years)

If the leakage management areas produce an amount equal or higher than the expected baseline production of a given commodity, leakage shall be assumed to be zero. In order to apply this factor, project proponents need to demonstrate the production of the volume of the relevant commodities used to estimate this deduction, as well as evidence that such goods have reached the national markets. Any increase in GHG emissions associated with the leakage management activities shall be accounted for, unless deemed de minimis or conservatively excluded.

The next step is to estimate the emissions associated with the displaced harvesting activity. This is based on the total volume that would have been logged in the baseline in the project area across strata and time periods:

$$AL_{FW/C,i} = \sum_{t=1}^{t} C_{BSL,XBFWC,i,t} \tag{8}$$

Where:

$AL_{FW/C,i}$	=	Summed emissions from fuelwood/charcoal harvests in stratum *i* in the baseline case potentially displaced through implementation of carbon (t CO_2e)
$C_{BSL,XBFWC,i,t}$	=	Carbon emission due to displaced fuelwood/charcoal harvests in stratum *i* in the baseline scenario in year *t* (t CO_2e)
i	=	*1, 2, 3, …M* strata
t	=	*1, 2, 3, …* t^* time elapsed since the start of the REDD project activity (years)

The carbon emission due to displaced harvests is calculated from the volume that would likely be extracted in the baseline scenario minus any fuel wood supplied in the with-project scenario:

$$C_{BSL,XBWC,i,t} = \left(\left(FG_{BSL,i,t} \times D_{mn} \times CF \right) - \left(FG_{LP,i,t} \times D_{mn} \times CF \right) + \right) \times \frac{44}{12} \tag{9}$$

Where:

$C_{BSL,XBWC,i,t}$	=	Likely carbon emission due to displaced fuelwood/charcoal harvests in the baseline scenario in stratum *i* in year *t* (t CO_2e)
$FG_{BSL,i,t}$	=	Average projected annual volume of fuelwood to be gathered in the project area in the baseline scenario in stratum *i* in year *t* (m^3 yr^{-1})
D_{mn}	=	Mean wood density of commercially harvested species (t d.m.m^{-3})
CF	=	Carbon fraction of biomass for commercially harvested species *j* (t C t d.m.$^{-1}$)
i	=	*1, 2, 3, …*M_B strata in the baseline scenario
t	=	*1, 2, 3, …* t^* time elapsed since the start of the REDD project activity (years)

5.3 Market-Effects Leakage Through Decreased Timber, Fuelwood and Charcoal Harvest Resulting in Increased Peatland Drainage

$$LK_{MarketEffects,Peat} = \left(LK_{MarketEffects,Timber} + LK_{MarketEffects,FW/C} \right) \times PROP_{Peat-MLF} \times LK_{EFMKT,Peat} \tag{10}$$

Where:

$LK_{MarketEffects,Peat}$	=	Total GHG emissions due to market-effects leakage through decreased timber, fuelwood and charcoal harvest resulting in increased peatland drainage (t CO-e))
$LK_{MarketEffects,Timber}$	=	Total GHG emissions due to market-effects leakage through decreased timber harvest (t CO_2e)

$LK_{MarketEffects,FW/C}$	=	Total GHG emissions due to market-effects leakage through decreased harvest of fuelwood and charcoal sold into regional and/or national markets (t CO_2e)
$PROP_{Peat-MLF}$	=	Proportion of undrained peatland areas in the 'market leakage forest' areas with respect to the total market leakage forest areas (dimensionless)
$LK_{EFMKT,Peat}$	=	Leakage emission factor from market-effects leakage resulting in peatland drainage (t CO_2-e)

Step 1. Identify any undrained peatlands in the forests where harvesting could take place due to market-effects leakage.

Based on the identification of forest areas where harvesting would likely be displaced to, carried out in Sections 1 and 2 above, investigate if these areas contain undrained peatlands using official data, where available, or recent (ie, less than 5-year old) remote sensing products. If undrained peatlands are not found in such areas, $LK_{MarketEffects,Peat}$ is set to zero. In the case that undrained peatlands are identified, proceed to Step 2 below.

