



## A/R Methodological Tool

### “Estimation of non-CO<sub>2</sub> GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity”

(Version 04.0.0)

## I. SCOPE, APPLICABILITY AND ASSUMPTIONS

### Scope

1. This tool can be used for estimation of non-CO<sub>2</sub> GHG emissions resulting from burning of biomass and forest fires.

### Applicability

2. The tool is applicable to all occurrence of fire within the project boundary.

3. Non-CO<sub>2</sub> GHG emissions resulting from any occurrence of fire within the project boundary shall be accounted for each incidence of fire which affects an area greater than the minimum threshold area reported by the host Party for the purpose of defining forest, provided that the accumulated area affected by such fires in a given year is  $\geq 5\%$  of the project area.

### Assumptions

4. This tool applies the following assumptions:

- (a) Aboveground biomass of living trees shall be considered not to result in significant non-CO<sub>2</sub> GHG emission in case of fire, when
  - (i) A forest fire burns through the understory but does not climb into the tree canopy; or
  - (ii) A forest fire singes trees but does not cause mortality such that leaf regeneration can be observed within six months (this may be demonstrated in remote sensing imagery);
- (b) 60% of the dead organic matter is entirely burnt in all fires.

### Parameters

5. This tool provides steps to estimate the parameter(s) given in Table 1.

**Table 1: Parameters determined by the tool**

Parameter	Unit	Description
$GHG_{E,t}$	t CO <sub>2</sub> -e	Emission of non-CO <sub>2</sub> GHGs resulting from burning of biomass and forest fires within the project boundary, in year $t$

## II. ESTIMATION OF EMISSIONS OF GREENHOUSE GASES

6. Emission of non-CO<sub>2</sub> GHGs resulting from burning of biomass and forest fires within the project boundary in year  $t$  is estimated as follows:



$$GHG_{E,t} = GHG_{SPF,t} + GHG_{FMF,t} + GHG_{FF,t} \quad (1)$$

where:

$GHG_{E,t}$  Emission of non-CO<sub>2</sub> GHGs resulting from burning of biomass and forest fires within the project boundary in year  $t$ ; t CO<sub>2</sub>-e

$GHG_{SPF,t}$  Emission of non-CO<sub>2</sub> GHGs resulting from use of fire in site preparation in year  $t$ ; t CO<sub>2</sub>-e

$GHG_{FMF,t}$  Emission of non-CO<sub>2</sub> GHGs resulting from use of fire to clear the land of harvest residue prior to replanting of the land or other forest management, in year  $t$ ; t CO<sub>2</sub>-e

$GHG_{FF,t}$  Emission of non-CO<sub>2</sub> GHGs resulting from fire in year  $t$ ; t CO<sub>2</sub>-e

$t$  1, 2, 3, ... years counted from the start of the A/R CDM project activity

### Emission resulting from use of fire in site preparation

7. Emission of non-CO<sub>2</sub> GHGs resulting from use of fire in site preparation in year  $t$  is estimated as follows:

- (a) For all areas of land where: (i) Slash-and-burn is a common practice in the baseline, and (ii) Fire has been used in the area at least once during the period of ten years preceding the start of the A/R CDM project activity:

$$GHG_{SPF,t} = 0 \quad (2)$$

- (b) For all areas of land where the condition (a) above is not satisfied:

$$GHG_{SPF,t} = 0.07 * \sum_{i=1}^M \left( A_{SPF,i,t} * \frac{44}{12} * (CF_{TREE} * b_{TREE,i,t} + CF_{SHRUB} * BDR_{SF} * B_{FOREST} * CC_{SHRUB,i,t}) \right) \quad (3)$$

where:

$GHG_{SPF,t}$  Emission of non-CO<sub>2</sub> GHGs resulting from use of fire in site preparation in year  $t$ ; t CO<sub>2</sub>-e

0.07 Ratio of non-CO<sub>2</sub> GHG emissions to CO<sub>2</sub> emission resulting from burning of biomass; dimensionless

The value of this ratio has been adapted from Table 2.5 of the 2006 IPCC Guidelines for National GHG Inventories, taking into account methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) emissions only

$b_{TREE,i,t}$  Mean tree biomass per hectare within stratum  $i$  in the project boundary at the start of the project; t d.m. ha<sup>-1</sup>

Estimated using the tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”. Where pre-project living trees are not burned during site preparation,  $b_{TREE,i}$  shall be set equal to zero

$CF_{TREE}$  Carbon fraction of biomass ; t C (t d.m.)<sup>-1</sup>.

