PV CLIMATE MODULE

PU003

Estimation of baseline and project GHG emissions from emission sources in Plan Vivo projects

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1 Summary

This module is part of the Plan Vivo Agriculture and Forestry Carbon Benefit Assessment Methodology (**PM001**). It is applicable to all Plan Vivo project interventions, and can be used to provide values for the following parameters.

Baseline emissions from eligible emission sources:

$BE_{NF,a,y}$ Net GHG emissions from nitrogen fertiliser under the baseline scenario for project area *a* up to year *y* (t CO_2e; see Section 4.1)

$BE_{NS,a,y}$ Net GHG emissions from nitrogen fixing species under the baseline scenario for project area *a* up to year *y* (t CO_2e; see Section 4.2)

$BE_{BB,a,y}$ Net GHG emissions from biomass burning under the baseline scenario for project area *a* up to year *y* (t CO_2e; see Section 4.3)

$BE_{FF,a,y}$ Net GHG emissions from fossil fuel use under the baseline scenario for project area *a* up to year *y* (t CO_2e; see Section 4.4)

$BE_{EF,a,y}$ Net GHG emissions from enteric fermentation under the baseline scenario for project area *a* up to year *y* (t CO_2e; see Section 4.5)

$BE_{MD,a,y}$ Net GHG emissions from manure decomposition under the baseline scenario for project area *a* up to year *y* (t CO_2e; see Section 0)

$BE_{SM,a,y}$ Net GHG emissions from soil methanogenesis under the baseline scenario for project area *a* up to year *y* (t CO_2e; see Section 4.7)

Project emissions from eligible emission sources:

$PE_{NF,a,y}$ Net GHG emissions from nitrogen fertiliser application under the project scenario for project area *a* up to year *y* (t CO_2e; see Section 4.1)

$PE_{NS,a,y}$ Net GHG emissions from nitrogen fixing species under the project scenario for project area *a* up to year *y* (t CO_2e; see Section 4.2)

$PE_{BB,a,y}$ Net GHG emissions from biomass burning under the project scenario for project area *a* up to year *y* (t CO_2e; see Section 4.3)

$PE_{FF,a,y}$ Net GHG emissions from fossil fuel use under the project scenario for project area *a* up to year *y* (t CO_2e; see Section 4.4)

$PE_{EF,a,y}$ Net GHG emissions from enteric fermentation under the project scenario for project area *a* up to year *y* (t CO_2e; see Section 4.5)

$PE_{MD,a,y}$ Net GHG emissions from manure decomposition under the project scenario for project area *a* up to year *y* (t CO_2e; see Section 0)

$PE_{SM,a,y}$ Net GHG emissions from soil methanogenesis under the project scenario for project area *a* up to year *y* (t CO_2e; see Section 4.7)

Procedures for estimating baseline and project emissions involve combining activity data with relevant emission factors, following the approaches described in **IPCC 2006** and **IPCC 2019** and **IPCC 2021**.

2 Sources

This module applies the following CDM Tools:

AR-TOOL05 Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities, Version 1.0

AR-TOOL07 Estimation of direct nitrous oxide emission from nitrogen fertilization, Version 1.0

AR-TOOL08 Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity, Version 4.0

This module uses approaches described in the following IPCC Guidelines:

IPCC 2006 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry, and Other Land Use.

IPCC 2019 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry and Other Land Use

IPCC 2021 Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change Definitions

Definitions used in this module follow the latest version of the PV Climate Glossary and definitions in **PM001**.

3 Applicability Conditions

This module is applicable to all Plan Vivo project interventions. This includes the following intervention types:

- Agroforestry and farm forestry;
- Changes to cultivation practices;
- Changes to livestock and manure management;
- Afforestation and reforestation;
- Forest restoration;
- Forest protection; and
- Improved forest management.

This module is applicable for:

- Estimation of net GHG emissions by emission sources in the baseline scenario,
- Estimation of expected net GHG emissions by emission sources in the project scenario, and
- Estimation of net GHG emissions by emission sources in the project scenario

This module is applicable under the following conditions:

- Projects applying this module shall also comply with the applicability conditions of any tools applied.

4 Procedures

4.1 Nitrogen fertilisers

Baseline and project emissions from nitrogen fertilisers can be estimated following the procedures described in **AR-TOOL07** v1.0, and calculated with Equation 1.

