VCS MODULE VMD0028

ESTIMATION OF EMISSIONS FROM DOMESTICATED ANIMALS

Version 1.0

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Sectoral Scope 14

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Table of Contents

1 SOURCES

CDM methodology *AR-AM 0004 Reforestation or afforestation of land currently under agricultural use*

2 SUMMARY DESCRIPTION OF THE MODULE

The module provides methods for estimating the emissions of CH_4 and N_2O both from domesticated animals directly, and from emissions due to the decomposition of manure. Estimates for domesticated animal populations and associated manure management systems are determined using *VMD0027 Estimation of Domesticated Animal Populations*.

3 DEFINITIONS

Emission Factor: The average emission rate of a given pollutant for a given source, relative to the intensity of a specific activity.

Project Area: The area or areas of land on which the project proponent will undertake the project activities.

Significant: A pool or source is significant if it does not meet the criteria for being deemed de minimis. Specific carbon pools and GHG sources, including carbon pools and GHG sources that cause project and leakage emissions, may be deemed de minimis and do not have to be accounted for if together the omitted decrease in carbon stocks (in carbon pools) or increase in GHG emissions (from GHG sources) amounts to less than five percent of the total GHG benefit generated by the project.

4 APPLICABILITY CONDITIONS

None

5 PROCEDURES

Introduction

Estimation of emissions of non-CO_2 GHGs from domesticated animals must be required where project activities result in one of three conditions:

a) Increases in the total population of a species of domesticated animal, including both animals in the project area, and animals outside the project area as a result of leakage.
b) A change in the feed mix used for the domesticated animals, resulting in increased CH_4 or N_2O emissions.
c) A change in the manure management systems used for managing manure from domesticated animals, resulting in increased CH_4 or N_2O emissions.

The methods given below must be undertaken independently for each species or type of domesticated animal (for instance, dairy cattle must be treated separately from other cattle). These estimates must also be undertaken under both the project scenario and the baseline scenario.

Emissions from domesticated animals are conservatively excluded when the project activities result in lower emissions from domesticated animals in the project scenario as compared with the baseline scenario. Project scenario emissions must include both emissions from domesticated animals within the project area and any increases in emissions from domesticated animal populations outside of the project area resulting from the project activity. Excluding these emissions from accounting under these conditions is conservative, because it ensures that crediting is not undertaken solely on the basis of estimated reductions in domesticated animal populations.

Step 1: Estimation of CH_4 emissions from enteric fermentation ($E_{l,CH4,ferm}$)

The amount of methane[1] emitted by a population of animals is calculated by multiplying the emission rate per animal by the number of animals. To reflect the variation in emission rates among animal types, the population of animals is divided into subgroups, and an *emission factor* per animal is estimated for each subgroup. As per IPCC GPG 2000 and IPCC 2006 Guidelines for AFOLU, use the following equation[2]:

$$E_{CH4,ferm} = \sum_{l} (EF_1 * Population_l) * 10^{-3} * GWP_{CH4} \qquad (12.1)$$

Where:

$E_{CH4,ferm}$	=	CH_4 emissions from enteric fermentation; tonnes CO_2e yr^{-1}
l	=	Types of livestock
EF_1	=	Enteric CH_4 emission factor for the livestock type; kg CH_4 $head^{-1}$ yr-1
$Population_l$	=	Number of livestock for the livestock type; heads
GWP_{CH4}	=	Global warming potential for CH_4 (with a value of 21 for the first commitment period); dimensionless
0.001	=	Conversion factor of kilograms into tonnes; dimensionless

Country-specific emission factors for enteric CH_4 emissions are documented in peer reviewed literature or can be obtained from national GHG inventories. Default values are given in Table 10.10 and 10.11 in the IPCC 2006 Guidelines for AFOLU. Emission factors must be appropriate to the characteristics of the project area. The tables in Annex 10A.1 of the IPCC 2006 Guidelines for AFOLU specify the animal characteristic such as weight, growth rate and milk production used to estimate the emission factors. These tables must be consulted in order to ensure that the local conditions are similar. In particular, data on average milk production by dairy livestock must be analyzed when selecting an emission factor for dairy livestock. To estimate the emission factor, the data in Table 10 A.1 can be interpolated using the data on the local average milk production.