Step 2. Estimate the CO_2 emission factor from market-effects leakage to peatlands causing drainage.

The leakage emission factor from market-effects leakage resulting in peatland drainage ($LK_{EFMKT,Peat}$) is estimated as the amount of carbon lost at peat depletion time ($C_{peatloss,tPDT}$) in the forests to which displacement would occur ('market leakage forests') per each ton of carbon in the commercial species found in such forests (C_{MLF}).

$$LK_{EFMKT,Peat} = C_{peatloss,tPDT}/C_{MLF} \tag{11}$$

Where:

$LK_{EFMKT,Peat}$	=	Leakage emission factor from market-effects resulting in peatland drainage (t CO_2-e)
$C_{peatloss,tPDT}$	=	Cumulative peat carbon loss at tPDT (t CO_2-e)
C_{MLF}	=	Carbon in commercial species in market leakage forests (t CO_2-e)

Estimate the total carbon lost at peat depletion time ($C_{peatloss,tPDT}$) in the undrained peatlands in all the forested areas in the country that might be affected by market-effects leakage identified in Step 1 above:

$$C_{peatloss,tPDT} = 10 \times \left(\sum_{t=1}^{tPDT} \left(Depth_{peatloss,tPDT} \times VC_{peat} \right) \right) \tag{12}$$

Where:

$C_{peatloss,tPDT}$	=	Cumulative peat carbon loss at tPDT (t CO_2-e)
$Depth_{peatloss,tPDT}$	=	Depth of peat loss at tPDT (m)

VC_{peat} = Volumetric carbon content of peat in the baseline scenario (kg C m^{-3})
tPDT = Peat depletion time in stratum *i* (yr)

$C_{peatloss,tPDT}$ may be conservatively set to the thickness of the peatlayer.

$tPDT$ can be taken from tPDT-BSL,i in module *X-STR* (noting that similarity in peat depth and land use with stratum i referred to must be demonstrated. $tPDT$ may be assumed to exceed the project crediting period) or by using default values derived from the peer-reviewed literature, including default factors, where available.

Official or peer-reviewed data on the peatlands in the country may be applied instead of direct measurements to estimate $C_{peatloss,tPDT}$. Project participants shall demonstrate that the selected data will lead to conservative estimates of leakage emissions from peatlands.

The next step is to estimate the amount of carbon in the commercially harvested species of 'market leakage forests' ($C_{MLF,i}$):

$$C_{MLF,i} = \sum_{i=j}^{M} (C_{CS,i}) \tag{13}$$

Where:

$C_{MLF,i}$ = Total carbon in commercial species in stratum *i* in market leakage forests (t CO_2-e)
$C_{CS,i}$ = Carbon in commercial species in market leakage forests in stratum *I* (t CO_2-e)
i = *1, 2, 3, … M* strata

The carbon in commercial species in 'market leakage forests' $C_{CS,i}$ is estimated as the biomass carbon of the potentially extracted timber:

$$C_{CS,i} = (V_{MLF,i} \times D_{mn} \times CF) \times \frac{44}{12} \tag{14}$$

Where:

$C_{CS,i}$ = Carbon in commercial species in market leakage forests in stratum *I* (t CO_2-e)
$V_{MLF,i}$ = Volume of timber in stratum *i* in market leakage forest (m^3)
D_{mn} = Mean wood density of commercially harvested species (t d.m.m^{-3}). The value must be the same as that used in Equation (4).
CF = Carbon fraction of biomass for commercially harvested species *j* (t C t d.m.$^{-1}$). The value must be the same as that used in Equation (4).
i = *1, 2, 3, … M* strata

