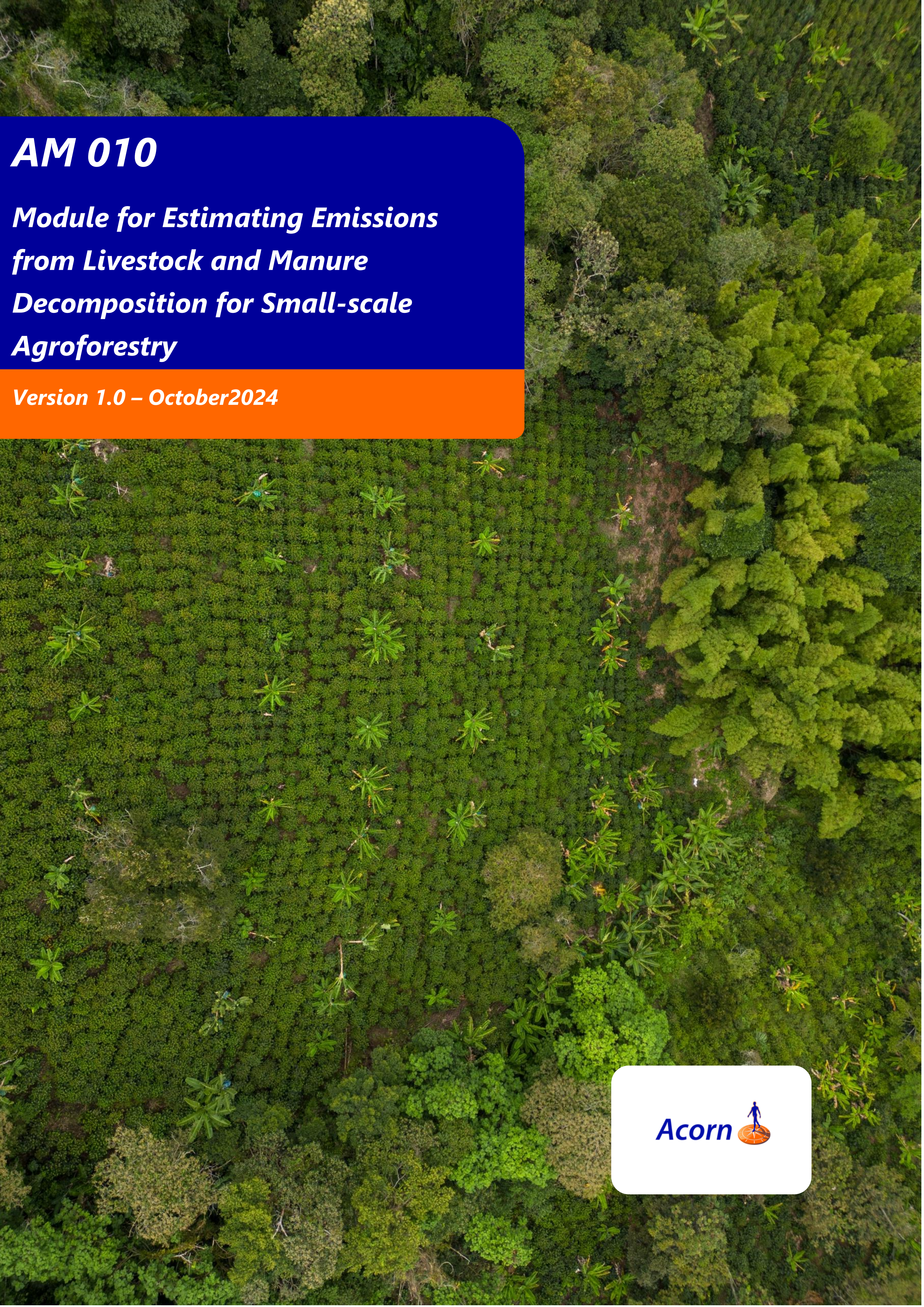

AM 010

Module for Estimating Emissions from Livestock and Manure Decomposition for Small-scale Agroforestry

Version 1.0 – October2024

Acorn

Contents

1 Summary

This module provides procedures for the estimation of emissions of methane (CH_4) from *enteric fermentation* in livestock digestion system, and the emissions of methane and nitrous oxide (N_2O) from manure. Silvopastoral activities can result in greenhouse gas emissions including CH_4 and N_2O through grazing practice and *manure decomposition*. As a result, it is important to take into account these sources of emissions when calculating *carbon benefits* from *Acorn project intervention*s. This module can be applied to *Smallholder Farmers* that carry out silvopastoral land management activities.

