Food and Agriculture Organization of the United Nations

ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

Smallholder dairy methodology

Draft Methodology for Quantification of GHG Emission Reductions from Improved Management in Smallholder Dairy Production Systems using a Standardized Baseline

Gold Standard®

Climate Security & Sustainable Development

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Published by
the Food and Agriculture Organization of the United Nations
and
the International Livestock Research Institute
and
State Department of Livestock
Ministry of Agriculture, Livestock and Fisheries Republic of Kenya
and
The Gold Standard Foundation

ISBN 978-92-5-109457-0 (FAO)

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Acknowledgements

This methodology was developed as part of a collaboration between the UN Food and Agriculture Organization (FAO) and the International Livestock Research Institute (ILRI) and the State Department of Livestock, Kenya. The methodology was prepared by Unique Forestry and Land Use GmbH and ClimateCHECK Corporation.

ILRI thanks all donors that globally support its work through their contributions to the CGIAR system

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1. Sources

1. This methodology refers to and makes use of elements from the latest approved versions of the following methodologies, methodological tools, and guidelines:

- The Gold Standard Agriculture Requirements Draft v0.9 Dec 2014
- The Gold Standard Mandatory Guidelines – Annex C: Specific Eligibility Criteria
- UNFCCC Standard for sampling and surveys in CDM project activities and programme of activities
- UNFCCC CDM Guidelines for data quality assurance in standardized baselines
- AMS-III.BK: Strategic feed supplementation in smallholder dairy sector to increase productivity --- Version 1.0
- UNFCCC CDM A/R methodological tool Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity
- IPCC Good Practice Guidelines 2006 Volume 1 Chapter 2 on Data Collection
- IPCC Good Practice Guidelines 2006 Volume 1 Chapter 3 on Uncertainties
- IPCC Good Practice Guidelines 2006 Volume 1 Chapter 6 on QA/QC
- IPCC Good Practice Guidelines 2006 Volume 4 Chapter 5 on Cropland
- IPCC Good Practice Guidelines 2006 Volume 4 Chapter 10 on Emissions from Livestock and Manure Management
- International Committee for Animal Recording (ICAR) – 2012
- FAO Greenhouse Gas Emissions from the Dairy Sector – A Life Cycle Assessment, 2010
- FAO Greenhouse Gas Emissions from Ruminant Supply Chains – A Global Life Cycle Assessment, 2013

2. Introduction

1. The use of standardized baselines can potentially reduce transaction costs, enhance transparency, objectivity and predictability, and facilitate enhanced access to carbon markets, particularly for project types where high transaction costs pose barriers to application of project-based approaches. This small-scale methodology is developed to be compatible with The Gold Standard Agriculture Requirements, and users of this methodology are required to satisfy the requirements therein, such as (but not limited to) sustainability.

2. This methodology presents requirements for development and assessment of a standardized baseline for quantification of greenhouse gas (GHG) emission reductions in smallholder dairy systems.[1] It also includes guidance for quantification of baseline GHG emissions from dairy production in a defined geographical area within a country, for quantification of project GHG emissions, leakage, and net emission reductions due to project implementation.

3. The following table describes the key features of the methodology:

Table 1 – Methodology key elements	
Mitigation activities	Any activity not excluded in Section 3.2 below that decreases the GHG emission intensity of milk production, such as improved feeding practices, improved animal health or improved breeds.
Sources of GHG emission reductions	Reduction in enteric methane emissions, emissions from manure management and/or emissions embodied in feed per kg of fat and protein corrected milk produced.
Sources of leakage	Leakage emissions due to land use change induced by change in demand for feed.

4. The general approach outlined in the methodology is based on the following key elements. A standardized baseline for the project region is set on the basis of a baseline survey, which establishes a statistically robust relationship between milk yields and the GHG intensity of milk production measured as kg CO_2e * kg^{-1} fat and protein corrected milk (FPCM), i.e. mass of greenhouse gas emissions expressed as kg carbon dioxide equivalent per mass of FPCM expressed as kg. This statistical relationship provides estimated emission factors per kg FPCM. In both baseline and project scenarios, total emissions are calculated by multiplying the annual FPCM yield by the appropriate emission factors. Emission reductions represent the difference in the baseline and project scenario emission factors, multiplied by the project scenario total annual FPCM yield, adjusted for land use change leakage, as appropriate.

[1] Refer to The Gold Standard Agriculture Requirements V 0.9 (Dec 2014): Smallholders are farmers that have more than 50% of farm work done by family members, cooperative members or neighbors (General Terms, Point 4).

3. Scope, applicability, and definitions

3.1. Scope

1. This methodology covers project activities that decrease the GHG emissions intensity of milk production on smallholder dairy farms in a defined geographic region to achieve GHG emission reductions.

2. The methodology is applicable to dairy production operations, specifically from cattle and buffaloes only (not sheep, goats, or others), in a defined geographical region (i.e. project region). The geographical region may be defined to be consistent with administrative boundaries (e.g. a given province or district, or group of districts), or with agroecological zones as defined in national or sub-national agroecological zoning standards.

3. Within the project region, multiple farms raising dairy cattle and producing milk may be identified as project participants. Eligible individual dairy farms that meet the applicability criteria can be identified as an individual project area within the project.

4. Figure 1 presents the sources, sinks and reservoirs (SSRs) relevant to typical smallholder dairy production systems. Table 2 presents the SSRs that are included and excluded from the methodology. The dairy system "project boundary" as used in this methodology is outlined in Figure 2. Sources of emissions included in the methodology are enteric methane emissions, emissions from manure management and emissions embodied in feed and supplement production, including fertilizer. When calculating the emissions of each farm, only emissions from animals in the productive dairy herd are included, i.e. dry and lactating cows, heifers and female calves intended as cow replacements, and intact bull calves intended as bull replacements. Where a farm does not maintain sufficient replacement animals on-farm, emissions from replacement animals currently off-farm are also included. Project proponents shall assess the potential sources of leakage: including land use change (including conversion of grasslands) induced by increased demand for dairy cattle feed by project participants. All other emissions from on-farm sources and post-farm gate sources are excluded.

Figure 1 – Identification of system boundaries and the sources, sinks and reservoirs (SSRs) for emissions from typical smallholder dairy production systems