6 DATA AND PARAMETERS

6.1 Data and Parameters Available at Validation

Data / Parameter	PML_{FT}
Data unit	%
Description	Mean merchantable biomass as a proportion of total aboveground tree biomass for each forest type
Equations	N/A
Source of data	Data sources or own measurements
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	The source of data shall be chosen with priority from higher to lower preference as follows: 1) Peer-reviewed published sources (including carbon/biomass maps or growing stock volume[1] maps with a scale of at least 1km) 2) Official Government data and statistics 3) Original field measurements The forest types considered shall be only those relevant for the specific market-effects leakage; ie, only forest types with active timber production. An appropriate source of data will be Government records on annual allowable cuts for the areas of commercial forests. Where volumes are used the source of data wood density is required to convert to merchantable biomass. The source of data on wood densities shall be chosen with priority from higher to lower preference as follows: 1) Knowledge on commercial species and thus an appropriately weighted wood density derived from the density of these species 2) A region-specific mean wood density as given eg, in Brown 1997[2]
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	$PRODMB_{BL,t}$
Data unit	Tonnes of biomass in commercial species that is merchantable per year
Description	Production of biomass in commercial species that is merchantable in year t in the baseline case
Equations	3

[1] Volumes shall be converted to merchantable biomass using wood densities/specific gravities. A weighted wood density shall be used to convert multi-species data on growing stock volume to merchantable biomass

[2] Brown, S. 1997. Estimating biomass and biomass change of tropical forests: a Primer. FAO Forestry Paper 134. http://www.fao.org/docrep/W4095E/W4095E00.htm

Source of data	Own assessment
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Estimated taking into account the proportion of the project area that would be used for the production of the biomass in commercial species that is merchantable each year of the baseline period and the average productivity of the project area.
Purpose of Data	Calculation of leakage emissions
Comments	Must be re-evaluated whenever the baseline is revised

Data / Parameter	CF
Data unit	t C t d.m.$^{-1}$
Description	Carbon fraction of dry matter
Equations	5, 9, 14
Source of data	IPCC or default provided
Value applied	Default value 0.47 t C t^{-1} d.m., if no species-specific values are available
Justification of choice of data or description of measurement methods and procedures applied	Species specific values from the literature (eg, IPCC 2006 INV GLs AFOLU Chapter 4 Table 4.3)
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	D_{mn}
Data unit	t d.m. m^{-3}
Description	Mean wood density of commercially harvested species
Equations	5, 9, 14
Source of data	Data sources
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	The source of data shall be chosen with priority from higher to lower preference as follows: a) Averaged national and commercial species-specific (eg, from National GHG inventory);

	b) Averaged commercial species-specific from neighboring countries with similar conditions. Sometimes (b) may be preferable to (a). c) Averaged regional commercial species-specific (eg, Table 4.13 IPCC National Guidance for Greenhouse Gas Inventories AFOLU Section). d) Regional average (0.58 t d.m.m^{-3}- tropical Africa; 0.60 t d.m.m-3- tropical America; 0.57 d.m.m^{-3}- tropical Asia) from Brown, S. 1997. Estimating Biomass and Biomass Change of Tropical Forests: a Primer. For the Food and Agriculture Organization of the United Nations. Rome, 1997. FAO Forestry Paper - 134. ISBN 92-5-103955-0. Must use the same value in module CP-W if this module is used.
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	LDF
Data unit	t C m^{-3}
Description	Factor for calculating the biomass of dead wood created during logging operations per cubic meter extracted
Equations	5
Source of data	Default value provided
Value applied	Default value for broadleaf and mixed forests of 0.53 t C m^{-3} Default value for coniferous forests of 0.25 t C m^{-3}
Justification of choice of data or description of measurement methods and procedures applied	Default value for broadleaf and mixed forests of 0.53 t C m^{-3} from 774 logging gaps measured by Winrock International in Bolivia, Belize, the Republic of Congo, Brazil and Indonesia may be used for tropical broadleaf forests (cf. Appendix 1). Default value for coniferous forests of 0.25 t C m^{-3} from 134 logging gaps measured by Winrock International in Mexico (cf. Appendix 1).
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	LIF
Data unit	t C m^{-3}
Description	Factor for calculating the emissions arising from the creation of logging infrastructure (roads, skid trails and decks) during logging operations per cubic meter extracted
Equations	5