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[1] Methane is produced in herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream. Both ruminant animals (e.g., cattle, sheep) and some non-ruminant animals (e.g., pigs, horses) produce CH_4, although ruminants are the largest source since they are able to digest cellulose, due to the presence of specific micro organisms in their digestive tracts. The amount of CH_4 that is released depends on the type, age, and weight of the animal, the quality and quantity of the feed, and the energy expenditure of the animal.

[2] Refer to equation 10.19 and equation 10.20 in IPCC 2006 GL AFOLU or equation 4.12 and equation 4.13 in GPG 2000 for agriculture.

Step 2: Estimation of CH_4 emissions from manure management ($E_{l,CH4,manure}$)

The storage and treatment of manure under anaerobic conditions produces CH_4. Anaerobic conditions occur most readily when large numbers of animals are managed in a confined area (e.g. dairy farms, beef feedlots, and swine and poultry farms) and where manure is disposed of in liquid based systems. The main factors affecting CH_4 emissions are the amount of manure produced and the portion of manure that decomposes anaerobically. The former depends on the rate of waste production per animal and the number of animals, and the latter on how the manure is managed. When manure is stored or treated as a liquid (e.g. in lagoons, ponds, tanks, or pits), it decomposes anaerobically and can produce a significant quantity of CH_4. The temperature and the retention time of storage greatly affect the amount on CH_4 produced. When manure is handled as a solid (e.g. in stacks or piles), or when it is deposited on pastures and rangelands, it tends to decompose under more aerobic conditions and less CH_4 is produced.

CH_4 emissions from manure management for forage-fed livestock can be estimated using IPCC methods[3].

$$E_{CH4,manure} = \sum_{l}\sum_{m}(EF_{2i} \bullet Population_l) \bullet 10^{-3} \bullet GWP_{CH4} \qquad (12.2)$$

Where:

$E_{CH4,manure}$	=	CH_4 emissions from manure management; tonnes CO_2e yr^{-1}
l	=	Livestock type
m	=	Manure management system
EF_{2lm}	=	Manure management CH_4 emission factor for the livestock type l using the manure management system m; kg CH_4 $head^{-1}$ yr-1
$Population_l$	=	Population of livestock type; head
GWP_{CH4}	=	Global warming potential for CH_4 (IPCC default value; 21 for the first commitment period); dimensionless
0.001	=	Conversion factor of kilograms into tonnes; dimensionless

The best estimate of emissions is obtained using country-specific emission factors that have been published in peer-reviewed literature or in the national GHG inventory. Country-specific emission factors must be appropriate to the actual duration of manure storage and the type of manure management system used. If appropriate country-specific emission factors are unavailable, the default emission factors presented in table 10.14-10.16 of IPCC 2006 Guidelines for AFOLU may be used. These emission factors represent those for a range of livestock types and associated management systems, by regional management practices and temperature. When selecting a default factor, consult the supporting tables in Annex 10A.2 of IPCC 2006 Guidelines for AFOLU for the distribution of manure management systems and animal waste characteristics used to estimate emissions. Select an appropriate emission factor for a region that most closely matches the circumstances of the livestock that are fed forage from the project area.

Step 3: Estimation of N_2O emissions from manure management ($E_{l,N2O,manure}$) [4]

Nitrous oxide emissions from manure management vary significantly between the type of management system used, and can also result in indirect emissions due to other forms of nitrogen loss from the

[3] Refer to equation 10.22 in AFOLU volume of the IPCC 2066 Guidelines or equation 4.15 in GPG 2000 for agriculture.

[4] Taken from CDM methodology AR-AM0006 version 3

system. The N_2O emissions from manure management can be estimated using method provided in the IPCC 2006 Guidelines for AFOLU, or in IPCC GPG 2000[5]

$$E_{N_2O,manure} = E_{Direct\_N_2O,manure} + E_{Indirect\_N_2O,manure} \quad (12.3)$$

$$E_{Direct\_N2O,manure} = \sum_l \sum_m (Population_l \bullet Nex \bullet EF_3) \bullet 10^{-3} \bullet (44/28) \bullet GWP_{N2O} \quad (12.4)$$

$$E_{Indirect\_N2O,manure} = \sum_l \sum_m (Population_l \bullet Nex \bullet Frac_{gas} \bullet EF_4) \bullet 10^{-3} \bullet (44/28) \bullet GWP_{N2O} \quad (12.5)$$

Where:

$E_{N2O,manure}$	=	N_2O emissions from manure management; tonnes CO_2e yr^{-1}
$E_{Direct\_N2O,manure}$	=	Direct N_2O emissions from manure management; tonnes CO_2e yr^{-1}
$E_{Indirect\_N2O,manure}$	=	Indirect N_2O emissions from manure management; tonnes CO_2e yr^{-1}
l	=	livestock type
m	=	manure management system
$Population_l$	=	Population of livestock; heads
Nex	=	Annual average N excretion per livestock head; kg N $head^{-1}$ yr^{-1}
EF_3	=	Emission factor for N_2O emissions from manure management for the livestock group; kg N_2O-N (kg N^{-1}) $head^{-1}$ yr^{-1}
EF_4	=	Emission factor for N_2O emissions from atmospheric deposition of forage-sourced nitrogen on soils and water surfaces; kg N_2O-N (kg NH_3-N and NO_x-N emitted)$^{-1}$ $head^{-1}$ yr^{-1} Note: The use of the IPCC default factor 0.01 is recommended.
$Frac_{gas}$	=	Fraction of managed livestock manure nitrogen that volatilizes as NH_3 and NO_x in the manure management phase; kg NH_3-N and NO_x-N emitted (Kg N)$^{-1}$
GWP_{N2O}	=	Global warming potential for N_2O (310 for the first commitment period); dimensionless
$44/28$	=	Conversion of N_20-N emissions to N_2O emissions
0.001	=	Conversion factor of kilograms into tonnes; dimensionless

The best estimate of the annual nitrogen excretion rates for each livestock group is obtained using country-specific rates from published peer reviewed literature or from the national GHG inventory. If country-specific data cannot be collected or derived, or appropriate data are not available from another country with similar conditions, default nitrogen excretion rates can be obtained from table 10.19 of IPCC 2006 Guidelines for AFOLU.

The possible data sources for N_2O emission factors are similar. Default emission factors are given in table 10.21 and 11.3 of the IPCC 2006 Guidelines for AFOLU and default values for volatilization of NH_3 and NO_x ($Frac_{gas}$) in the manure management system are presented in table 10.22 of the same IPCC 2006

[5] Refer to equations 10.25, 10.26 and 10.27 in AFOLU volume of the IPCC 2006 Guidelines and/or equation 4.18 in GPG 2000 for agriculture.

Guidelines. For EF_4 the IPCC default value 0.01 is recommended (equation 10.27, IPCC 2006 Guidelines for AFOLU).

Step 4: Summation of emissions

Total emissions will be summed using the following equation:

$$E_l = E_{CH_4,\,ferm} + E_{CH_4,manure} + E_{N_2O,manure} \quad (12.6)$$

Where:

E_l	=	Emissions from livestock management; tonnes CO_2e yr^{-1}
$E_{CH4,ferm}$	=	CH_4 emissions from enteric fermentation; tonnes CO_2e yr^{-1}
$E_{CH4,manure}$	=	CH_4 emissions from manure management; tonnes CO_2e yr^{-1}
$E_{N2O,manure}$	=	N_2O emissions from manure management; tonnes CO_2e yr^{-1}

6 PARAMETERS

Data Unit / Parameter:	$E_{l,CH4,ferm}$
Data unit:	tonnes CO_2e yr^{-1}
Description:	CH_4 emissions
Source of data:	Modeled from field data
Justification of choice of data or description of measurement methods and procedures applied:	CH_4 emissions from enteric fermentation
Any comment:	

Data Unit / Parameter:	EF_1
Data unit:	kg CH_4 $head^{-1}$ yr-1
Description:	Enteric CH_4 emission factor
Source of data:	Peer reviewed literature, accepted variable values for national GHG inventories
Justification of choice of data or description of measurement methods and procedures applied:	Enteric CH_4 emission factor for the livestock group
Any comment:	

Data Unit / Parameter:	$Population_l$
Data unit:	#
Description:	Number of livestock
Source of data:	Data gathered using the module *VMD0027 Estimation of Domesticated Animal Populations*
Justification of choice of data or description of measurement methods and procedures applied:	Number of livestock of a given livestock type
Any comment:	

Data Unit / Parameter:	GWP_{CH4}
Data unit:	Dimensionless
Description:	Global warming potential for CH_4
Source of data:	IPCC
Justification of choice of data or description of measurement methods and procedures applied:	Global warming potential for CH_4 (with a value of 21 for the first commitment period)
Any comment:	

Data Unit / Parameter:	$E_{l,CH4,manure}$
Data unit:	t CO_2e yr^{-1}
Description:	CH_4 emissions from manure management
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	CH_4 emissions from manure management
Any comment:	