2 Sources

This module is based on the following existing methodology:

- **PU003 -** Estimation of baseline and project GHG emissions from emission sources in Plan Vivo projects.

This methodology refers to the following IPCC Guidance:

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

3 Definitions

Definitions used in this module follow the latest version of the Acorn Glossary available on the Acorn website.

4 Applicability Conditions

For this module, the applicability conditions of the Acorn Methodology **AM-001 v2.0** should be met. The module is designed to account for the emissions from livestock of silvopastoral land management activities carried out by *Smallholder Farmer*s. This module is only to be applied for projects focusing on *silvopastoral projects*. These projects are those where the *Agroforestry Design* is purposefully designed and applied for farming on *plots* where the main economic dedication is *animal husbandry* with ruminants (cattle, buffalo, sheep and goat).

5 Procedures

5.1 Baseline

A *silvopastoral project* will define a farmer baseline group of a minimum of 100 farmers. These farmers should be selected reflecting the diversity of all project farmers, taking into account factors such as farm size, productivity level, geographical spread, climate, manure practice, and livestock purpose. The baseline emissions from *enteric fermentation* and *manure decomposition* from this farmer baseline group are calculated according to the equations under Section 5.2.

5.2 Livestock emissions

Silvopastoral systems that combine trees and *animal husbandry* are eligible under the *Acorn program*. If *Local Partners* decide to include these types of activities in an *Acorn project*, the emissions from *enteric fermentation* (CH_4) and *manure deposition* (CH_4 and N_2O) must be determined following the Tier 1 approach in IPCC 2019 for ruminant animals.

$$LE_{\Delta,y} = LE_y - LE_{UBy}$$

Equation 1

Where:

$LE_{\Delta,y}$	= Change in livestock greenhouse gas emissions for a *plot* between year *y* and upper bound livestock greenhouse gas emissions in the baseline year (t CO_2e/ha)
LE_y	= Livestock greenhouse gas emissions for a *plot* in year *y* (t CO_2e/ha; see Equation 3)
LE_{UBy}	= Upper bound livestock greenhouse gas emissions for a *plot* in the baseline year (t CO_2e/ha; see Equation 2)

$$LE_{UBy} = LE_{By} \times ELHFF$$

Equation 2

Where:

LE_{UBy} = Upper bound livestock greenhouse gas emissions for a *plot* in the baseline year (t CO_2e/ha)

LE_{By} = Livestock greenhouse gas emissions for a *plot* in the baseline year (t CO_2e/ha; see Equation 3)

$ELHFF$ = Expected livestock herd fluctuation factor, which is based on a value of 1.15

$$LE_{y/By} = (ENT_{y/By} + MD_{y/By}) \,/\, P$$

Equation 3

Where:

$LE_{y/\,By}$ = Livestock greenhouse gas emissions for a *plot* in year *y*/ the baseline year (t CO_2e)

$ENT_{y/\,By}$ = *Enteric fermentation* greenhouse gas emissions in the *project area* in year *y*/ the baseline year (t CO_2e; See Equation 4)

$MD_{y/\,By}$ = *Manure decomposition* greenhouse gas emissions in the *project area* in year *y*/ the baseline year (t CO_2e; see Equation 6)

P = Total *plot* size in the *project area* in year *y*/ the baseline year (ha)

5.3 Enteric fermentation

Change in emissions from *enteric fermentation* are calculated and quantified following Equations 4 to 5.