Source of data	Default value provided
Value applied	Conservative default value of 0.29 t CO_2e m^{-3}
Justification of choice of data or description of measurement methods and procedures applied	Conservative default value of 0.29 t CO_2e m^{-3} calculated from 1,839 hectares of logging concessions analysed by Winrock International in the Republic of Congo and Brazil, may be used for tropical broadleaf forests (cf. Appendix 1).
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	$V_{BSL,EX,i,t}$
Data unit	m^3
Description	Volume of timber projected to be extracted from within the project boundary during the baseline in stratum *i* in year *t*
Equations	5
Source of data	Data sources or own measurements
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	The source of data shall be chosen with priority from higher to lower preference as follows: 1. Timber harvest records and/or 2. Estimates derived from field measurements and/or 3. Assessments with aerial photography or satellite imagery.
Purpose of Data	Calculation of leakage emissions
Comments	Note that this volume does not include logging slash left onsite (tracked as part of the dead wood pool). Data compilers should also make sure that extracted volumes reported are gross volumes removed (ie, reported volume does not already discount for estimated wood waste, as is often the practice in harvest records)

Data / Parameter	$PRODFC_{BL,t}$
Data unit	Tonnes of fuelwood/charcoal per year
Description	Production of fuelwood/charcoal in year t in the baseline case
Equations	7
Source of data	Own assessment
Value applied	N/A

Justification of choice of data or description of measurement methods and procedures applied	Estimated taking into account the proportion of the project area that would be used for the production of fuelwood/charcoal each year of the baseline period and the average productivity of the project area for fuelwood/charcoal
Purpose of Data	Calculation of leakage emissions
Comments	Must be re-evaluated whenever the baseline is revised

Data / Parameter	$FG_{BSL,i,t}$
Data unit	m^3 yr^{-1}
Description	Average projected annual volume of fuelwood to be gathered in the project area in the baseline scenario in stratum *i* in year *t*
Equations	9
Source of data	Community survey
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Projected volumes must be derived from survey of resident communities and projections of population growth (for sampling requirements, refer to the latest version of *Guideline: Sampling and surveys for CDM project activities and programmes of activities*.[3])
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	$FP_{P,i,t}$
Data unit	m^3 yr^{-1}
Description	Average projected annual volume of fuelwood to be gathered in the project area in the project scenario in stratum *i* in year *t*
Equations	9
Source of data	Community survey
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Projected volumes must be derived from survey of resident communities and projections of population growth (for sampling

[3] Available at: https://cdm.unfccc.int/sunsetcms/storage/contents/stored-file-20151023152925068/Meth_GC48_%28ver04.0%29.pdf

	requirements, refer to the latest version of *Guideline: Sampling and surveys for CDM project activities and programmes of activities*.[4])
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	$tPDT_{,i}$
Data unit	yr
Description	Peat depletion time in stratum *i*
Equations	12
Source of data	Taken from $t_{PDT-BSL,i}$ in module *X-STR*
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See module *X-STR*
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	VC_{peat}
Data unit	kg C m^{-3}
Description	Volumetric carbon content of peat
Equations	13
Source of data	Data sources or own measurements
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	The source of data shall be chosen with priority from higher to lower preference as follows: 1. Peer-reviewed published sources 2. Official Government data and statistics 3. Original field measurements
Purpose of Data	Calculation of leakage emissions
Comments	N/A

[4] Available at: https://cdm.unfccc.int/sunsetcms/storage/contents/stored-file-20151023152925068/Meth_GC48_%28ver04.0%29.pdf

