Verified Carbon Standard

VCS Module

VMD0013

ESTIMATION OF GREENHOUSE GAS EMISSIONS FROM BIOMASS AND PEAT BURNING (E-BPB)

Version 1.3

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Sectoral Scope 14

Avoided Deforestation Partners and Climate Focus convened the development of version 1.0 of this module. It was authored by Silvestrum Climate Associates (Igino Emmer and Eveline Trines), Winrock International (Dr. Sandra Brown and Dr. Tim Pearson), Carbon Decisions International (Lucio Pedroni), and TerraCarbon (David Shoch).

Version 1.1 of this module was developed by Verra.

Version 1.2 of this module was prepared by Silvestrum Climate Associates.

Version 1.3 of this module was prepared by Verra with support from Tim Pearson.

CONTENTS

1 SOURCES

This module uses the latest versions of the following modules:

- *VMD0001 Estimation of carbon stocks in the above- and belowground biomass in live tree and non-tree pools (CP-AB)*
- *VMD0003 Estimation of carbon stocks in the litter pool (CP-L)*
- *VMD0002 Estimation of carbon stocks in the dead-wood pool (CP-D)*
- *VMD0016 Methods for stratification of the project area (X-STR)*

2 SUMMARY DESCRIPTION OF THE MODULE

This module provides a step-wise approach for estimating GHG emissions from biomass burning ($E_{biomassburn,i,t}$) and peat burning ($GHG_{peatburn,i,t}$).

3 DEFINITIONS

Definitions are set out in the *VCS Program Definitions*.

4 APPLICABILITY CONDITIONS

This module is applicable to REDD project activities with emissions from biomass burning and REDD-WRC project activities with emissions from biomass and/or peat burning. This module is also applicable to RWE and ARR-RWE project activities with emissions from peat burning.

5 PROCEDURES

Where vegetation and/or peat burn, emissions of CO_2, N_2O and CH_4 result. Inclusion of fire in the baseline is always optional. Where used in the baseline, accounting must occur under both the baseline and project scenarios in both the project area and in the leakage belt. Where fires occur *ex post*, the module must be used to account GHG emissions.

GHG emissions from biomass burning can result from the following:

1) Conversion of forest land to non-forest land using fire.
2) Periodical burning of grassland or agricultural land after deforestation.
3) Controlled burning in forest land remaining forest land.
4) Uncontrolled fire in drained peat swamp forest.
5) Uncontrolled peat burning in (abandoned) drained peat sites.

5.1 Estimation of Emissions Due to Biomass Burning($E_{biomassburn,i,t}$)

Some GHG emissions can be measured, but because of the high spatial and temporal variability, the following method must be used. Based on the IPCC 2006 Inventory Guidelines, estimating greenhouse gas emissions from biomass burning must be determined using the following:

$$E_{biomassburn,i,t} = \sum_{g=1}^{G} \left(\left(\left(A_{burn,i,t} \times B_{i,t} \times COMF_i \times G_{g,i} \right) \times 10^{-3} \right) \times GWP_g \right) \qquad (1)$$

Where:

$E_{biomassburn,i,t}$	=	Greenhouse gas emissions due to biomass burning in stratum *i* in year *t* of each GHG (CO_2, CH_4, N_2O) (t CO_2e)
$A_{burn,i,t}$	=	Area burnt for stratum *i* in year *t* (ha)
$B_{i,t}$	=	Average aboveground biomass stock before burning stratum *i*, year (t d.m. ha^{-1})
$COMF_i$	=	Combustion factor for stratum *i* (unitless)
$G_{g,i}$	=	Emission factor for stratum *i* for gas *g* (kg t^{-1} d.m. burnt)
GWP_g	=	Global warming potential for gas *g* (t CO_2/t gas g)
g	=	1, 2, 3 … *G* greenhouse gases including carbon dioxide[1], methane and nitrous oxide (unitless)
i	=	1, 2, 3, …*M* strata (unitless)
t	=	1, 2, 3, … *t** time elapsed since the start of the project activity (years)

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.