$$ENT_y = ENT_{CH4,y} \cdot GWP_{CH_4}$$

Equation 4

Where:

ENT_y = *Enteric fermentation* greenhouse gas emissions in the *project area* in year *y* (t CO_2e)

$ENT_{CH4,y}$ = *Enteric fermentation* CH_4 emissions in year *y* (t CH_4; see Equation 5)

GWP_{CH_4} = Global warming potential of CH_4 (t CO_2e / t CH_4)

$$ENT_{CH4,y} = \sum_{i} EF_{ENT,i,pl} \cdot N_{i,y}$$

Equation 5

Where:

$ENT_{CH4,y}$ = *Enteric fermentation* CH_4 emissions in year *y* (t CH_4)

$EF_{ENT,i,pl}$ = Emission factor for *enteric fermentation* for livestock type i and productivity level *pl* (t CH_4/heads/year)

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

5.4 Manure decomposition

Emissions from *manure decomposition* are calculated following Equations 6 to 9.

$$MD_{y} = MD_{CH4,y} \cdot GWP_{CH_4} + (MD_{directN2O,y} + MD_{indirectN2O,y}) \cdot GWP_{N_2O}$$

Equation 6

Where:

MD_y =*Manure decomposition* greenhouse gas emissions in the *project area* in year *y* (t CO_2e)

$MD_{CH4,y}$ = *Manure decomposition* CH_4 emissions in year *y* (t CH_4; see Equation 7)

GWP_{CH_4} = Global warming potential of CH_4 (t CO_2e / t CH_4)

$MD_{directN2O,y}$ = *Manure decomposition* direct N_2O emissions in year *y* (t N_2O; see Equation 8)

$MD_{indirectN2O,y}$ = *Manure decomposition* indirect N_2O emissions in year *y* (t N_2O; see Equation 9)

GWP_{N_2O} = Global warming potential of N_2O (t CO_2e / t N_2O)

$$MD_{CH4,y} = \sum_i EF_{MD,CH4,i} \cdot N_{i,y}$$

Equation 7

Where:

$MD_{CH4,y}$	= *Manure decomposition* CH_4 emissions in year *y* (t CH_4)
$EF_{MD,CH4,i}$	= Emission factor for CH_4 from *manure decomposition* for livestock type *i* (t CH_4/heads/year)
$N_{i,y}$	= Number of livestock of type *i* in year *y* (heads)

$$MD_{directN2O,y} = \sum_i N_{i,y} \cdot Nex_i \cdot EF_{MD,directN2O,i} \cdot C_{N_2O}$$

Equation 8

Where:

$MD_{directN2O,y}$	= *Manure decomposition* direct N_2O emissions in year *y* (t N_2O)
$N_{i,y}$	= Number of livestock of type *i* in year *y* (heads)
Nex_i	= Annual average nitrogen excretion per head of livestock type *i* (t N/head/year)
$EF_{MD,directN2O,i}$	= Emission factor for direct N_2O from *manure decomposition* for livestock type *i* (t N_2O/heads/year)
C_{N_2O}	= Conversion factor from N to N_2O (t N_2O / t N)

$$MD_{indirectN2O,y} = \sum_i N_{i,y} \cdot Nex_i \cdot Frac_{gas} \cdot EF_{MD,indirectN2O} \cdot C_{N_2O}$$

Equation 9

Where:

$MD_{indirectN2O,y}$	= *Manure decomposition* indirect N_2O emissions in year *y* (t N_2O)
$N_{i,y}$	= Number of livestock of type *i* in year *y* (heads)

Nex_i = Annual average nitrogen excretion per head of livestock type i (t N/head/year)

$Frac_{gas}$ = Fraction of managed manure nitrogen that volatilizes as NH_3 and NO_x in the *manure decomposition* process

$EF_{MD,indirectN2O}$ = Emission factor for N2O emissions atmospheric deposition of nitrogen on soils and water surfaces (t N_2O-N / t NH_3-N and NO_X-N emitted/head/year)