6.2 Data and Parameters Monitored

Data / Parameter:	PMP_j
Data unit:	%
Description:	Merchantable biomass as a proportion of total aboveground tree biomass for stratum i within the project boundaries
Equations	N/A
Source of data:	Own measurements
Description of measurement methods and procedures to be applied:	Within each stratum divide the summed merchantable biomass (defined as "Total gross biomass (including bark) of a tree 30 cm DBH or larger from a 30 cm stump to a minimum 10 cm top DOB of the central stem") by the summed total aboveground tree biomass. Merchantable biomass is equal to merchantable volume multiplied by wood density (D_{mn})
Frequency of monitoring/recording:	Must be monitored at least every 5 years or if verification occurs on a frequency of less than every 5 years examination must occur prior to any verification event. Ex ante a time zero measurement shall be made of this factor.
QA/QC procedures to be applied:	Direct measurement – project must have standard operating procedures for measurement to assure consistent defensible biomass and volume estimations
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$PRODMB_{LMA,t}$
Data unit:	Tonnes per year
Description:	Production of biomass in commercial species that is merchantable in year *t* in leakage management areas
Equations	3
Source of data:	Own measurements
Description of measurement methods and procedures to be applied:	Direct measurement of the volumes of biomass in commercial species that are merchantable produced in leakage management areas under control of the project participants that are sold in the relevant national/regional markets.
Frequency of monitoring/recording:	Must be examined at least every 5 years or if verification occurs on a frequency of less than every 5 years examination must occur prior to any verification event
QA/QC procedures to be applied:	See Section 9.3 of *REDD-MF* or other VCS methodology that uses this module. Direct measurement – project must have standard operating procedures for measurement to assure consistent defensible volume estimations
Purpose of data:	Calculation of leakage emissions

Calculation method:	N/A
Comments:	Project proponents shall demonstrate that the whole volume of biomass in commercial species that is merchantable is sold in the national markets has been produced in their leakage management areas (ie, that therefore no biomass has been bought from other producers and resold in such markets).

Data / Parameter:	$PRODFC_{LMA,t}$
Data unit:	Tonnes per year
Description:	Production of fuelwood/charcoal in year *t* in leakage management areas
Equations	7
Source of data:	Own measurements
Description of measurement methods and procedures to be applied:	Direct measurement of the volumes of the fuelwood/charcoal produced in leakage management areas under control of the project participants that are sold in the relevant national/regional markets.
Frequency of monitoring/recording:	Must be examined at least every 5 years or if verification occurs on a frequency of less than every 5 years examination must occur prior to any verification event
QA/QC procedures to be applied:	See Section 9.3 of *REDD-MF* or other VCS methodology that uses this module. Direct measurement – project must have standard operating procedures for measurement to assure consistent defensible volume estimations
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	Project proponents shall demonstrate that the whole volume of fuelwood/charcoal sold in the national markets has been produced in their leakage management areas (ie,, that therefore the fuelwood/charcoal sold has not been bought from other producers and resold in such markets).

Data / Parameter:	$PROP_{Peat-MLF}$
Data unit:	%
Description:	Proportion of undrained peatland areas in the 'market leakage forest' areas with respect to the total 'market leakage forest' areas
Equations	10
Source of data:	Own measurements
Description of measurement methods and procedures to be applied:	Divide the total area of undrained peatland areas in the 'market leakage forest' areas by the total area of 'market leakage forests'

Frequency of monitoring/recording:	Must be monitored at least every 5 years or if verification occurs on a frequency of less than every 5 years examination must occur prior to any verification event. *Ex ante* a time zero measurement shall be made of this proportion.
QA/QC procedures to be applied:	N/A
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$C_{peatloss,tPDT}$
Data unit:	t C
Description:	Cumulative peat carbon loss due to activity shifting leakage at $tPDT$
Equations	11
Source of data:	Module *X-STR*
Description of measurement methods and procedures to be applied:	See module *X-STR*
Frequency of monitoring/recording:	See module *X-STR*
QA/QC procedures to be applied:	N/A
Purpose of data:	N/A
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$Depth_{peatloss,tPDT,i}$
Data unit:	m
Description:	Depth of peat loss at $tPDT$ in 'market leakage forests'
Equations	13
Source of data:	Data sources or own measurements
Description of measurement methods and procedures to be applied:	The source of data shall be chosen with priority from higher to lower preference as follows: 1. Peer-reviewed published sources 2. Official Government data and statistics 3. Project-specific field measurements $Depth_{peatloss,tPDT}$ may be conservatively set to the thickness of the peat layer.