Data Unit / Parameter:	EF_{2l}
Data unit:	kg CH_4 $head^{-1}$ yr-1
Description:	CH_4 emission factor
Source of data:	Peer reviewed literature, accepted variable values for national GHG inventories
Justification of choice of data or description of measurement methods and procedures applied:	Manure management CH_4 emission factor for the livestock group
Any comment:	

Data Unit / Parameter:	$E_{l,N2O,manure}$
Data unit:	tonnes CO_2e yr^{-1}
Description:	N_2O emissions
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	N_2O emissions from manure management
Any comment:	

Data Unit / Parameter:	$E_{l,Direct\_N2O,manure}$
Data unit:	tonnes CO_2e yr^{-1}
Description:	Direct N_2O emissions
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Direct N_2O emissions from manure management
Any comment:	

Data Unit / Parameter:	$E_{l,Indirect\_N2O,manure}$
Data unit:	tonnes CO_2e yr^{-1}
Description:	Indirect N_2O emissions
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Indirect N_2O emissions from manure management
Any comment:	

Data Unit / Parameter:	*Nex*
Data unit:	kg N $head^{-1}$ yr^{-1}
Description:	Annual average N excretion
Source of data:	Peer reviewed literature, accepted variable values for national GHG inventories
Justification of choice of data or description of measurement methods and procedures applied:	Annual average N excretion per livestock head
Any comment:	

Data Unit / Parameter:	EF_3
Data unit:	kg N_2O-N (kg N^{-1}) $head^{-1}$ yr^{-1}
Description:	Emission factor for N_2O emissions
Source of data:	Peer reviewed literature, accepted variable values for national GHG inventories
Justification of choice of data or description of measurement methods and procedures applied:	Emission factor for N_2O emissions from manure management for the livestock group
Any comment:	

Data Unit / Parameter:	EF_4
Data unit:	kg N_2O-N (kg NH_3-N and NO_x-N emitted)$^{-1}$ $head^{-1}$ yr^{-1}
Description:	Emission factor for N_2O emissions from atmospheric deposition
Source of data:	Peer reviewed literature, accepted variable values for national GHG inventories
Justification of choice of data or description of measurement methods and procedures applied:	Emission factor for N_2O emissions from atmospheric deposition of forage-sourced nitrogen on soils and water surfaces
Any comment:	

Data Unit / Parameter:	$Frac_{gas}$
Data unit:	kg NH_3-N and NO_x-N emitted (Kg N)$^{-1}$
Description:	Fraction of managed livestock manure nitrogen
Source of data:	Peer reviewed literature, accepted variable values for national GHG inventories
Justification of choice of data or description of measurement methods and procedures applied:	Fraction of managed livestock manure nitrogen that volatilizes as NH3 and NOx in the manure management phase
Any comment:	

Data Unit / Parameter:	GWP_{N2O}
Data unit:	Dimensionless
Description:	Global warming potential for N_2O
Source of data:	IPCC (2006) Guidelines for national GHG inventories, Volume 4, Agriculture, forestry and other Land uses
Justification of choice of data or description of measurement methods and procedures applied:	Global warming potential for N_2O (310 for the first commitment period)
Any comment:	

Data Unit / Parameter:	*44/28*
Data unit:	Dimensionless
Description:	Conversion of N emissions to N_2O emissions
Source of data:	Periodic table
Justification of choice of data or description of measurement methods and procedures applied:	Conversion of N emissions to N_2O emissions
Any comment:	

Data Unit / Parameter:	E_l
Data unit:	tonnes CO_2e yr^{-1}
Description:	Emissions from livestock management
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Emissions from livestock management
Any comment:	

7 REFERENCES AND OTHER INFORMATION

CDM methodology AR-AM 0004: Reforestation or afforestation of land currently under agricultural use. http://cdm.unfccc.int/methodologies/DB/S2OMSUTOWYOMLW75MPR0CG6SAKNG4Y (last visited 19-09-2011)

CDM methodology AR-AM0006 version 3.1.1 Afforestation/Reforestation with Trees Supported by Shrubs on Degraded Land, http://cdm.unfccc.int/UserManagement/FileStorage/T05CO1LWYIJ7EHD9GBVAKZPUSQ2N8X (last visited 19-09-2011)

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

IPCC. 2000. IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Chapter 4, Agriculture.

DOCUMENT HISTORY

Version	Date	Comment
v1.0	16 Nov 2012	Initial version released