C_{N_2O} = Conversion factor from N to N_2O (t N_2O / t N)

6 Parameters

Data/Parameter	C_{N_2O}
Units	t (tonne)
Description	Conversion factor from nitrogen to nitrous oxide (*t* N_2O/*t* N)
Equations	Equation 8 & Equation 9
Source	IPCC 2006
Value	$\frac{44}{28}$
Justification of choice of data or description of measurement methods and procedures applied	Common practices, well known recognized ratio of molecular weights
Purpose of Data	Calculation of N_2O from N
Comments	N/A

Data/Parameter	$EF_{ENT,i,pl}$
Units	t CH_4/heads/year
Description	Emission factor for *enteric fermentation* for livestock type *I* and productivity level *pl*
Equations	Equation 5
Source	IPCC 2019 Table 10.10 to 10.11. The livestock category should be determined by reliable sources, including but not limited to farmer surveys, or official documentation recognized by public authorities such as veterinary services documents, licenses, permissions, or livestock inventory documentation. The productivity level should be either based on scientific studies or

	publications from relevant authorities for the specific country, such as an official census from the Ministry of Agriculture or farmer surveys in the *project area*.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See IPCC 2019
Purpose of Data	Estimation of CH_4 emissions from *enteric fermentation*
Comments	N/A

Data/Parameter	$EF_{MD,CH4,i}$
Units	t CH4/head/year
Description	Emission factor for CH_4 emissions from *manure decomposition* for livestock type i
Equations	Equation 7
Source	IPCC 2019 Table 10.14 to 10.15
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See IPCC 2019
Purpose of Data	Estimation of CH_4 emissions from *manure decomposition*
Comments	N/A

Data/Parameter	$EF_{MD,directN20,i}$
Units	t N_2O/heads/year
Description	Emission factor for direct N_2O emissions from *manure decomposition* for livestock type i
Equations	Equation 8
Source	IPCC 2019 Table 10.21
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See IPCC2019
Purpose of Data	Estimation of direct N_2O emissions from *manure decomposition*
Comments	N/A

Data/Parameter	$EF_{MD,indirectN2O}$
Units	t N_2O-N / t NH_3-N and NO_X-N emitted/head/year
Description	Emission factor for N_2O emissions atmospheric deposition of nitrogen on soils and water surfaces
Equations	Equation 9
Source	IPCC 2019 Table 11.3
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See IPCC 2019
Purpose of Data	Estimation of indirect N_2O emissions from *manure decomposition*
Comments	N/A

Data/Parameter	$ELHFF$
Units	N/A
Description	Expected livestock herd fluctuation factor
Equations	Equation 2
Source	Tester et al. (2019)
Value	1.15
Justification of choice of data or description of measurement methods and procedures applied	The expected livestock herd fluctuation factor takes into account the natural fluctuations in the livestock herds on farms, due to the gestation period required for cattle, and the time needed for raising calves among other factors (Tester et al, 2019). Herd size fluctuations for different herd management strategies can reach and surpass 15% compared to the baseline in livestock cycles.
Purpose of Data	Estimation of the upper bound livestock greenhouse gas emissions for a *plot* in the baseline year
Comments	N/A

Data/Parameter	$ENT_{y/\,By}$
Units	tonne CO_2e
Description	*Enteric fermentation* greenhouse gas emissions in *project area* in year *y*/ the baseline year
Equations	Equation 3 & Equation 4
Source	Surveys or inventory of *project areas* and IPCC 2019
Value	N/A
Justification of choice of data or description of	See IPCC 2019

measurement methods and procedures applied	
Purpose of Data	Estimation of emissions from *enteric fermentation*
Comments	N/A

Data/Parameter	$Frac_{gas}$
Units	t NH3-N and NOx-N emitted / t N
Description	Fraction of managed manure nitrogen that volatilizes as NH_3 and NO_x in the *manure decomposition* process
Equations	Equation 9
Source	IPCC 2019 Table 10.22
Value	N/A
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	N/A