Calculation of baseline and project emissions from nitrogen fertiliser use

$$BE/PE_{NF,a,y} = \sum_{t=1}^{y} N_2O_{direct-N,t}$$

Equation 1

Where:

$BE/PE_{NF,a,y}$ Net GHG emissions from nitrogen fertiliser use under the baseline scenario or project scenario for project area *a* up to year *y* (t CO_2e)

$N_2O_{direct-N,t}$ Direct N_2O emission as a result of nitrogen application within the project boundary in year *t* (t CO_2e; from **AR-TOOL07** v1.0)

4.2 Nitrogen fixing species

Baseline and project emissions from nitrogen fixing species are estimated with the procedures described in **IPCC 2006 and 2019** and calculated with Equation 2.

Calculation of baseline and project emissions from nitrogen fixing species

$$BE/PE_{NS,a,y} = \sum_{t=1}^{y} F_{CR,t} \cdot EF_{NS} \cdot CF_{N2O} \cdot GWP_{N2O}$$

Equation 2

Where:

$BE/PE_{NS,a,y}$ Net GHG emissions from nitrogen-fixing species under the baseline scenario or project scenario for area *a* up to year *y* (t CO_2e)

$F_{CR,t}$ Annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually (t N/yr; from **IPCC 2019** Equation 11.6)

EF_{NS} Emission factor for emissions from N inputs (t N_2O-N/t N; from **IPCC 2019** Table 11.1 if a country or area specific value is not available)

CF_{N2O} Conversion factor for converting from N to N_2O (t N_2O/t N; based on ratio of molecular weights = 44/28)

GWP_{N2O} 100-year global warming potential of N_2O (t CO_2e/t N2O; **IPCC 2021** default = 273)

4.3 Biomass burning

Baseline and project emissions from biomass burning are estimated following the procedures described in **AR-TOOL08** v4.0, and calculated with Equation 3.

Calculation of baseline and project emissions from biomass burning

$$BE/PE_{BB,a,y} = \sum_{t=1}^{y} GHG_{E,t}$$

Equation 3

Where:

$BE/PE_{BB,a,y}$ Net GHG emissions from biomass burning under the baseline scenario or project scenario for project area *a* up to year *y* (t CO_2e)

$GHG_{E,t}$ Emission of non-CO_2 GHGs resulting from burning of biomass and forest fires within the project boundary, in year *t* (t CO_2e; from **AR-TOOL08** v4.0)

4.4 Fossil fuel combustion

Baseline and project emissions from fossil fuel combustion are estimated following the procedures described in **AR-TOOL05** v1.0 and calculated with Equation 4.

Calculation of baseline and project emissions from fossil fuel use

$$BE/PE_{FF,a,y} = \sum_{t=1}^{y} ET_{FC,t}$$

Equation 4

Where:

$BE/PE_{FF,a,y}$ Net GHG emissions from fossil fuel use under the baseline scenario or project scenario for project area *a* up to year *y* (t CO_2e)

$ET_{FC,t}$ CO_2 emissions from fossil fuel combustion during the year *t* (from **AR-TOOL05** v1.0; t CO_2)

4.5 Enteric fermentation

Baseline and project emission from enteric fermentation are estimated following the Tier 1 Approach in **IPCC 2006 and 2019** and calculated with Equation 5 and Equation 6.

Calculation of baseline and project emissions from enteric fermentation

$$BE/PE_{EF,a,y} = \sum_{t=1}^{y} E_{EF,t} \cdot GWP_{CH4}$$

Equation 5

$$E_{EF,t} = \sum_{i} EF_{EF,i} \cdot N_{i,t}$$

Equation 6

Where:

$BE/PE_{EF,a,y}$ Net GHG emissions from enteric fermentation under the baseline scenario or project scenario for project area *a* up to year *y* (t CO_2e)

$E_{EF,t}$ CH_4 emissions from enteric fermentation in year *t* (t CH_4; see Equation 6)

GWP_{CH4} 100-year global warming potential of CH_4 (t CO_2e/t CH_4; **IPCC 2021** default = 27.2)

$EF_{EF,i}$ Emission factor for enteric fermentation for livestock type *i* (t CH_4/heads/year; from **IPCC 2006 and 2019** Table 10.10 or 10.11 if a country or area specific value is not available)

$N_{i,t}$ Number of livestock of type *i* in year *t* (heads)

4.6 Manure decomposition

Baseline and project emission from manure decomposition are estimated following Tier 1 Approach in **IPCC 2006 and 2019** and calculated with Equation 7 to Equation 10. Default values for emission factors from **IPCC 2006 and 2019** can be used if country or area specific values are not available.