Frequency of monitoring/recording:	Must be monitored at least every 5 years or if verification occurs on a frequency of less than every 5 years examination must occur prior to any verification event. *Ex ante* a time zero measurement shall be made of this parameter.
QA/QC procedures to be applied:	N/A
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$V_{MLF,i,t}$
Data unit:	m^3
Description:	Volume of timber in stratum i in 'market leakage forest'
Equations	14
Source of data:	Data sources or own measurements
Description of measurement methods and procedures to be applied:	The source of data shall be chosen with priority from higher to lower preference as follows: 1. Peer-reviewed published sources 2. Official Government data and statistics 3. Project-specific field measurements
Frequency of monitoring/recording:	Must be monitored at least every 5 years or if verification occurs on a frequency of less than every 5 years examination must occur prior to any verification event. *Ex ante* a time zero measurement shall be made of this proportion.
QA/QC procedures to be applied:	N/A
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

APPENDIX I: LOGGING DAMAGE FACTOR (LDF)

Figure 1 below describes LDF for Broadleaf and Mixed Broadleaf/Conifer Forests.

Figure 1: LDF for Broadleaf and Mixed Broadleaf/Conifer Forests

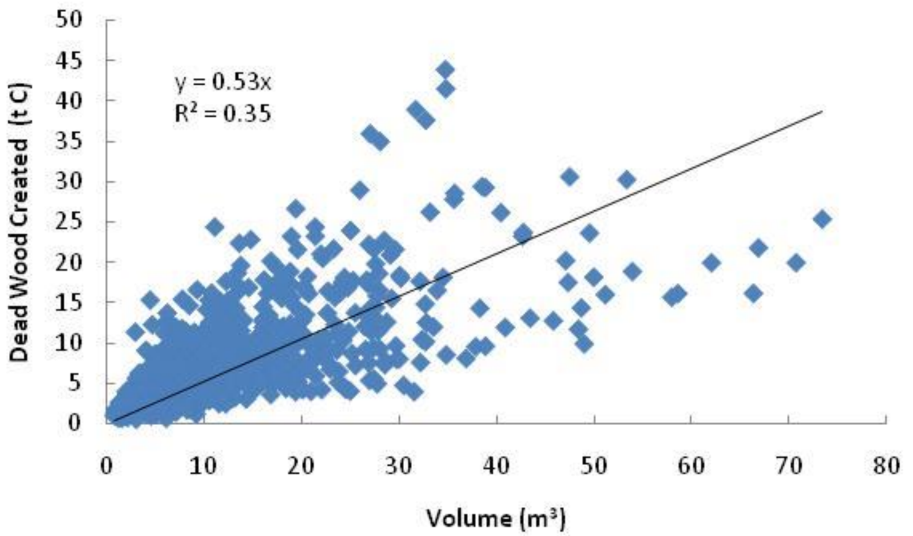
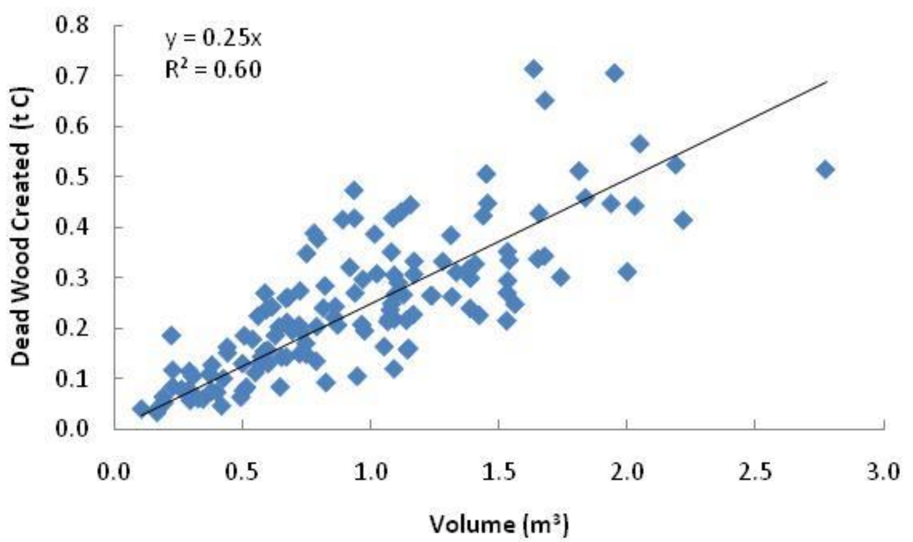


Figure 2 below describes LDF for Conifer Forests.