The IPCC default value of 0.50 is used

$CF_{SHRUB}$	Carbon fraction of shrub biomass; t C (t d.m.) <sup>-1</sup> The IPCC default value of 0.50 is used
$A_{SPF,t}$	Area of land in which fire is used in site preparation in stratum $i$ in year $t$ ; ha
$BDR_{SF}$	Ratio of shrub biomass per unit area in land having a shrub crown cover of 1.0 and the default above-ground biomass content in forest in the region/country where the A/R CDM project is located; dimensionless  A default value of 0.10 is used unless transparent and verifiable information can be provided to justify a different value
$B_{FOREST}$	Default above-ground biomass content in forest in the region/country where the A/R CDM project is located; t d.m. ha <sup>-1</sup>  The value of this parameter is selected according to the guidance provided in the relevant entry in the tables at the end of this tool
$CC_{SHRUB,i,t}$	Crown cover of shrubs in area of land within the project boundary at the start of the project in which fire is used for site preparation in stratum $i$ in year $t$ ; dimensionless
$t$	1, 2, 3, ... years counted from the start of the A/R CDM project activity
$i$	Stratum within the baseline

### Non-CO<sub>2</sub> emissions resulting from use of fire to clear the land of harvest residue prior to replanting of the land

8. Emissions of non-CO<sub>2</sub> GHGs resulting from use of fire to clear the land of harvest residue prior to replanting of the land is estimated on the basis of the ratio of the biomass left at site to the biomass harvested. In the case of fuelwood harvest this ratio is likely to be smaller than in the case of timber harvest. It is therefore conservative to apply the ratio in the case of timber harvest to the case of fuelwood and other harvests.

*When the data on biomass of the harvest removed are available*

9. If the data on biomass of the harvest removed are available, the emission of non-CO<sub>2</sub> GHGs resulting from use of fire to clear the land of harvest residue prior to replanting of the land is estimated as follows:

$$GHG_{FMF,t} = 0.07 * \frac{44}{12} * B_{HARVEST,t} * f_{BL} * CF_{TREE} \quad (4)$$

where:

$GHG_{FMF,t}$	Emission of non-CO <sub>2</sub> GHGs resulting from use of fire to clear the land of harvest residue prior to replanting of the land, in year $t$ ; t CO <sub>2</sub> -e
$B_{HARVEST,t}$	Biomass harvested from area subjected to use of fire to clear the land of harvest residue prior to replanting of the land in year $t$ ; t d.m.



$f_{BL}$	The fraction of aboveground tree biomass out of total harvest left on-site; dimensionless  A value of 0.10 for temperate forest and 0.25 for tropical forest is used. These values of the parameter have been conservatively adapted from Table 3A.1.11 of the IPCC GPG LULUCF 2003
$CF_{TREE}$	Carbon fraction of biomass of trees harvested; t C (t d.m) <sup>-1</sup> . IPCC default value of 0.50 t C (t d.m) <sup>-1</sup> is used
$t$	1, 2, 3, ... years counted from the start of the A/R CDM project activity

*When the data on biomass of the harvest removed are not available*

10. If the data on biomass of the harvest removed are not available, the biomass of harvest removed is estimated as follows:

$$B_{HARVEST,t} = \frac{B_{FOREST}}{BEF_2} * A_{FMF,t} \quad (5)$$

where:

$B_{HARVEST,t}$	Biomass harvested from area subjected to use of fire to clear the land of harvest residue prior to replanting of the land in year $t$ ; t d.m.
$B_{FOREST}$	Default above-ground biomass content in forest in the region/country where the A/R CDM project is located; t d.m. ha <sup>-1</sup>  The value of this parameter is selected according to the guidance provided in the relevant entry in the tables at the end of this tool
$BEF_2$	The biomass expansion factor for trees harvested; dimensionless A value of 1.25 is used
$A_{FMF,t}$	Area of land subjected to use of fire to clear the land of harvest residue prior to replanting of the land in year $t$ ; ha
$T$	1, 2, 3, ... years counted from the start of the A/R CDM project activity

#### **Non-CO<sub>2</sub> emissions resulting from forest fires**

11. Emission of GHGs resulting from the burning of aboveground project tree biomass in fire that is not site preparation or burning of harvest residue (defined from this point forward as forest fire) is calculated using the aboveground biomass in trees and dead wood of relevant strata in last verification.

$$GHG_{FF,t} = GHG_{FF\_TREE,t} + GHG_{FF\_DOM,t} \quad (6)$$



where:

$GHG_{FF,t}$	Emission of non-CO <sub>2</sub> GHGs resulting from forest fire, in year $t$ ; t CO <sub>2</sub> -e
$GHG_{FF\_TREE,t}$	Emission of non-CO <sub>2</sub> GHGs resulting from the loss of aboveground biomass of trees due to forest fire, in year $t$ ; t CO <sub>2</sub> -e
$GHG_{FF\_DOM,t}$	Emission of non-CO <sub>2</sub> GHGs resulting from the loss of dead organic matter due to forest fire, in year $t$ ; t CO <sub>2</sub> -e

12. Emission of non-CO<sub>2</sub> GHGs resulting from the loss of aboveground tree biomass due fire is calculated using the above ground biomass in trees of relevant strata in last verification and a combustion factor. For the first verification, emission of non-CO<sub>2</sub> GHGs resulting from the loss of trees due to natural or anthropogenic forest fire is assumed to be zero.

$$GHG_{FF\_TREE,t} = 0.001 * \sum_{i=1}^M A_{BURN,i,t} * b_{TREE,i,t_L} * COMF_i * (EF_{CH_4,i} * GWP_{CH_4} + EF_{N_2O,i} * GWP_{N_2O}) \quad (7)$$

where:

$GHG_{FF\_TREE,t}$	Emission of non-CO <sub>2</sub> gases resulting from the loss of aboveground biomass of trees due to fire, in year $t$ ; t CO <sub>2</sub> -e
$A_{BURN,i,t}$	Area burnt in stratum $i$ in year $t$ , ha
$b_{TREE,i,t_L}$	Mean aboveground tree biomass per hectare in stratum $i$ in year $t_L$ which is the year in which last verification was carried out before occurrence of the fire; t d.m. ha <sup>-1</sup>  Where aboveground biomass of living trees is not burnt by fire, $b_{TREE,i,t_L}$ may be set equal to zero
$COMF_i$	Combustion factor for stratum $i$ ; dimensionless
$EF_{CH_4,i}$	Emission factor for CH <sub>4</sub> in stratum $i$ ; g CH <sub>4</sub> (kg dry matter burnt) <sup>-1</sup>
$GWP_{CH_4}$	Global warming potential for CH <sub>4</sub> ; dimensionless Default value of 21 is used
$EF_{N_2O,i}$	Emission factor for N <sub>2</sub> O in stratum $i$ ; g N <sub>2</sub> O (kg dry matter burnt) <sup>-1</sup>
$GWP_{N_2O}$	Global warming potential for N <sub>2</sub> O; dimensionless Default value of 310 is used
$I$	1, 2, 3 ... $M$ strata
$T$	1, 2, 3, ... years elapsed since the start of the project activity

13. Emission of non-CO<sub>2</sub> GHGs resulting from the loss of dead organic matter due to fire is calculated using the dead organic matter stock at the last verification. Where PPs elected at validation not to account for dead organic matter pool, the dead organic matter stock is considered zero and non-CO<sub>2</sub> GHG emissions from fire are not accounted. Where dead organic matter is accounted, for the first verification period emission of non-CO<sub>2</sub> GHGs resulting from the loss of dead organic matter due to fire is assumed to be zero, and for subsequent verification periods emission of non-CO<sub>2</sub> GHGs is estimated as follows:

$$GHG_{FF\_DOM,t} = 0.07 * \sum_{i=1}^M A_{BURN,i,t} * (C_{DW,i,t_L} + C_{LI,i,t_L}) \quad (8)$$

where:

$GHG_{FF\_DOM,t}$	Emission of GHGs resulting from the loss of dead organic matter due to fire, in year $t$ ; t CO <sub>2</sub> -e
$A_{BURN,i,t}$	Area burnt in stratum $i$ in year $t$ ; ha
$C_{DW,i,t_L}$	Carbon stock in dead wood in stratum $i$ in year $t_L$ which is the year in which last verification was carried out before occurrence of the fire, as estimated using the “Tool for estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities”; t CO <sub>2</sub> -e
$C_{LI,i,t_L}$	Carbon stock in litter in stratum $i$ in year $t_L$ which is the year in which last verification was carried out before occurrence of the fire, as estimated using the “Tool for estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities”; t CO <sub>2</sub> -e
$I$	1, 2, 3 ... $M$ strata
$T$	1, 2, 3, ... years elapsed since the start of the project activity

### III. DATA AND PARAMETERS USED IN THE TOOL

14. The following tables describe the data and parameters used in this tool. The guidelines contained in these tables regarding selection of data sources, and procedures to be followed in measurement, where applicable, should be treated as an integral part of this tool.