Calculation of baseline and project emissions from manure decomposition

$$BE/PE_{MD,a,y} = \sum_{t=1}^{y} E_{MD,CH4,t} \cdot GWP_{CH4} + (E_{MD,directN20,t} + E_{MD,indirectN20,t}) \cdot GWP_{N20}$$

Equation 7

Where:

$BE/PE_{MD,a,y}$ Net GHG emissions from manure decomposition under the baseline scenario or project scenario for project area *a* up to year *y* (t CO_2e)

$E_{MD,CH4,t}$ CH_4 emissions from manure decomposition in year *t* (t CH_4; see Equation 8)

GWP_{CH4} Global warming potential of CH_4 (t CO_2e/t CH_4; **IPCC 2021** default = 27.2)

$E_{MD,directN20,t}$ Direct N_2O emissions from manure decomposition in year *t* (t N_2O; see Equation 9)

$E_{MD,indirectN20,t}$ Indirect N_2O emissions from manure decomposition in year *t* (t N_2O; see Equation 10)

GWP_{N2O} 100-year global warming potential of N_2O (t CO_2e/t N2O; **IPCC 2021** default = 273)

Calculation of annual CH_4 emissions from manure decomposition

$$E_{MD,CH4,t} = \sum_{i} EF_{MD,CH4,i} \cdot N_{i,t}$$

Equation 8

Where:

$E_{MD,CH4,t}$ CH_4 emissions from manure decomposition in year *t* (t CH_4)

$N_{i,t}$ Number of livestock of type *i* in year *t* (heads)

Calculation of annual direct N_2O emissions from manure decomposition

$$E_{MD,directN20,t} = \sum_{i} N_{i,t} \cdot Nex_i \cdot EF_{MD,directN2O,i} \cdot CF_{N2O}$$

Equation 9

Where:

$E_{MD,directN20,t}$ Direct N_2O emissions from manure decomposition in year *t* (t N_2O)

$N_{i,t}$ Number of livestock of type *i* in year *t* (heads)

Nex_i Annual average N excretion per head of livestock type *i* (t N/head/year; from **IPCC 2019** Table 10.19 if a country or area specific value is not available)

$EF_{MD,directN2O,i}$ Emission factor for direct N_2O emissions from manure decomposition for livestock type *i* (t N_2O-N/t N/ head/year; from **IPCC 2006 and 2019** Table 10.21 if a country or area specific value is not available)

CF_{N2O} Conversion factor for converting from N to N_2O (t N_2O/t N; based on ratio of molecular weights = 44/28)

Calculation of annual indirect N_2O emissions from manure decomposition

$$E_{MD,indirectN20,t} = \sum_i N_{i,t} \cdot Nex_i \cdot Frac_{gas} \cdot EF_{MD,indirectN2O} \cdot CF_{N2O}$$

Equation 10

Where:

$E_{MD,indirectN20,t}$ Indirect N_2O emissions from manure decomposition in year *t* (t N_2O)

$N_{i,t}$ Number of livestock of type *i* in year *t* (heads)

Nex_i Annual average N excretion per head of livestock type *i* (t N/head/year; from **IPCC 2006 and 2019** Table 10.19 if a country or area specific value is not available)

$Frac_{gas}$ Fraction of managed livestock manure nitrogen that volatilizes as NH_3 and NO_x in the manure management phase (t NH_3-N and NO_x-N emitted/t N; from **IPCC 2019** Table 10.22 if a country or area specific value is not available)

$EF_{MD,indirectN2O}$ Emission factor for N_2O emissions from atmospheric deposition of forage-sourced nitrogen on soils and water surfaces (t N2O-N/t NH_3- N and NO_x-N emitted/head/year; from default value in **IPCC 2019** Equation 10.27 = 0.01 kg if a country or area specific value is not available)

CF_{N2O} Conversion factor for converting from N to N_2O (t N_2O/t N; based on ratio of molecular weights = 44/28)

4.7 Soil methanogenesis

Methane emissions from soils under conditions of flooding or saturation are calculated following the Tier 1 Approach in **IPCC 2006** and are calculated with Equation 11 and Equation 12.