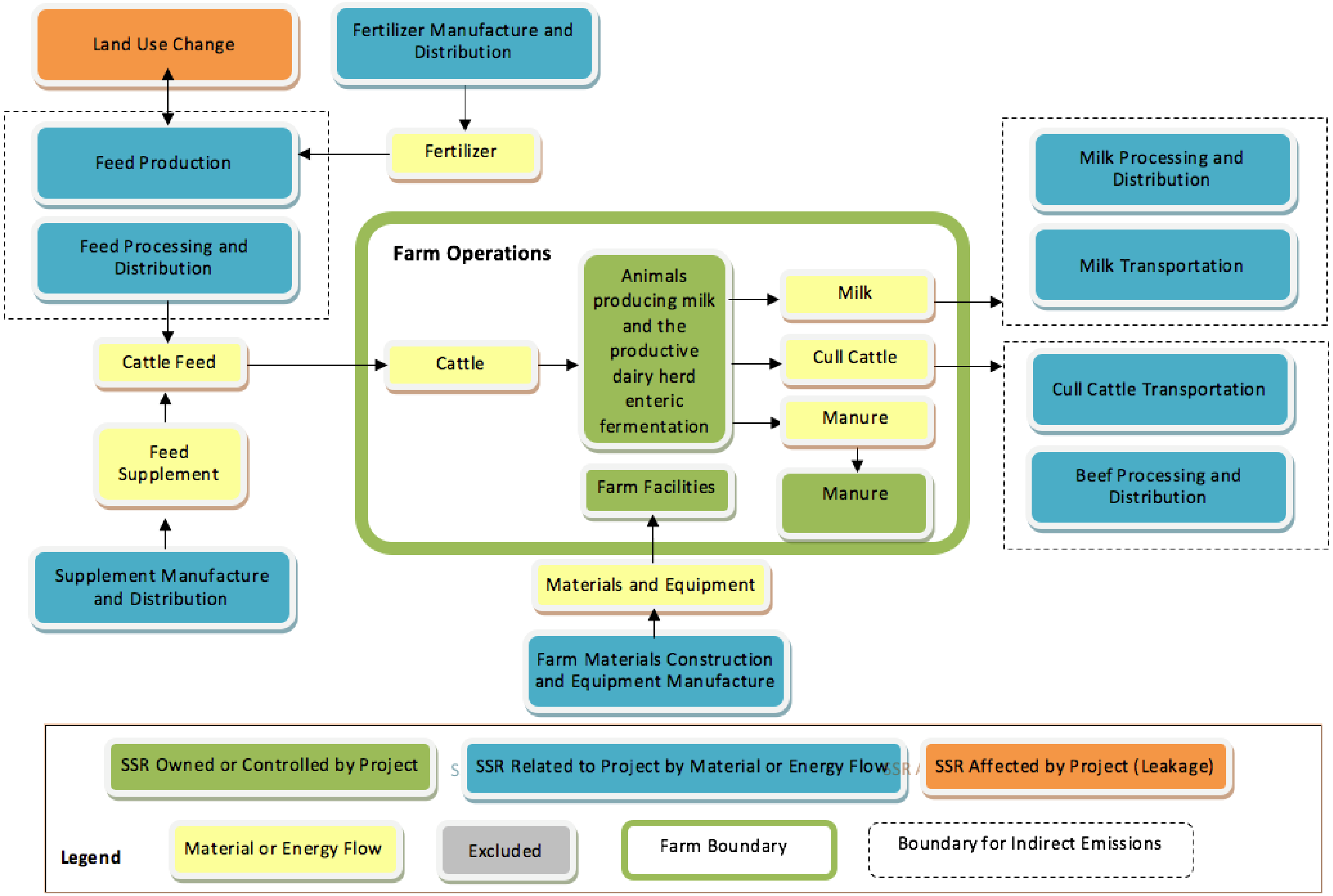


Table 2 – SSRs and GHGs included in or excluded from the project boundary

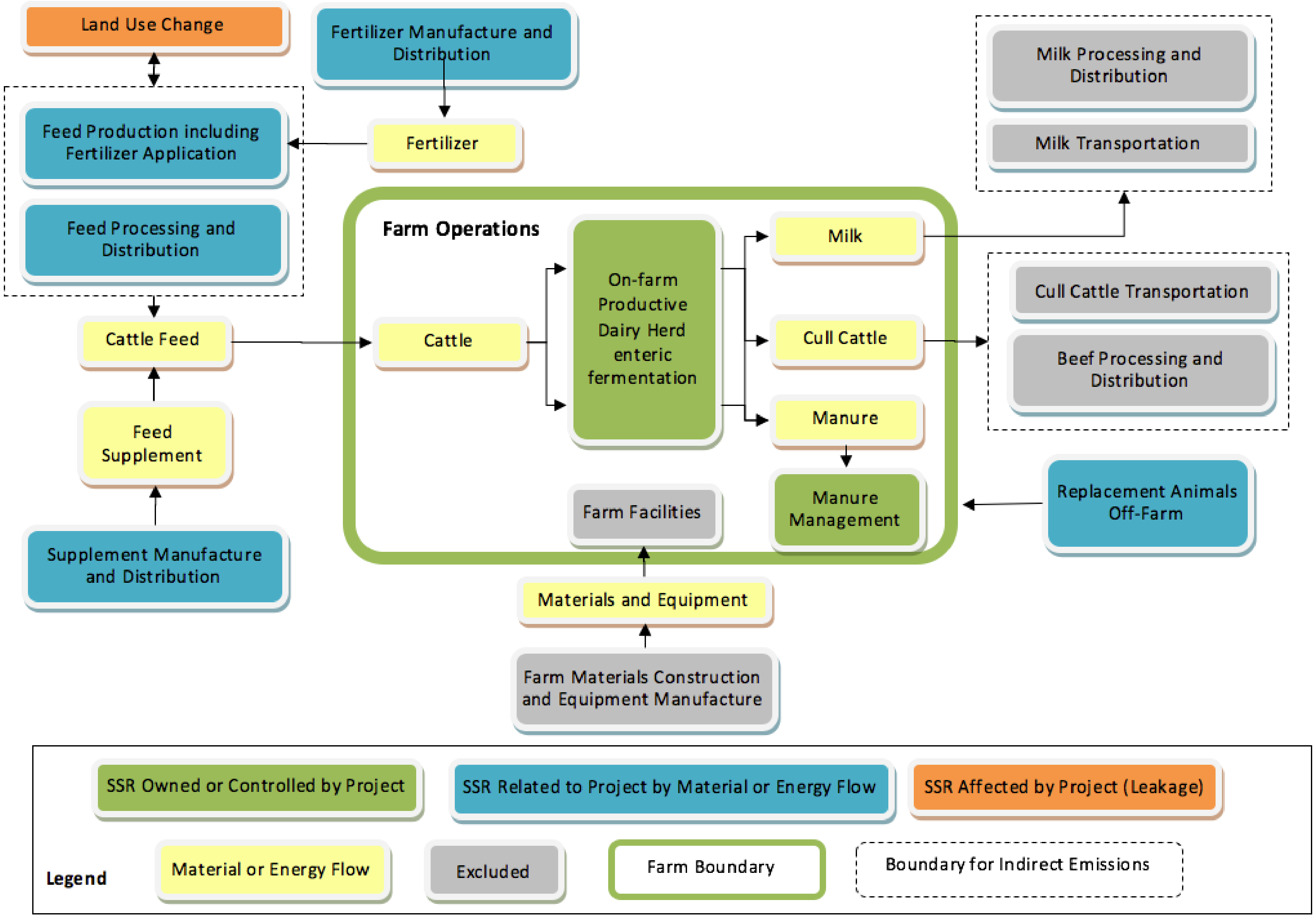
SSRs	SSR is Owned/Controlled by, or Related by Mass or Energy Flows in/out of, or Affected by, the Project?	Gas	Included?	Explanation of SSR (as necessary) or Justification for Excluded SSRs
Farm Materials, Construction and Equipment Manufacturing	Related by material and energy flows into the project	CO_2	No	Excluded because main physical assets are mostly in place already and emissions from minor activities (e.g. upgrade dairy equipment) are expected to be insignificant sources of emissions in comparison to the total emissions over a crediting period. Instances where the facilities are newly added have been assessed and it has been determined that GHG emissions would be insignificant.
		CH_4	No	
		N_2O	No	
Farm Facilities and Operations	Owned and controlled by the project	CO_2	No	Excluded because the new equipment for the dairy operation represents an immaterial one-time change.
		CH_4	No	
		N_2O	No	
Fertilizer Manufacture & Distribution	Related by material flows into the feed and into the project	CO_2	Yes	According to the FAO LCA report[2], synthetic fertilizer manufacturing is an energy-intensive process. According to the CDM ammonia-urea manufacture methodology, CH_4 is not a significant emission source. CH_4 and N_2O are not significant emission sources for transportation.
		CH_4	No	
		N_2O	Yes	
Feed Production and Fertilizer Use	Related by material and energy flows into the project	CO_2	Yes	CO_2 is produced from feed production and transportation (i.e. energy used for fertilization, field operations, drying, processing of feed crops and fodder and combustion of fossil fuels for transportation).
		CH_4	Yes	CH_4 is produced from combustion of fossil fuel
		N_2O	Yes	N_2O is the major emission source from fertilizer nitrogen application and manure application.
Feed Processing and Distribution	Related by material and energy flows into the project	CO_2	Yes	GHGs are produced in the processing and transportation
		CH_4	Yes	
		N_2O	Yes	
Land Use Change	Affected by the project because of change in feed	CO_2	Yes	When land is converted to cropland, e.g. from forests, GHGs are released to the atmosphere[3].
		CH_4	Yes	
		N_2O	No	
		CO_2	Yes	CO_2 is produced from supplement production, transport and processing of organic and inorganic supplements