Figure 2: LDF for Conifer Forests



Methods used by Winrock are described in the following reports to USAID:

- Deliverable 9: Use of Aerial Digital Imagery to measure the impact of selective logging on carbon stocks of tropical forests in Republic of Congo
- Deliverable 10: Quantification of carbon benefits in conservation project activities through spatial modeling: Republic of Congo as a case study
- Deliverable 13a: Impact of logging on carbon stocks of forests: Chihuahua, Mexico as a case study
- Deliverable 17: Impact of logging on carbon stocks of forests: The Brazilian Amazon as a case study
- Deliverable 21: Use of aerial digital imagery to measure the impact of selective logging on carbon stocks of tropical forest in Brazilian Amazon
- Deliverable 24: Impact of selective logging on carbon stocks of tropical forests in East Kalimantan, Indonesia

Other methods are described in the following:

- Under Carbon and Co-Benefits from Sustainable Land-Use Management project: Cooperative Agreement No. EEM-A-00-03-00006-00
- Casarim, F.M., S.K. Grimland, and S. Brown. 2010. Carbon Impacts from Selective Logging of Forests in Berau, East Kalimantan, Indonesia
- Pearson, TRH and Brown, S. 2009. Impact of selective logging on the carbon stocks of tropical forests: case studies from Belize, Bolivia, Brazil, Indonesia, Mexico and the Republic of Congo.

Results are from uneven forest management practices. Application to even-aged forest management practices is conservative as under even-aged practices the emissions are solely from the non-extracted proportion of the timber trees while in uneven-aged practices emissions also come from trees incidentally damaged and killed during the felling of timber trees.

APPENDIX II: LOGGING INFRASTRUCTURE FACTOR (LIF)

Figure 3 below describes the LIF for Congo and Brazil.

Figure 3: LIF for Congo and Brazil

	Congo		Brazil	
Area examined (ha)	1,473		366	
Area of logging gaps (ha)	31.9		3.7	
Length of skid trails (km)	18.4		3.2	
Length of roads (km)	4.6		0.8	
Calculated extraction (m^3 +/- 95% C.I.)	14,150	±870	1,617	±327

Mean biomass of trees killed during logging operations:

Roads: 0.15 t C m^{-3} (± 0.08; 95 % confidence interval)

Skid Trails: 0.01 t C m^{-3} (± 0.05; 95 % confidence interval)

Logging Decks: 0.03 t C m^{-3} (± 0.04; 95 % confidence interval)

Therefore LIF = 0.1865 t C m^{-3} (± 0.11; 95 % confidence interval)

Therefore the conservative value for LIF = 0.29 t C m^{-3} (mean plus 95% confidence interval)

Methods used by Winrock are described in the following reports to USAID:

- Deliverable 9: Use of Aerial Digital Imagery to measure the impact of selective logging on carbon stocks of tropical forests in Republic of Congo
- Deliverable 10: Quantification of carbon benefits in conservation project activities through spatial modeling: Republic of Congo as a case study
- Deliverable 17: Impact of logging on carbon stocks of forests: The Brazilian Amazon as a case study
- Deliverable 21: Use of aerial digital imagery to measure the impact of selective logging on carbon stocks of tropical forest in Brazilian Amazon

Other methods are described in the following:

- Under Carbon and Co-Benefits from Sustainable Land-Use Management project: Cooperative Agreement No. EEM-A-00-03-00006-00
- Pearson, TRH and Brown, S. 2009. Impact of selective logging on the carbon stocks of tropical forests: case studies from Belize, Bolivia, Brazil, Indonesia, Mexico and the Republic of Congo.

DOCUMENT HISTORY

Version	Date	Comment
v1.0	3 Dec 2010	Initial version
v1.1	9 March 2015	The module was updated to include activities on peatlands.
v1.2	27 Nov 2023	• Update to latest VCS methodology template • Removal of references to VM0007