Calculation of baseline and project emissions from soil methanogenesis under conditions of flooding or saturation

$$BE/PE_{SM,a,y} = \sum_{t=1}^{y} E_{SM,CH4,t} \cdot GWP_{CH4}$$

Equation 11

Where:

$BE/PE_{SM,a,y}$ Net GHG emissions from soil methanogenesis under the baseline scenario or project scenario for project area *a* up to year *y* (t CO_2e)

$E_{SM,CH4,t}$ CH_4 emissions from soil methanogenesis in year *t* (t CH_4; see Equation 12)

GWP_{CH4} 100-year global warming potential of CH_4 (t CO_2e/t CH_4; **IPCC 2021** default = 27.2)

Calculation of CH_4 emissions from soil methanogenesis under conditions of flooding or saturation

$$E_{SM,CH4,t} = A_{sat} \cdot P \cdot E_{CH4,diff}$$

Equation 12

Where:

$E_{SM,CH4,t}$ CH_4 emissions from soil methanogenesis in year *t* (t CH_4)

A_{sat} Area of saturated soils (ha)

P Ice free period (days/year)

$E_{CH4,diff}$ Averaged daily diffusive emissions (t CH_4/ha/day; from **IPCC 2006** Appendix 3 Table 3A.2 if a country or area specific value is not available)

5 Parameters

Data/Parameter	$N_2O_{direct-N,t}$
Units	t CO_2e
Description	Direct N_2O emission as a result of nitrogen application within the project boundary in year *t*
Equations	Equation 1
Source	AR-TOOL07 v1.0
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See AR-TOOL07 v1.0
Purpose of Data	Calculation of baseline and project emissions
Comments	NA

Data/Parameter	$F_{CR,t}$
Units	t N/yr
Description	Annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually
Equations	Equation 2
Source	**IPCC 2019** Equation 11.6
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See **IPCC 2019**

Purpose of Data	Estimation of emissions from nitrogen fixing species
Comments	

Data/Parameter	EF_{NS}
Units	t N_2O-N/t N
Description	Emission factor for emissions from N inputs
Equations	Equation 2
Source	**IPCC 2019** Table 11.1 if a country or area specific value is not available
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See **IPCC 2019**
Purpose of Data	Estimation of emissions from nitrogen fixing species
Comments	NA

Data/Parameter	CF_{N2O}
Units	t N_2O/t N
Description	Conversion factor for converting from N to N_2O
Equations	Equation 2, Equation 9, Equation 10
Source	**IPCC 2006**
Value	44/28
Justification of choice of data or description of measurement methods and procedures applied	Based on ratio of molecular weights of N_2O and N.
Purpose of Data	Conversion from N to N_2O
Comments	NA

Data/Parameter	GWP_{N2O}
Units	t CO_2e/t N2O
Description	100-year global warming potential of N_2O
Equations	Equation 2, Equation 7
Source	**IPCC 2021** Table 7.15
Value	273
Justification of choice of data or description of measurement methods and procedures applied	See **IPCC 2021**
Purpose of Data	Conversion of N_2O to CO_2e
Comments	NA

Data/Parameter	$GHG_{E,t}$
Units	t CO_2e
Description	Emission of non-CO_2 GHGs resulting from burning of biomass and forest fires within the project boundary, in year t

Equations	Equation 3
Source	AR-TOOL08 v4.0
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See AR-TOOL08 v4.0
Purpose of Data	Calculation of baseline and project emissions
Comments	NA

Data/Parameter	$ET_{FC,t}$
Units	t CO_2
Description	CO_2 emissions from fossil fuel combustion during the year *t*
Equations	Equation 4
Source	AR-TOOL05 v1.0
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See AR-TOOL05 v1.0
Purpose of Data	Calculation of baseline and project emissions
Comments	NA

Data/Parameter	GWP_{CH4}
Units	t CO_2e/t CH_4
Description	100-year global warming potential of CH_4
Equations	Equation 5, Equation 7, Equation 11
Source	**IPCC 2021** Table 7.15
Value	27.0
Justification of choice of data or description of measurement methods and procedures applied	See **IPCC 2021**
Purpose of Data	Conversion of CH_4 to CO_2e
Comments	NA