[2] www.fao.org/docrep/018/i3461e/i3461e.pdf, page 101.
[3] Refer to Step 5 in https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-09-v2.pdf

SSRs	SSR is Owned/Controlled by, or Related by Mass or Energy Flows in/out of, or Affected by, the Project?	Gas	Included?	Explanation of SSR (as necessary) or Justification for Excluded SSRs
Supplement Manufacture and Distribution	Related by material flows as additives into the feed and into the project	CH_4	Yes	CH_4 is produced from combustion of fossil fuels to process crops into by-products and concentrates.
		N_2O	Yes	N_2O may be a major emission source from fertilizer nitrogen application and manure application in organic supplement production
Animals Producing Milk and the Productive Dairy Herd Enteric Fermentation	Owned and controlled by the project	CO_2	No	Excluded because included in the biogenic carbon neutral cycle
		CH_4	Yes	CH_4 is produced as a result of digestion of feed by cattle, released through exhalation.
		N_2O	No	Excluded – assumed negligible.
Manure Management	Owned and controlled by the project	CO_2	No	CH_4 and N_2O are produced from manure management.
		CH_4	Yes	
		N_2O	Yes	
Milk Transportation	Related	CO_2	No	Excluded because change between baseline and project is assumed to be immaterial. For example, GHG emissions from transportation of milk (i.e. the primary commodity and material flow) is estimated to be less than 1% of the total GHG emissions. According to the FAO LCA report,[4] average GHG emissions to transport milk from the farm to the milk processing facility are 16 g CO_2 per kg milk. By comparison, the FAO LCA report estimates global average emission intensity of milk production as 2.8 kg CO_2 per kg milk.
		CH_4	No	
		N_2O	No	
Milk Distribution and Processing	Related	CO_2	No	
		CH_4	No	
		N_2O	No	
Cull cattle transportation	Related	CO_2	No	Excluded because project activities do not increase culled cattle.
		CH_4	No	
		N_2O	No	
Beef Processing and Distribution	Related	CO_2	No	
		CH_4	No	
		N_2O	No	

[4] www.fao.org/docrep/018/i3461e/i3461e.pdf, page 21.

Figure 2– Project boundary



3.2. Applicability conditions

1. The standardized baseline approach set out in this methodology is only applicable under the following conditions:

   a) In regions where dairy production already occurs on a scale sufficient that a sample survey can quantify baseline management practices to a precision level of 90%±10%;
   b) The survey to determine the standardized baseline covers the different types of dairy farm operations that raise at least 80% of dairy animals in the project region (excluding dairy operations that are not small-scale as defined in footnote 1 above);
   c) There is sufficient and verifiable documentation of management activity data to support the quantification of the standardized baseline as outlined in Section 4 below;
   d) Data used to quantify management activities to determine the standardized baseline should be current at the start of project activities, and in no case older than 5 years;
   e) Where existing databases are used in the quantification of the standardized baseline, the Project proponents shall ensure that they are from a recognized authority and publicly accessible (i.e. not only available, but also cost is not a barrier to access);
   f) Where data is collected specifically for development of a standardized baseline for the project region, sampling should follow the guidance in Sections III and IV of the CDM "Standard for Sampling and Surveys for CDM Project Activities and Programme of Activities";[5]
   g) The project activity is not mandated by any law or regulation;[6]
   h) The project results in certified emission reductions less than 60,000 t CO_2e annually;[7]
   i) The project is located in countries with a Human Development Indicator[8] below or equal to 0.7 in the previous 5 years for which data are publicly available before the start of the project activities.

2. The project activities shall satisfy the following conditions:

   1. The project activities involve management changes that decrease the GHG emissions intensity of milk production. Typically, the project activities will be associated with improved feeding practices, but other practices that decrease the GHG intensity of milk production are also eligible, such as adoption of improved breeds or improved animal health practices.
   2. The methodology is not applicable to off-farm management practices, including milk transportation, processing and distribution;
   3. Eligible dairy operations (farms) shall be smallholder farms, where members of the owner's family, neighbours or cooperative members perform more than 50% of the work on the farm.[9] Dairy farms with more than 100 dairy animals are not eligible.

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[5] https://cdm.unfccc.int/Reference/Standards/meth/meth_stan05.pdf
[6] The Gold Standard Agriculture Requirements Draft v0.9 Nov 2014, Section 5: Additionality – Option 3.
[7] The Gold Standard Agriculture Requirements Draft v0.9 Nov 2014, Section 5: Additionality – Option 3.
[8] http://hdr.undp.org/en/countries
[9] http://www.goldstandard.org/sites/default/files/agr-requirements-draft-v.-0.9.pdf (General Terms, Point 4)

4. Where project areas involve dairy farms that were producing milk prior to the start of project activities, reliable and verifiable data on the amount of milk produced per animal per year shall be available for a minimum of one year;
5. Where project areas involve dairy farms that begin to engage in dairy production only after the start of project activities, the project proponent shall provide evidence to substantiate the dairy farm stratum to which each new project area is allocated (see paragraph 17 on the identification of dairy farm strata);
6. Project areas (i.e. a dairy farm) become ineligible for GHG crediting if land management change as a result of project activities decreases aboveground woody biomass or soil carbon stocks on the dairy farm;
7. The Project proponents shall provide a clear and convincing demonstration that no double counting and/or claiming would arise from the issuance of Gold Standard carbon credits; and
8. Animal welfare and livestock management requirements set out in the Gold Standard Agriculture Requirements shall be met in all project areas. The welfare of animals shall be ensured by:

    a) Provision of sufficient drinking water, and
    b) Access to daylight, and
    c) The prohibition of cattle trainers[10], and
    d) No hindrance in their sensory perception and performing their basic needs, and
    e) No mistreatment.[11]
    f) Injured or sick animals shall be treated and isolated, if necessary, for recovery.
    g) Excessive or inadequate use of veterinary medicines shall be avoided. Thus, all medications shall be administered strictly according to label and package instructions, or according to instructions from a trained veterinarian.
    h) Synthetic growth promoters including hormones shall not be used.
    i) Animals shall be exposed to the least stress possible during transportation and slaughtering.
    j) Appropriate space per animal and stocking rates per land unit should be set according to their developmental and physical needs.