Data/Parameter	GWP_{CH_4}
Units	tCO_2e / tCH_4
Description	Global Warming Potential of CH_4
Equations	Equation 4 & Equation 6
Source	2021 IPCC Sixth Assessment Report
Value	27.2
Justification of choice of data or description of measurement methods and procedures applied	Global warming potential values are applied in line with common scientific values used by IPCC
Purpose of Data	Conversion of CH_4 to CO_2e
Comments	N/A

Data/Parameter	GWP_{N_2O}
Units	t CO_2e / tN_20
Description	Global Warming Potential for N_2O
uations	Equation 6
Source	2021 IPCC Sixth Assessment Report
Value	273

Justification of choice of data or description of measurement methods and procedures applied	Global warming potential values are applied in line with common scientific values used by IPCC
Purpose of Data	Conversion of N_2O to CO_2e
Comments	N/A

Data/Parameter	$LE_{y/By}$
Units	tonne CO_2e/ ha
Description	Livestock greenhouse gas emissions for a *plot* in year *y*/ the baseline year
Equations	Equation 1 & Equation 2 & Equation 3
Source	See Equation 3. For the baseline year, it is suggested to use the surveys or livestock inventory of *project areas* of the 3 years prior to the *Acorn Project Period* to calculate the average baseline year emissions. Only when the data of those 3 years is not available can a *silvopastoral project* use a single year prior to the *Acorn Project Period* as baseline year data.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See IPCC 2019
Purpose of Data	Estimation of livestock greenhouse gas emissions from *enteric fermentation* and *manure decomposition*
Comments	N/A

Data/Parameter	LE_{UBy}
Units	tonne CO_2e/ ha
Description	Upper bound livestock greenhouse gas emissions for a *plot* in the baseline year
Equations	Equation 1 & Equation 2
Source	See Equation 2
Value	N/A
Justification of choice of data or description of	Determines the upper bound of emissions for the baseline due to the natural fluctuation of the livestock herd in the silvopastoral system.

measurement methods and procedures applied	
Purpose of Data	Estimation of emissions from *enteric fermentation* and *manure decomposition*
Comments	N/A

Data/Parameter	$MD_{y/\,By}$
Units	tonne CO_2e
Description	*Manure decomposition* greenhouse gas emissions in *project area* in year *y*/ the baseline year
Equations	Equation 3 & Equation 6
Source	Surveys or inventory of *project areas* and IPCC 2019
Value	N/A
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	N/A

Data/Parameter	$N_{i,y}$
Units	Heads
Description	Number of livestock of type *i* in year *y*
Equations	Equation 5 & Equation 7 & Equation 8 & Equation 9
Source	For the baseline year, it is suggested to use the surveys or livestock inventory of *project areas* of the 3 years prior to the *Acorn Project Period* to calculate the average baseline year emissions. Only when the data of those 3 years is not available can a *silvopastoral project* use a single year prior to the *Acorn Project Period* as baseline year data. For any year, livestock inventory should be based on reliable sources, such as official documentation recognized by public authorities such as the veterinary services documents, licenses, permissions, or inventory documentation.
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Plan Vivo Module PU003

Purpose of Data	Estimation of CH_4 and N_2O emissions from *enteric fermentation* and *manure decomposition*
Comments	N/A

Data/Parameter	Nex_i
Units	t N/head/year
Description	Annual average nitrogen excretion per head of livestock type *i*
Equations	Equation 8 & Equation 9
Source	IPCC 2019 Table 10.19
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See IPCC 2019
Purpose of Data	Estimation of N_2O emissions from *manure decomposition*
Comments	N/A

Data/Parameter	P
Units	Ha
Description	*Total plot size in the project area in year y/ the baseline year*
Equations	*Equation 8 & Equation 9*
Source	*Plot* polygon
Value	N/A
Justification of choice of data or description of measurement methods and procedures applied	See IPCC 2019
Purpose of Data	Estimation of N_2O emissions from *manure decomposition* per *plot*
Comments	N/A

7 References

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