[1]Carbon dioxide may be omitted where carbon dioxide emissions are calculated in an alternate module through stock change

The average aboveground biomass stock before burning for a particular stratum is estimated as follows:

$$B_{i,t} = (C_{AB\_tree,i,t} + C_{DWi,t} + C_{LI,i,t}) \times \frac{12}{44} \times \left(\frac{1}{CF}\right) \quad (2)$$

Where:

$B_{i,t}$	=	Average aboveground biomass stock before burning for stratum *i*, year *t* (tonnes d.m. ha^{-1})
$C_{AB\_tree,i,t}$	=	Carbon stock in aboveground biomass in trees in stratum *i* in year *t* (t CO_2e ha^{-1})
$C_{DWi,t}$	=	Carbon stock in dead wood for stratum *i* in year *t* (t CO_2e ha^{-1})
$C_{LI,i,t}$	=	Carbon stock in litter for stratum *i* in year *t* (t CO_2e ha^{-1})
$\frac{12}{44}$	=	Inverse ratio of molecular weight of CO_2 to carbon (t CO_2e t C^{-1})
CF	=	Carbon fraction of biomass (t C t^{-1} d.m.)
i	=	1, 2, 3, …*M* strata (unitless)
t	=	1, 2, 3, … $t*$ time elapsed since the start of the project activity (years)

5.2 Estimation of GHG Emissions Due to Peat Burning ($GHG_{peatburn,i,t}$)

Estimating greenhouse gas emissions from peat burning must be determined as:

$$GHG_{peatburn,i,t} = \sum_{g=1}^{G} (P_{i,t} \times G_{g,i} \times 10^{-3} GWP_g) \quad (3)$$

Where:

$GHG_{peatburn,i,t}$	=	Greenhouse gas emissions due to peat burning in stratum *i* in year *t* of each GHG (CO_2, CH_4, N_2O) (t CO_2e ha^{-1} yr^{-1})
$P_{i,t}$	=	Average mass of peat burnt for stratum *i* in year *t* (t d.m. ha^{-1})
$G_{peat,g,i}$	=	Emission factor in stratum *i* for gas *g* (kg t-1 d.m. burnt)
GWP_g	=	Global warming potential for gas *g* (t CO_2/t *g*)
g	=	1, 2, 3 **…** G greenhouse gases including carbon dioxide[2], methane and nitrous oxide[3] (unitless)
i	=	1, 2, 3, …*M* strata (unitless)
t	=	1, 2, 3, … $t*$ time elapsed since the start of the project activity (years)

The average mass of peat carbon burnt for a particular stratum is estimated as follows:

[2] Carbon dioxide may be omitted where carbon dioxide emissions are calculated in an alternate module through stock change

[3] As emissions from peat fires are higher in the baseline as per the applicability conditions, CH_4 and N_2O emissions can conservatively be omitted

$$P_{i,t} = D_{peatburn,i,t} \times BD_{upper,i} \times 10^4 \quad (4)$$

Where:

$P_{i,t}$	=	Average mass of peat burnt for stratum *i* in year *t* (t d.m. ha^{-1})
$D_{peatburn,i,t}$	=	Average fire scar depth in stratum *i* in year *t* (m)
$BD_{upper,i}$	=	Bulk density of the upper peat in stratum *i* (g cm^{-3})
i	=	1, 2, 3, …*M* strata (unitless)
t	=	1, 2, 3, … $t*$ time elapsed since the start of the project activity (years)

Module *M-PEAT* provides a rapid and conservative alternative approach to acknowledge peat fire emission reductions as a result of rewetting without having to develop complex baseline scenarios for peat fires (the fire reduction premium).

6 DATA AND PARAMETERS

6.1 Data and Parameters Available at Validation

Data / Parameter	$COMF_i$
Data unit	Dimensionless
Description	Combustion factor for stratum *i* (vegetation type)
Equations	1
Source of data	IPCC
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Default values in Table 2.6 of IPCC, 2006 (Appendix 2). The combustion factor is a measure of the proportion of the fuel that is actually combusted, which varies as a function of the size and architecture of the fuel load (i.e., a smaller proportion of large, coarse fuel such as tree stems will be burnt compared to fine fuels, such as grass leaves), the moisture content of the fuel and the type of fire (i.e., intensity and rate of spread). Default values must be updated whenever new guidelines are produced by the IPCC.
Purpose of Data	Calculation of baseline and project emissions
Comments	N/A

Data / Parameter	G_{gi}

Data unit	g kg^{-1} dry matter burnt
Description	Emission factor for stratum *i* for gas *g*
Equations	1
Source of data	IPCC
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Defaults can be found in Volume 4, Chapter 2, of the IPCC 2006 Inventory Guidelines in table 2.5 (see Appendix 2: emission factors for various types of burning for CH_4 and N_2O). Default values must be updated whenever new guidelines are produced by the IPCC.
Purpose of Data	Calculation of baseline and project emissions
Comments	N/A

Data / Parameter	CF
Data unit	t C t dry matter-^{1}
Description	Carbon fraction of dry matter
Equations	2
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 baseline and project emissions
Comments	N/A

Data / Parameter	GWP_g
Data unit	Dimensionless
Description	Global warming potential for gas g
Equations	2, 4
Source of data	Default factor from the latest IPCC Assessment Report
Value applied	N/A

Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Calculation of baseline and project emissions
Comments	N/A

Data / Parameter	$BD_{upper,i}$
Data unit	g cm^{-3} (= t m^{-3})
Description	Bulk density of the upper peat layer in stratum *i*
Equations	4
Source of data	Applicable VCS methodology
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See applicable VCS methodology
Purpose of Data	Calculation of baseline and project emissions
Comments	N/A

Data / Parameter	$G_{peat,i}$
Data unit	Dimensionless
Description	Emission factor of peat for gas *g* for stratum *i*
Equations	4
Source of data	Default values from scientific literature such as Muraleedharan *et al*. 2000, Christian *et al.* 2007, Hamade *et al.* 2013 or IPCC.
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Default values must be updated whenever new information becomes available or new guidelines are produced by the IPCC.
Purpose of Data	Calculation of baseline and project emissions
Comments	N/A

6.2 Data and Parameters Monitored

Data / Parameter:	$A_{burn,i,t}$
Data unit:	ha
Description:	Area burnt in stratum *i* in year *t*
Equations	1
Source of data:	Remote sensing
Description of measurement methods and procedures to be applied:	Best practices for remote fire area monitoring
Frequency of monitoring/recording:	Prior to each verification event
QA/QC procedures to be applied:	Best practices for remote fire area monitoring
Purpose of data:	Calculation of baseline and project emissions
Calculation method:	N/A
Comments:	To be determined ex ante when accounting of $E_{biomassburn,i,t}$ is included in the baseline scenario To be monitored when accounting of $E_{biomassburn,i,t}$ is included in the project scenario

Data / Parameter:	$D_{peatburn,i,t}$
Data unit:	m
Description:	Area burnt in stratum *i* in year *t*
Equations	4
Source of data:	Relevant VCS methodology
Description of measurement methods and procedures to be applied:	Relevant VCS methodology
Frequency of monitoring/recording:	Relevant VCS methodology
QA/QC procedures to be applied:	Relevant VCS methodology
Purpose of data:	Calculation of baseline and project emissions
Calculation method:	N/A
Comments:	To be determined *ex ante* when accounting of $GHG_{peatburn,i,t}$ is included in the baseline scenario

	To be monitored when accounting of $GHG_{peatburn,i,t}$ is included in the project scenario

Data / Parameter:	$C_{AB,tree,i}$
Data unit:	t CO_2e ha^{-1}
Description:	Carbon stock in aboveground biomass in trees in stratum *i*
Equations	2
Source of data:	Module *CP-AB*
Description of measurement methods and procedures to be applied:	See module *CP-AB*
Frequency of monitoring/recording:	See module *CP-AB*
QA/QC procedures to be applied:	See module *CP-AB*
Purpose of data:	Calculation of baseline and project emissions
Calculation method:	N/A
Comments:	To be determined *ex ante* when accounting of $GHG_{biomassburn,i,t}$ is included in the baseline scenario To be monitored when accounting of $GHG_{biomassburn,i,t}$ is included in the project scenario

Data / Parameter:	$C_{DW,i}$
Data unit:	t CO_2e ha^{-1}
Description:	Carbon stock in aboveground biomass in trees in stratum *i*
Equations	2
Source of data:	Module *CP-D*
Description of measurement methods and procedures to be applied:	See module *CP-D*
Frequency of monitoring/recording:	See module *CP-D*
QA/QC procedures to be applied:	See module *CP-D*
Purpose of data:	Calculation of baseline and project emissions
Calculation method:	N/A

Comments:	To be determined *ex ante* when accounting of $E_{biomassburn,i,t}$ is included in the baseline scenario To be monitored when accounting of $E_{biomassburn,i,t}$ is included in the project scenario

Data / Parameter:	$C_{LI,i}$
Data unit:	t CO_2e ha^{-1}
Description:	Carbon stock in litter in the baseline in stratum *i*
Equations	2
Source of data:	Module *CP-L*
Description of measurement methods and procedures to be applied:	See module *CP-L*
Frequency of monitoring/recording:	See module *CP-L*
QA/QC procedures to be applied:	See module *CP-L*
Purpose of data:	Calculation of baseline and project emissions
Calculation method:	N/A
Comments:	To be determined *ex ante* when accounting of $E_{biomassburn,i,t}$ is included in the baseline scenario To be monitored when accounting of $E_{biomassburn,i,t}$ is included in the project scenario

Data / Parameter:	$v_{burn,i,t}$
Data unit:	m^3 ha^{-1}
Description:	Peat volume burnt in stratum *i* in year *t*
Equations	4
Source of data:	Ree relevant VCS methodology
Description of measurement methods and procedures to be applied:	See relevant VCS methodology
Frequency of monitoring/recording:	See relevant VCS methodology
QA/QC procedures to be applied:	See relevant VCS methodology
Purpose of data:	Calculation of baseline and project emissions