Furthermore, in order to ensure the welfare of animals raised in each project area, each project must:

a) develop a set of guidelines on animal welfare that is suited to the project context. When developing animal welfare guidelines, the project proponent shall aim to meet or exceed national guidelines where these exist, and where national guidelines do not exist the project proponent shall develop project-specific guidelines based on international guidelines on animal welfare in dairy production.[12] At a minimum, the

[10] A Cattle trainer is a metal holder or wire that is fixed slightly above the back of tethered cattle, which gives an electric shock to the animal if it bends its back during urinating or defecating. The electric shock forces the animal to step backwards and to urinate or defecate in the manure trench instead of in its own laying bed.
[11] Mistreatment is the use of sharp objects, misusing irritating substances, including potash for branding and moving animals in a pain-inflicting way.
[12] E.g., relevant guidelines of the World Organization for Animal health (OIE, http://www.oie.int/animal-welfare/animal-welfare-key-themes/); International Dairy Federation (2008) Guide to Good Animal Welfare in Dairy Production (http://www.fil-idf.org/Public/ListPage.php?ID=37463);

project-specific guidelines should be consistent with the animal welfare requirements of the Gold Standard.

b) develop and implement a plan for capacity building and other support to farmers to improve animal welfare in all participating project areas. The aim of the plan is to support project participants to continually improve the welfare of the animals they care for in ways consistent with the animal welfare guidelines.
c) monitor implementation of the plan for capacity building and other support to project participants to improve animal welfare; and
d) document evidence of efforts undertaken to improve or maintain animal welfare in each project area

3.3. Crediting thresholds and crediting period

1. Where a project area involves a farm that was producing milk prior to the start of project activities, any farm on which cows produce on average an equal or higher annual milk yield than the pre-project milk yield shall be deemed additional and eligible for crediting with GHG emission reductions. Where a project area involves a dairy farm that began to engage in dairy production only upon or after the start of project activities, any farm that produces annual milk yields that are higher than a conservative estimate of mean milk yields for cows in the stratum as determined in the standardized baseline survey shall be deemed additional and eligible for crediting with GHG emission reductions.

2. To provide transparency and certainty to project proponents, baselines and crediting period thresholds shall remain valid for the whole of each crediting period (7 years). A crediting period may be extended twice, but before the beginning of each crediting period, the distribution of performance in the project region shall be reassessed, and if necessary the baseline emission factors shall be adjusted to ensure continued environmental integrity of credits issued.

3.4. Definitions

For the purposes of this methodology the following definitions apply:

Dairy farm stratum	A distinct sub-type of dairy farm. When dairy farms are not homogeneous but instead consist of several sub-types that are known to vary with reference to the GHG intensity of milk production, then farms with similar characteristics affecting the GHG intensity of milk production may be allocated to the same dairy farm stratum.
Dry matter intake (DMI)	The amount (kg) of feed consumed by an animal, excluding its water content.
Enteric methane emissions	Emissions of methane (CH_4) from the cattle as part of the digestion of the feed materials.

European Animal Welfare Platform (2012) Beef & Dairy Production Strategic Approach Documents (http://www.animalwelfareplatform.eu/documents/EAWPStrategicApproachDocumentsBeefandDairyProduction.pdf); FAO (2013) SAFA Guidelines (http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/SAFA_Guidelines_Final_122013.pdf) .

Fat and protein corrected milk (FPCM)	Quantity of milk, normalized to a common energy basis. FPCM is used in the scientific literature to mean 4% fat and 3.3% protein corrected milk.[13]
Feed	Feed for cattle includes roughage, concentrates and organic or inorganic supplements.[14]
Lactation	Process of producing and/or secreting milk.
Methane (CH_4)	A greenhouse gas with a global warming potential (GWP) of 25.[15]
Nitrous oxide (N_2O)	A greenhouse gas with a global warming potential (GWP) of 298.
Productive Dairy Herd	The productive dairy herd are all replacement animals raised for the purpose of replacing productive dairy animals that are expected to retire from the dairy herd. See 'Replacement Animal' as defined by the methodology below.
Project area	A project may include project activities implemented in more than one dairy production operation (farm). Each dairy production operation (farm) is a project area.
Replacement animal	A dairy animal that is raised for the purpose of replacing productive dairy animals that are expected to retire from the dairy herd. Replacement heifers are young female bovines raised to replace productive cows. Where the dairy herd includes bulls used for breeding, replacement bull calves are raised to replace bulls.
Smallholder dairy systems	Farms raising dairy animals and producing milk where more than 50% of farm work is done by family members, cooperative members or neighbours[16].
Total mixed ration (TMR)	Consists of all the feed ingredients (concentrates, forage, minerals and vitamins) mixed together to form the ration allowance for the animal.

[13] IPCC – Chapter 10 – Emissions from Livestock and Manure Management
[14] http://www.fao.org/ag/againfo/programmes/en/lead/toolbox/Refer/fcrpsec1.pdf
[15] UNFCCC Decision 4/CMP.7
[16] http://www.goldstandard.org/sites/default/files/agr-requirements-draft-v.-0.9.pdf

4. Quantification of the standardised baseline

1. The general approach to quantification of baseline emission intensity is as follows:

    1. Undertake a survey of prevailing dairy management practices and milk yields in the project region;
    2. Calculate the baseline GHG emissions for each dairy animal on each farm surveyed;
    3. Calculate baseline GHG emissions attributable to the average replacement animal off-farm;
    4. Calculate the baseline GHG emission intensity per farm surveyed;
    5. Estimate emission factors in the standardized baseline using regression analysis.

Specific procedures are set out in the sections below.

4.1. Survey of prevailing practices in the project region

6. The baseline scenario is the situation where, in the absence of the project and carbon finance, dairy producers would continue the use of prevailing practices. Prevailing practices in the region can be determined by conducting a survey of dairy farm operations that is able to represent dairy management practices applied to the management of at least 80% of dairy animals in the project region (excluding dairy operations that do not meet the smallholder definition). Alternatively, the full range of management practices applied to at least 80% of dairy animals in the project region may be characterized by expert judgment based on current data from existing data sources. When either expert judgment or surveys are used, the project proponents shall quantify specific management practices for each identified stratum (i.e., sub-type of dairy farm).