Data/Parameter	$EF_{EF,i}$
Units	t CH_4/heads/year
Description	Emission factor for enteric fermentation for livestock type *i*
Equations	Equation 6
Source	From **IPCC 2019** Table 10.10 or 10.11, or a country or area specific value from a credible source
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See **IPCC 2019**
Purpose of Data	Estimation of emissions from enteric fermentation

Comments	NA

Data/Parameter	$N_{i,t}$
Units	Heads
Description	Number of livestock of type *i* in year *t*
Equations	Equation 6, Equation 8, Equation 9, Equation 10
Source	Surveys or inventory of project areas
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	Approach used in **IPCC 2019**
Purpose of Data	Estimation of emissions from enteric fermentation and manure decomposition
Comments	NA

Data/Parameter	$EF_{MD,CH4,i}$
Units	t CH_4/head/year
Description	Emission factor for CH_4 from livestock type *i*
Equations	Equation 8
Source	**IPCC 2019** Table 10.14 to 10.16 or a country or area specific value from a credible source
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See **IPCC 2019**
Purpose of Data	Estimation of emissions from manure decomposition
Comments	NA

Data/Parameter	Nex_i
Units	t N/head/year
Description	Annual average N excretion per head of livestock type *i*
Equations	Equation 9, Equation 10
Source	**IPCC 2019** Table 10.19 or a country or area specific value from a credible source
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See **IPCC 2019**
Purpose of Data	Estimation of emissions from manure decomposition
Comments	NA

Data/Parameter	$EF_{MD,directN2O,i}$
Units	t N_2O-N/t N/ head/year

Description	Emission factor for direct N_2O emissions from manure decomposition for livestock type *i*
Equations	Equation 9
Source	**IPCC 2019** Table 10.21 or a country or area specific value from a credible source
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See **IPCC 2019**
Purpose of Data	Estimation of emissions from manure decomposition
Comments	NA

Data/Parameter	$Frac_{gas}$
Units	t NH_3-N and NO_x-N emitted/t N
Description	Fraction of managed livestock manure nitrogen that volatilizes as NH_3 and NO_x in the manure management phase
Equations	Equation 10
Source	**IPCC 2019** Table 10.22 or a country or area specific value from a credible source
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See **IPCC 2019**
Purpose of Data	Estimation of emissions from manure decomposition
Comments	NA

Data/Parameter	$EF_{MD,indirectN2O}$
Units	t N2O-N/t NH_3- N and NO_x-N emitted/head/year
Description	Emission factor for N_2O emissions from atmospheric deposition of forage-sourced nitrogen on soils and water surfaces
Equations	Equation 10
Source	**IPCC 2019** Equation 10.27 or a country or area specific value from a credible source
Value	0.01 kg if a country or area specific value is not available
Justification of choice of data or description of measurement methods and procedures applied	See **IPCC 2019**
Purpose of Data	Estimation of emissions from manure decomposition
Comments	NA

Data/Parameter	A_{sat}
Units	ha
Description	Area of saturated soils
Equations	Equation 12
Source	Mapping of project area

Value	NA
Justification of choice of data or description of measurement methods and procedures applied	Approach used in **IPCC 2006**
Purpose of Data	Estimation of emissions from soil methanogenesis
Comments	NA

Data/Parameter	P
Units	days/year
Description	Ice free period
Equations	Equation 12
Source	Regional statistics
Value	365 for areas where ice does not form
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of Data	Estimation of emissions from soil methanogenesis
Comments	NA

Data/Parameter	$E_{CH4,diff}$
Units	t CH_4/ha/day
Description	Averaged daily diffusive emissions
Equations	Equation 12
Source	**IPCC 2006** Table 3A.2 or a country or area specific value from a credible source
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See **IPCC 2006** Appendix 3
Purpose of Data	Estimation of emissions from soil methanogenesis
Comments	NA

6 References

AR-TOOL05 Estimation of GHG emissions related to fossil fuel combustion in A/R CDM project activities. Version 1. CDM Tool. Available from: https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-05-v1.pdf/history_view

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PM001 Plan Vivo Agriculture and Forestry Project Carbon Benefit Assessment Methodology, Version 1.0. PV Climate Methodology. Available from: https://www.planvivo.org/pv-climate-documentation