#### Data and parameters obtained from existing sources

<b>Data / Parameter:</b>	$BDR_{SF}$
Data unit:	Dimensionless
Used in equations:	3
Description	Ratio of shrub biomass per unit area in land having a shrub crown cover of 1.0 and the default above-ground biomass content in forest in the region/country where the A/R CDM project is located
Source of data:	A default value of 0.10 should be used unless transparent and verifiable information can be provided to justify a different value

<b>Data / Parameter:</b>	$B_{FOREST}$
Data unit:	t d.m. ha <sup>-1</sup>
Used in equations:	3, 5
Description:	Default above-ground biomass content in forest in the region/country where the A/R CDM project is located



Source of data:	The source of data shall be selected, in order of preference, from the following: <ul style="list-style-type: none"> <li>(a) Regional/national inventories e.g. national forest inventory, national GHG inventory;</li> <li>(b) Inventory from neighbouring countries with similar conditions;</li> <li>(c) Globally available data applicable to the project site or to the region/country where the site is located (e.g. latest data from FAO);</li> <li>(d) Default values from Table 3A.1.4 of IPCC GPG-LULUCF 2003</li> </ul>
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<b>Data / Parameter:</b>	$COMF_i$																		
Data unit:	dimensionless																		
Used in equations:	7																		
Description:	Combustion factor for stratum $i$ (per vegetation type)																		
Source of data:	The source of data shall be selected, in order of preference, from the following: <ul style="list-style-type: none"> <li>(a) Project-specific calculation, regional/national inventories e.g. national forest inventory, national GHG inventory;</li> <li>(b) Inventory from neighbouring countries with similar conditions;</li> <li>(c) Globally available data applicable to the project site or to the region/country where the site is located;</li> <li>(d) Default values as follows: <table border="1"> <thead> <tr> <th>Forest type</th> <th>Mean age (years)</th> <th>Default value</th> </tr> </thead> <tbody> <tr> <td rowspan="4">Tropical forest</td> <td>3-5</td> <td>0.46</td> </tr> <tr> <td>6-10</td> <td>0.67</td> </tr> <tr> <td>11-17</td> <td>0.50</td> </tr> <tr> <td>18 and above</td> <td>0.32</td> </tr> <tr> <td>Boreal forest</td> <td>All</td> <td>0.40</td> </tr> <tr> <td>Temperate forest</td> <td>All</td> <td>0.45</td> </tr> </tbody> </table> </li> </ul>	Forest type	Mean age (years)	Default value	Tropical forest	3-5	0.46	6-10	0.67	11-17	0.50	18 and above	0.32	Boreal forest	All	0.40	Temperate forest	All	0.45
Forest type	Mean age (years)	Default value																	
Tropical forest	3-5	0.46																	
	6-10	0.67																	
	11-17	0.50																	
	18 and above	0.32																	
Boreal forest	All	0.40																	
Temperate forest	All	0.45																	

<b>Data / Parameter:</b>	$EF_{CH_4}$
Data unit:	$g\ kg^{-1}$ dry matter burnt
Used in equations:	7
Description:	Emission factor for $CH_4$ in stratum $i$
Source of data:	The source of data shall be selected, in order of preference, from the following: <ul style="list-style-type: none"> <li>(a) Regional/national inventories e.g. national forest inventory, national GHG inventory;</li> <li>(b) Inventory from neighbouring countries with similar conditions;</li> <li>(c) Globally available data applicable to the project site or to the region/country where the site is located;</li> <li>(d) Default values as follows: <ul style="list-style-type: none"> <li>(i) Tropical forest: 6.8</li> <li>(ii) Other forest: 4.7</li> </ul> </li> </ul>

<b>Data / Parameter:</b>	$EF_{N_2O}$
Data unit:	$g\ kg^{-1}$ dry matter burnt
Used in equations:	7
Description:	Emission factor for $N_2O$ in stratum $i$



Source of data:	The source of data shall be selected, in order of preference, from the following: <ul style="list-style-type: none"> <li>(a) Regional/national inventories e.g. national forest inventory, national GHG inventory;</li> <li>(b) Inventory from neighbouring countries with similar conditions;</li> <li>(c) Globally available data applicable to the project site or to the region/country where the site is located;</li> <li>(d) Default values as follows: <ul style="list-style-type: none"> <li>(i) Tropical forest: 0.20</li> <li>(ii) Other forest: 0.26</li> </ul> </li> </ul>
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**Data and parameters obtained from measurements**