7. Strata should be identified as distinct where the management practices adopted in each sub-type of dairy farm lead to statistically significant differences in the mean GHG intensity of milk production (kg CO_2e * kg FPCM $^{-1}$). Strata may initially be identified on the basis of characteristics of the dairy production system (e.g., feed sources), and analysis should confirm the existence of significantly different strata by comparing the mean GHG intensity of milk production in each identified stratum. Where the difference in mean GHG intensity of milk production between strata is statistically significant, distinct strata may be identified. Where no statistically significant difference exists, strata may be combined or criteria for stratification adjusted and the significance of differences reassessed.

8. The survey shall be used to quantify the GHG intensity of milk production (kg CO_2e * kg FPCM $^{-1}$) for each farm, which is the sum of the intensity of enteric methane emissions, GHG emissions from the manure management system and emissions embodied in feed (including feed supplement) from all lactating cows, dry cows, heifers and the replacement herd on the farm. Cattle raised on-farm that are not part of the dairy herd (e.g. castrated males or male calves intended for sale or slaughter) are not included.

Where a farm does not maintain sufficient breeding stock to replace its current herd, emissions due to replacement animals currently off-farm shall be included in the estimate of emissions per farm. Therefore, the baseline survey shall document the average age of replacement animals procured (whether by purchasing, gift or other means) from off-farm sources, and the average age of calving, average calving interval, cull rate, calf mortality rate and non-completion rate for heifers for each stratum.

9. The sampling and survey approach used to collect the management activity data shall follow the guidance in Sections III and IV of the CDM "Standard for Sampling and Surveys for CDM Project Activities and Programme of Activities".[17]

10. Considering that multiple management practices (e.g., feed, breeds, animal health) are simultaneously adopted in dairy production operations and several GHG emission reduction options may be adopted, by estimating baseline emissions in terms of the intensity of emissions (kg CO_2e * kg FPCM $^{-1}$), estimates of baseline emissions reflect the combined effect of these measures.

4.2. Quantification of emission intensity of milk production in the standardized baseline

Quantification of milk yield for the standardized baseline

1. Milk yield (uncorrected for fat and protein content) may be estimated using any survey method that produces unbiased and reliable estimates of milk production per cow per year. Widely used methods for estimation of annual milk yields include recording of consecutive milk yields,[18] and estimation of milk yields based on previously validated lactation curve models and farmer self-reporting. Where farmer self-reporting is used to estimate annual milk yields, studies should be available demonstrating that the data is unbiased and reliable. Further guidance is given in the parameter table for milk yield (see Section 8.1).

2. Alternatively, milk yields may be estimated on the basis of unbiased and reliable data on the total milk yield of all cows in a farm:

$$\mathbf{Milk_{BS,j,i,t} = Milk_{BS,j,t}/N_j} \quad \textbf{(Equation 1)}$$

Where:

$Milk_{BS,j,i,t}$ = Average annual milk yield per cow in the baseline in the jth farm (kg uncorrected milk yield * head^{-1} * year^{-1})
$Milk_{BS,j,t}$ = Total uncorrected milk yield produced on farm j in the baseline year t (kg uncorrected milk yield * farm^{-1} * year^{-1})
N_j = Number of lactating cows on the jth farm (head^{-1} * year^{-1})
BS = index of baseline scenario
i = index of individual animals
j= index of individual farms
t = index of year

[17] https://cdm.unfccc.int/Reference/Standards/meth/meth_stan05.pdf
[18] http://web.archive.org/web/20130317002814/http://www.icar.org/Documents/Rules%20and%20regulations/Guidelines/Guidelines_2012.pdf

Determining fat and protein corrected milk (FPCM)

1. Correcting milk yield estimates for fat and protein content normalizes estimates of the quantity of milk to a common energy basis. Regional values for fat and protein content may be used that are derived from peer reviewed publications or publications of authoritative government or international agencies. Where regional values for milk fat and milk protein content are not available, IPCC default values of 4% fat and 3.3% protein corrected milk may be used.[19]

   The equation for calculating FPCM from uncorrected milk yield data is:

$$\mathbf{FPCM_{i,t} = Milk_{i,t} \times \left(0.337 + 0.116 \times Milk_{fat} + 0.06 \times Milk_{protein}\right)}$$ **(Equation 2)**

Where:
$FPCM_{i,t}$ = Fat and protein corrected milk yield for the ith cow (kg FPCM * head^{-1} * year^{-1})
$Milk_{I,t}$ = Total uncorrected milk production for the ith animal (kg^{-1} * head^{-1} * year^{-1})
$Milk_{fat}$ = % fat content of milk (IPCC default value is 4.0)
$Milk_{protein}$ = % protein content of milk (IPCC default value is 3.3)
i = index of individual animals

Quantification of emissions from milk production for the standardised baseline

1. Following the applicability conditions of the methodology, emissions estimated with baseline survey data (BE_{BS}) include emissions from all lactating cows, dry cows, heifers and the replacement herd on the farm associated with enteric fermentation ($BE_{Enteric}$), embodied emissions in feed (BE_{Feed}) and emissions associated with manure management (BE_{Manure}), and for farms that do not maintain sufficient breeding stock to replace their current herd, emissions associated with replacement animals currently off-farm ($BE_{Replace}$). For each individual animal sampled in the baseline survey, baseline annual emissions shall be calculated using Equation 3:

$$\mathbf{BE_{BS,i} = \left(BE_{Enteric,i} + BE_{Feed,i} + BE_{Manure,i}\right)}$$ **(Equation 3)**

Where:
$BE_{BS,i}$ = Baseline emissions estimated with baseline survey data for the ith animal (kg CO_2e)
$BE_{Enteric,i}$ = Baseline enteric methane emissions for the ith animal (kg CO_2e)
$BE_{Feed,i}$ = Baseline embodied emissions in feed (including supplements) for the ith animal (kg CO_2e)
$BE_{Manure,i}$ = Baseline methane emissions from manure management for the ith animal (kg CO_2e)
BS = index of baseline scenario
i = index of individual animals

[19] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Table 10.12

Quantification of enteric methane emissions for the standardised baseline

1. Enteric methane emissions shall be quantified for each individual animal in the baseline survey from gross energy (GE) intake based on IPCC Tier 2 equation 10.21, as in Equation 4:

$$\mathbf{BE_{Enteric\,,i}} = \left(\mathbf{25 \times 365 \times GE_i} \times \left(\frac{\mathbf{Y_M}}{\mathbf{100}}\right)\right) \div \mathbf{55.65} \qquad \textbf{(Equation 4)}$$

Where:
$BE_{Enteric,i}$ = Baseline enteric methane emissions for the ith dairy animal (kg CO_2e)
25 = Global warming potential over 100 years of methane (see Definitions)
GE_i = Gross energy[20] intake of the daily total mixed ration (feed and supplements) of the ith animal (MJ * head^{-1} * day^{-1})
Y_M = Methane conversion factor (IPCC default factor for dairy cattle = 6.5 ±1.0%)[21]
55.65 = energy content of methane (MJ * kg CH_4^{-1})
i = index of individual animals

GE_i may be estimated using either of the following two options:

Option 1:

Gross energy can be quantified for each individual animal in the baseline survey using the IPCC Tier 2 equations, as in Equation 5:

$$\mathbf{GE_i} = \left[\frac{\left(\left(\frac{\mathbf{NE_{m,i} + NE_{a,i} + NE_{l,i} + NE_{work,i} + NE_{p,i}}}{\mathbf{REM}}\right) + \left(\frac{\mathbf{NE_{g,i}}}{\mathbf{REG}}\right)\right)}{\frac{\mathbf{DE\%}}{\mathbf{100}}}\right]$$

(Equation 5)

Where:
GE_i = Gross energy[22] intake of the daily total mixed ration (feed and supplements) of the ith animal (MJ * head^{-1} * day^{-1})
$NE_{m,i}$ = net energy required by the ith animal for maintenance (Equation 5.1) (MJ * head^{-1} * day^{-1})
$NE_{a,i}$ = net energy for activity for the ith animal (Equation 5.2) (MJ * head^{-1} * day^{-1})
$NE_{l,i}$ = net energy for lactation for the ith animal (Equation 5.3) (MJ * head^{-1} * day^{-1})
$NE_{work,i}$ = net energy for work for the ith animal (Equation 5.4) (MJ * head^{-1} * day^{-1})
$NE_{p,i}$ = net energy required for pregnancy for the ith animal (Equation 5.5) (MJ * head^{-1} * day^{-1})
REM = ratio of net energy available in a diet for maintenance to digestible energy consumed (Equation 5.6)
$NE_{g,i}$ = net energy needed for growth for the ith animal (Equation 5.7) (MJ * head^{-1} * day^{-1})
REG = ratio of net energy available for growth in a diet to digestible energy consumed (Equation 5.8)
DE% = digestible energy expressed as a percentage of gross energy for the ith animal (%)
i = index of individual animals

[20] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Equation 10.16
[21] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Table 10.2
[22] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Equation 10.16

$$\mathbf{NE_{m,i}} = \mathbf{Cf_i} \times (\mathbf{BW_i})^{\mathbf{0.75}} \quad \text{(Equation 5.1)}$$

Where:
$NE_{m,i}$ = net energy for maintenance for the ith animal (MJ * head^{-1} * day^{-1})[23]
Cf_i = coefficient for each animal category (IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Table 10.4)
BW = live-weight of the ith animal, kg
i = index of individual animals

$$\mathbf{NE_{a,i}} = \mathbf{C_{a,i}} \times \mathbf{NE_{m,i}} \quad \text{(Equation 5.2)}$$

Where:
$NE_{a,i}$ = net energy for activity for the ith animal (MJ * head^{-1} * day^{-1})[24]
$C_{a,i}$ = coefficient corresponding to the ith animal's feeding situation (IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Table 10.5)
$NE_{m,i}$ = net energy for activity for the ith animal (MJ * head^{-1} * day^{-1}) calculated from Equation 5.1 above
i = index of individual animals

$$\mathbf{NE_{l,i}} = \mathbf{Milk_{dailyi}} \times (\mathbf{1.47} + \mathbf{0.40} \times \mathbf{Milk_{Fat}}) \quad \text{(Equation 5.3)}$$

Where:
$NE_{l,i}$ = net energy for lactation for the ith animal (MJ * head^{-1} * day^{-1})[25]
$Milk_{daily,i}$ = Total uncorrected milk production per day for the ith animal (kg milk per head per day)
$Milk_{fat}$ = % fat content of milk (IPCC default value is 4.0)
i = index of individual animals

$$\mathbf{NE_{work,i}} = \mathbf{0.10} \times \mathbf{NE_{m,i}} \times \mathbf{Hours_i} \quad \text{(Equation 5.4)}$$

Where:
$NE_{work,i}$ = net energy for work for the ith animal (MJ * head^{-1} * day^{-1})[26]
$NE_{m,i}$ = net energy for activity for the ith animal (MJ * head^{-1} * day^{-1}) calculated from Equation 5.1 above
$Hours_i$ = number of hours of work per day for the ith animal (hours^{-1} * head^{-1} * day^{-1})
i = index of individual animals

$$\mathbf{NE_{p,i}} = \mathbf{C_{pregnancy}} \times \mathbf{NE_{m,i}} \quad \text{(Equation 5.5)}$$

Where:
$NE_{p,i}$ = net energy required for pregnancy for the ith animal (MJ * head^{-1} * day^{-1})[27]
$C_{pregnancy}$ = pregnancy coefficient (IPCC default factor for cattle and buffalo = 0.10)[28]
$NE_{m,i}$ = net energy for activity for the ith animal (MJ * head^{-1} * day^{-1}) calculated from Equation 5.1 above
i = index of individual animals

[23] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Equation 10.3.
[24] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Equation 10.4.
[25] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Equation 10.8.
[26] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Equation 10.11.
[27] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Equation 10.13.
[28] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Table 10.7.

$$\mathbf{REM} = \left[\mathbf{1.123} - \left(\mathbf{4.092} \times \mathbf{10^{-3}} \times \mathbf{DE\%}\right) + \left[\mathbf{1.126} \times \mathbf{10^{-5}} \times (\mathbf{DE\%})^{2}\right] - \left(\frac{\mathbf{25.4}}{\mathbf{DE\%}}\right)\right] \quad \text{(Equation 5.6)}$$

Where:
REM = ratio of net energy available in a diet for maintenance to digestible energy consumed[29]
DE% = Digestible energy expressed as a percentage of gross energy for the ith animal (%)

$$\mathbf{NE_{g,i}} = \mathbf{22.02} \times \left(\frac{\mathbf{BW}}{\mathbf{Cg \times MW}}\right)^{\mathbf{0.75}} \times \mathbf{WG^{1.097}} \quad \text{(Equation 5.7)}$$

Where:
$NE_{g,i}$ = net energy needed for growth for the ith animal (MJ * head^{-1} * day^{-1})[30]
BW = the average live body weight (BW) of the animals in the population (kg)
C_g = a coefficient with a value of 0.8 for females, 1.0 for castrates and 1.2 for bulls
MW = the mature live body weight of an adult female in moderate body condition (kg)
WG = the average daily weight gain of the animals in the population (kg * head^{-1} * day^{-1})
i = index of individual animals

$$\mathbf{REG} = \left[\mathbf{1.164} - \left(\mathbf{5.160} \times \mathbf{10^{-3}} \times \mathbf{DE\%}\right) + \left[\mathbf{1.308} \times \mathbf{10^{-5}} \times (\mathbf{DE\%})^{2}\right] - \left(\frac{\mathbf{37.4}}{\mathbf{DE\%}}\right)\right] \quad \text{(Equation 5.8)}$$

Where:
REG = ratio of net energy available for growth in a diet to digestible energy consumed (Equation 5.8)[31]
DE% = Digestible energy expressed as a percentage of gross energy (%)

Option 2:

If, the above data are unavailable to calculate gross energy using Equation 5, then Equation 6 can be used to quantify GE for each individual animal in the baseline survey:

$$\mathbf{GE_{Feed,i}} = (\mathbf{DMI_i} \times \mathbf{18.45}) \quad \text{(Equation 6)}$$

Where:
GE_i = Gross energy[32] intake of the daily total mixed ration (feed and supplements) of the ith animal (MJ * head^{-1} * day^{-1})
DMI_i = Daily dry matter intake for the ith animal (kg^{-1} dry matter * head^{-1} * day^{-1})
i = index of individual animals

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[29] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Equation 10.14.
[30] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Equation 10.6.
[31] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Equation 10.15.
[32] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Equation 10.16.