Calculation method:	N/A
Comments:	To be determined *ex ante* when accounting of $GHG_{peatburn,i,t}$ is included in the baseline scenario To be monitored when accounting of $GHG_{peatburn,i,t}$ is included in the project scenario

7 REFERENCES

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Muraleedharan, T.R., Radojevic, M., Waugh, A. and Caruana, A., (2000). Emissions from the combustion of peat: an experimental study. Atmospheric Environment 34: 3033-3035;

APPENDIX I: COMBUSTION FACTOR VALUES FOR FIRES

Combustion Factor Values (Proportion of Prefire Fuel Biomass Consumed) for Fires in a Range of Vegetation Types				
Vegetation type	**Subcategory**	**Mean**	**SD**	**References**
Shrublands	Shrubland (general)	0.95	-	44
	Calluna heath	0.71	0.30	26, 56, 39
	Fynbos	0.61	0.16	70, 44
All shrublands		**0.72**	**0.25**	
Savanna woodlands (early dry season burns)*	Savanna woodland	0.22	-	28
	Savanna parkland	0.73	-	57
	Other savanna woodlands	0.37	0.19	22, 29
All savanna woodlands (early dry season burns)		**0.40**	**0.22**	
Savanna woodlands (mid/late dry season burns)*	Savanna woodland	0.72	-	66, 57
	Savanna parkland	0.82	0.07	57, 6, 51
	Tropical savanna	0.73	0.04	52, 73, 66, 12
	Other savanna woodlands	0.68	0.19	22, 29, 44, 31, 57
All savanna woodlands (mid/late dry season burns)*		**0.74**	**0.14**	
Savanna Grasslands/ Pastures (early dry season burns)*	Tropical/sub-tropical grassland	0.92	0.11	44, 73, 66, 12, 57
	Tropical pasture~	0.35	0.21	4, 23, 38, 66
	Savanna	0.86	0.12	53, 5, 56, 42, 50, 6, 45, 13, 44, 65, 66
All savanna grasslands (mid/late dry season burns)*		**0.77**	**0.26**	
Other vegetation types	Peatland	0.50	-	20, 44
	Tropical Wetlands	0.70	-	44
Agricultural residues (Post harvest field burning)	Wheat residues	0.90	-	see Note b
	Maize residues	0.80	-	see Note b
	Rice residues	0.80	-	see Note b
	Sugarcanea	0.80	-	see Note b

* Surface layer combustion only

~ Derived from slashed tropical forest (includes unburned woody material)

a For sugarcane, data refer to burning before harvest of the crop

b Expert assessment by authors

Values in column 'mean' are to be used for quantity C_f in Equation 2.27

APPENDIX II: EMISSIONS FACTORS FOR VARIOUS TYPES OF BURNING

Emission Factors (g kg^{-1} dry matter burnt) for Various Types of Burning					
Category	CO_2	CO	CH_4	N_2O	NO_X
Savanna and grassland	1613 ± 95	65 ± 20	2.3 ± 0.9	0.21 ± 0.10	3.9 ± 2.4
Agricultural residues	1515 ± 177	92 ± 84	2.7	0.07	2.5 ± 1.0
Tropical forest	1580 ± 90	104 ± 20	6.8 ± 2.0	0.20	1.6 ± 0.7
Extra tropical forest	1569 ± 131	107 ± 37	4.7 ± 1.9	0.26 ± 0.07	3.0 ± 1.4
Biofuel burning	1550 ± 95	78 ± 31	6.1 ± 2.2	0.06	1.1 ± 0.06

Note: Values are Means ± SD and are Based on the Comprehensive Review by Andreae and Merlet (2001)
Note: To be used to quantify 'Gef' in Equation 2.27
Note: The "extra tropical forest" category includes all other forest types.
Note: For combustion of non-woody biomass in Grassland and Cropland, CO_2 emissions do not need to be estimated and reported, because it is assumed that annual CO_2 removals (through growth) and emissions (whether by decay or fire) by biomass are in balance (see earlier discussion on synchrony in Section 2.4).

DOCUMENT HISTORY

Version	Date	Comment
v1.0	3 Dec 2010	Initial version
v1.1	9 March 2015	The module was updated to include emissions from peat burning.
v.1.2	8 Sep 2020	The module was updated to include emissions from biomass and peat burning in REDD-WRC activities and peat burning in RWE and ARR-RWE activities.
v1.3	27 Nov 2023	• Update to latest VCS methodology template • Removal of references to VM0007