<b>Data / Parameter:</b>	$A_{SPF,t}$
Data unit:	ha
Used in equations:	3
Description:	Area of land in which fire is used for site preparation in year $t$
Measurement procedures:	Standard operating procedures (SOPs) prescribed under national forest inventory are applied. In absence of these, SOPs from published handbooks, or from the <i>IPCC GPG LULUCF 2003</i> , may be applied
Monitoring frequency:	This area is measured whenever fire is used in site preparation
QA/QC procedures:	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In absence of these, QA/QC procedures from published handbooks, or from the <i>IPCC GPG LULUCF 2003</i> , may be applied

<b>Data / Parameter:</b>	$A_{FMF,t}$
Data unit:	ha
Used in equations:	5
Description:	Area of land subjected to use of fire to clear the land of harvest residue prior to replanting of the land in year $t$
Measurement procedures:	Standard operating procedures (SOPs) prescribed under national forest inventory are applied. In the absence of these, SOPs from published handbooks, or from the <i>IPCC GPG LULUCF 2003</i> , may be applied
Monitoring frequency:	This area is measured whenever fire is used to clear the land of harvest residue prior to replanting of the land
QA/QC procedures:	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the <i>IPCC GPG LULUCF 2003</i> , may be applied

<b>Data / Parameter:</b>	$A_{BURN,i,t}$
Data unit:	ha
Used in equations:	7





Description:	Area of land subjected to use of fire to clear the land of harvest residue prior to replanting of the land in year $t$
Source of data:	Field measurement or remote sensing measurement
Measurement procedures:	The area shall be delineated either on the ground using GPS or from georeferenced remote sensing data
Monitoring frequency:	This area is measured whenever forest fire has occurred
QA/QC procedures:	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the IPCC GPG LULUCF 2003, may be applied

<b>Data / Parameter:</b>	$CC_{SHRUB,t}$
Data unit:	Dimensionless
Used in equations:	3
Description:	Crown cover of shrubs in land where fire is used for site preparation in year $t$ ; dimensionless
Source of data:	Field measurement
Measurement procedures:	Ocular estimation of crown cover may be carried out or any other method such as the line transect method
Monitoring frequency:	This parameter is measured whenever fire is used in site preparation
QA/QC procedures:	Quality control/quality assurance (QA/QC) procedures prescribed under national forest inventory are applied. In the absence of these, QA/QC procedures from published handbooks, or from the IPCC GPG LULUCF 2003, may be applied

#### IV. References

IPCC, 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

URL: <<http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>>

IPCC, 2003. *Good Practice Guidance for Land Use, Land-Use Change and Forestry*, Prepared by the National Greenhouse Gas Inventories Programme, Jim Penman, Michael Gytarsky, Taka Hiraishi, Thelma Krug, Dina Kruger, Riitta Pipatti, Leandro Buendia, Kyoko Miwa, Todd Ngara (eds). Published: IGES, Japan. URL:

<<http://www.ipcc-nggip.iges.or.jp/public/gpplulucf/gpplulucf.html>>

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## History of the document

Version	Date	Nature of revision
04.0.0	EB 65, Annex 31 25 November 2011	The revision expands the applicability of the tool by including an approach for estimation of non-CO <sub>2</sub> GHG emissions resulting from forest fires. Due to overall modification of the document, no highlights of the changes are provided.
03.1.0	EB 60, Annex 11 15 April 2011	The amendment: (i) Provides simplified approaches for estimation of emissions resulting from use of fire in initial site preparation and site preparation for replanting after a harvest; (ii) Aligns the tool with other recently approved A/R methodological tools; (iii) Limits estimation methods to non-CO <sub>2</sub> emissions only since CO <sub>2</sub> emissions are taken into account as stock change in the relevant pools; (iv) Changes the title from “Estimation of GHG emissions due to clearing, burning and decay of existing vegetation attributable to a CDM A/R project activity to “Estimation of non-CO <sub>2</sub> GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity”. Due to the overall modification of the document, no highlights of the changes are provided.
03	EB 50, Annex 22 16 October 2009	Following the classification of documents contained in the information note: Definitions of documents types issued by the Board (Annex 31 to EB 49 report) the guidance provided by the tool was updated and partitioned among several documents in order to allow their separate application.
02	EB 42, Para 35 26 September 2008	Following the guidance provided by the Executive Board at its forty second meeting, references to emissions from removals of herbaceous vegetation were removed (refer to paragraph 35 of the meeting report).
01	EB 36, Annex 20 30 November 2007	Initial adoption.
<b>Decision Class:</b> Regulatory <b>Document Type:</b> Tool <b>Business Function:</b> Methodology		