Quantification of embodied feed emissions for the standardized baseline

2. Embodied feed emission intensity shall be quantified using Equation 7:

$$\mathbf{BE_{Feed,i}} = (\mathbf{EF_{Feed,i}} \times \mathbf{Feed_{Survey\,,i}}) \qquad \text{(Equation 7)}$$

Where:
$BE_{Feed,i}$ = Baseline embodied emissions in feed for the ith animal (kg CO_2e)
$EF_{Feed,i}$ = Emission factor for embodied emissions in feed in the total mixed ration of the ith animal (kg CO_2e)
Feed $_{Survey,i}$ = Feed used to feed the ith animal from the baseline survey (kg feed * head^{-1} * year^{-1})
i = index of individual animals

Note that feed may include roughage, concentrates and supplements (see Section 3.4). Where relevant, emission factors for embodied emissions in feed should include emissions from fertilizer use and fertilizer manufacture and distribution, as well as supplement manufacture and distribution. Emission factors may derive from peer reviewed publications, or publications of authoritative organizations, or be based on work conducted for the project proponents using life cycle assessment (LCA) approaches consistent with ISO 14040 and ISO 14044.[33]

Quantification of methane emissions from manure management for the standardized baseline

3. Methane emissions from manure management shall be quantified for each individual animal in the baseline survey from daily volatile solids (VS) based on IPCC Tier 2 equation 10.23, as in Equation 8:

$$\mathbf{BE_{Manure,i}} = (\mathbf{VS_i} \times \mathbf{365}) \times (\,\mathbf{B_{O,i}} \times \mathbf{0.67} * \textstyle\sum_S \left(\frac{\mathbf{MCF_{S,i}}}{\mathbf{100}} \times \mathbf{MS_{S,i}}\right)) \qquad \text{(Equation 8)}$$

Where:
$BE_{Manure,i}$ = Baseline manure emissions from manure management for the ith animal (kg CO_2e * head^{-1} * year^{-1})[34]
VS_i = Daily volatile solids[35] excreted by the ith animal (kg dry matter * head^{-1} * day^{-1})
$B_{O,i}$ = Maximum methane producing capacity[36] for manure produced by the ith animal (m^3 CH_4 * kg^{-1} of VS excreted)
0.67 = conversion factor of m^3 to kg CH_4
$MCF_{S,i}$ = Methane conversion factor[37] for manure management system S utilized by the ith animal (unitless)
$MS_{S,I}$ = Fraction of manure handled using the manure management system S for the ith animal (unitless)
S = index of manure management system
i = index of individual animals

Quantification of GHG emissions from replacement animals currently off-farm

4. Replacement animals are essential to the sustainable operation of dairy farms. Change in the dairy management system adopted by smallholder farms participating in the project may increase the number of replacement animals (e.g. heifers, intact males) raised off-farm. Therefore, emissions from replacement animals should be accounted for. To estimate emissions from replacement heifers currently off-farm, the baseline survey shall document for the baseline

[33] http://www.iso.org/iso/catalogue_detail?csnumber=37456
[34] IPCC – Chapter 10 - Emissions from Livestock and Manure Management, Equation 10.23
[35] IPCC – Chapter 10 - Emissions from Livestock and Manure Management, Equation 10.24
[36] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Table 10A-4
[37] IPCC – Chapter 10 - Emissions from Livestock and Manure Management, Table 10.17

population the average age of replacement females procured (whether by purchasing, gift or other means) from off-farm sources, and the average age of calving, average calving interval, cull rate, calf mortality rate and non-completion rate for heifers in each stratum. To estimate emissions from replacement males intended for use as breeding bulls, the baseline survey shall document the working lifetime of bulls and the non-completion rate for replacement males in each stratum. For farms that do not maintain sufficient breeding stock to replace its current herd, emissions due to replacement animals currently off-farm shall be quantified.[38]

5. The number of replacement heifers needed shall be calculated for each farm as follows:

$$\mathbf{RN_{k,j}} = \mathbf{HS_j} \times \left(\frac{\mathbf{AFC_j}}{\mathbf{AFC_k}}\right) \times \mathbf{CR_k} \times (\mathbf{1} + \mathbf{NCR_k}) \qquad \textbf{(Equation 9)}$$

Where:
$RN_{k,j}$ = The number of replacement heifers needed to maintain baseline herd size on the jth farm in stratum k (head)
j= index of individual farms
HS_j = number of mature lactating and dry cows on the jth farm (head)
AFC_j = average age at first calving of cows on the jth farm (months)
AFC_k = average age at first calving of cows in stratum k in the baseline survey (months)
CR_k = average cull rate for farms in stratum k in the baseline survey (ratio)
NCR_k = average non-completion rate for heifers on farms in stratum k in the baseline survey (%)

and

$$\mathbf{CR_k} = \frac{\mathbf{AE_k}}{\mathbf{HS_k}} \qquad \textbf{(Equation 10)}$$

Where:
AE_k = number of mature females exiting farms in stratum k due to culling, sales, gifts or other reasons in the year prior to the baseline survey (head)
HS_k= number of mature lactating and dry cows in stratum k (head)

and

$$\mathbf{NCR_k} = \frac{\mathbf{CE_k}}{\mathbf{CH_k}} \qquad \textbf{(Equation 11)}$$

Where:
CE_k = number of calves and heifers exiting farms in stratum k due to culling, sales, gifts or other reasons in the year prior to the baseline survey (head)
CH_k = number of calves and heifers on farms in stratum k in the baseline survey (head)

[38] For further general guidance, see Penn State Extension (2012) Herd data key to managing dairy replacement heifers (http://extension.psu.edu/animals/dairy/news/2012/herd-data-key-to-managing-dairy-replacement-heifers)

6. The number of replacement heifers expected within a year shall be calculated for each farm as follows:

$$\mathbf{RE_{k,j} = HS_j \times \left(\frac{12}{CI_k}\right) \times SR_k \times (1 - CM_k) \times \left(\frac{AFC_k}{AFC_j}\right)} \qquad \textbf{(Equation 12)}$$

Where:
$RE_{k,i}$ = The number of replacement heifers expected within a year on the jth farm ($head^{-1}$)
HS_j = number of mature lactating and dry cows on the jth farm in the baseline survey ($head^{-1}$)
CI_k = average calving interval for cows in stratum k in the baseline survey ($months^{-1}$)
SR_k = sex ratio of calves born in stratum k in the baseline survey (ratio)
CM_k = average calf mortality rate on farms in stratum k in the baseline survey (ratio)
j= index of individual farms

and

$$\mathbf{CM_k = \frac{CD_k}{CB_k}} \qquad \textbf{(Equation 13)}$$

Where:
CD_k = The number of calves on farms in stratum k that died in the year prior to the baseline survey ($head^{-1}$)
CB_k = the number of calves born on farms in stratum k in the year prior to the baseline survey ($head^{-1}$)

7. The gap between expected replacement heifers and the need for replacement heifers for each farm is to be calculated as:

$$\mathbf{RG_j = RN_j - RE_j} \qquad \textbf{(Equation 14)}$$

Where:
RG_j = The number of replacement heifers that the jth farm can be expected to procure within a year in order to maintain herd size ($head^{-1}$)
RN_j = The number of replacement heifers needed to maintain baseline herd size on the jth farm ($head^{-1}$)
RE_j = The number of replacement heifers expected within a year on the jth farm ($head^{-1}$)
j= index of individual farms

8. If the calculated value of RG_j is negative (i.e. the farm has sufficient replacement heifers to maintain its current herd size), then emissions attributable to replacement animals off-farm shall be equal to zero. If the calculated value of RG_j is positive (i.e. the farm does not have sufficient replacement heifers to maintain its current herd size), then emissions attributable to replacement animals currently off-farm ($BE_{RH,j}$) shall be calculated as follows

$$\mathbf{BE_{RH,j} = RG_j \times EF_{RH,k}} \qquad \textbf{(Equation 15)}$$

Where:
$BE_{RH,i}$ = emissions attributable to the jth farm due to replacement heifers that are not currently on farm (kg CO_2e * $year^{-1}$)
$EF_{RH,k}$ = the annual emissions due to enteric fermentation, feed and manure management for the average replacement heifer procured by farms in stratum k, calculated according to equation (3) applied to the replacement heifers (kg CO_2e * $year^{-1}$)
j= index of individual farms

9. If at the date when a farm enrols to participate in the project, it currently raises 1 or more bulls that are used for reproduction of the dairy herd, then emissions from bull replacements currently off-farm shall be accounted for as follows.

10. Calculate the number of replacement bulls needed each year for each farm:

$$\mathbf{BR_{k,j}} = \frac{\mathbf{CB_j}}{\mathbf{BL_k}} \qquad \textbf{(Equation 16)}$$

Where:
$BR_{k,j}$ = The number of replacement bulls needed to maintain baseline bull number on the jth farm in stratum k (head)
j= index of individual farms
CB_j = number of bulls maintained on the jth farm (head)
BL_k = average working lifetime of a bull in stratum k in the baseline survey (years)

11. Calculate the number of replacement bulls expected for each farm:

$$\mathbf{BF_{k,j}} = \mathbf{CBR_j} \times (\mathbf{1} - \mathbf{NCB_k}) \qquad \textbf{(Equation 17)}$$

Where:
$BF_{k,j}$ = The number of replacement bulls expected on the jth farm in stratum k (head)
CBR_j = The number of bull replacements maintained on the jth farm (head)
NCB_k = average non-completion rate for bull replacements on farms in stratum k in the baseline survey (%)

12. Calculate the gap between replacement bulls needed and replacement bulls expected for each farm:

$$\mathbf{BG_{k,j}} = \mathbf{BR_{k,j}} - \mathbf{BF_{k,j}} \qquad \textbf{(Equation 18)}$$

13. If the calculated value of $BG_{k,j}$ is negative (i.e. the farm has sufficient replacement bulls to maintain its current bull population), then emissions attributable to replacement bulls currently off-farm shall be equal to zero. If the calculated value of $BG_{k,j}$ is positive (i.e. the farm does not have sufficient replacement bulls to maintain its current bull population size), then emissions attributable to replacement bulls currently off-farm ($BE_{RB,j}$) shall be calculated as follows

$$\mathbf{BE_{RB,j}} = \mathbf{BG_j} \times \mathbf{EF_{RB,k}} \qquad \textbf{(Equation 19)}$$

Where:
$BE_{RB,i}$ = emissions attributable to the jth farm due to replacement bulls that are not currently on farm (kg CO_2e * $year^{-1}$)
$EF_{RB,k}$ = the annual emissions due to enteric fermentation, feed and manure management for the average replacement bull raised by farms in stratum k, calculated according to equation (3) applied to the replacement bulls (kg CO_2e * $year^{-1}$)
j= index of individual farms

14. The total emissions attributable to replacement animals currently off-farm shall be calculated for each farm as follows:

$$\mathbf{BE_{Replace,j} = BE_{RH,j} + BE_{RB,j}} \quad \textbf{(Equation 20)}$$

Quantification of GHG emission intensity per farm

15. For each farm in the baseline survey, GHG emission intensity from milk production in baseline year t ($BEI_{BS,\,j,t}$) shall be calculated as follows:

$$\mathbf{BEI_{BS,j,t} = \left(\left(\sum_i \left(BE_{Enteric,i,j} + BE_{Feed,i,j} + BE_{Manure,i,j}\right)\right) + BE_{Replace,j}\right) / \left(\sum_i FPCM_{BS,i,j,t}\right)}$$

(Equation 21)

Where:

$BEI_{BS,j,t}$ = Baseline emission intensity of milk production estimated with baseline survey data for the jth farm (kg CO_2e * kg FPCM $^{-1}$)
$BE_{Enteric,i,j}$ = Baseline enteric methane emissions for the ith animal on the jth farm (kg CO_2e)
$BE_{Feed,i,j}$ = Baseline embodied emissions in feed (including supplements) for the ith animal on the jth farm (kg CO_2e)
$BE_{Manure,i,j}$ = Baseline methane emissions from manure management for the ith animal on the jth farm (kg CO_2e)
$BE_{Replace,j}$ = Baseline GHG emissions from replacement animals currently off-farm for the jth farm (kg CO_2e)
$FPCM_{BS,i,j,t}$ = Baseline fat and protein corrected milk yield for the ith animal on the jth farm in the baseline survey (kg FPCM * head^{-1} * year^{-1})
BS = index of baseline scenario
i = index of individual animals
j= index of individual farms

4.3 Estimation of emission factors in the standardized baseline using regression analysis

16. A quantitative relationship between fat and protein corrected milk yield (kg FPCM) and baseline emissions (kg CO_2e) per farm shall be determined by applying regression analysis to the baseline survey data, using the general form:

$$\mathbf{Y \approx f(X, \beta)} \quad \textbf{(Equation 22)}$$

Where:

Y = the dependent variable
X = the independent variable
β = the vector of parameters to be estimated.

17. The specific form of regression equations used shall be determined by the nature of the data from the baseline survey.

18. The resulting equation shall be used to determine baseline emission factors in the project based on estimated average annual milk yields per farm.

19. For project areas involving dairy farms that were producing milk prior to the start of project activities, reliable and verifiable data on average annual milk yields per farm prior to the start of project activities shall be converted to FPCM using Equation 2 assuming the default fat and protein contents and used in conjunction with the results of regression analysis to provide an estimate of baseline emission intensity:

$$\mathbf{BEI_{BS,j,t} = f(FPCM_{BS,j,t}, \beta)} \qquad \textbf{(Equation 23)}$$

Where:

$BEI_{BS,j,t}$ = Baseline emission intensity estimated as a function of milk yield using the regression equation and baseline per farm average milk yield data specific to each project area (kg CO_2e * kg $FPCM^{-1}$)
$FPCM_{BS,j,t}$ = Baseline fat and protein corrected milk yield on the jth farm in the baseline survey (kg FPCM * $year^{-1}$)
BS = index of baseline scenario
j = index of farms
t = index of year
β = the vector of parameters to be estimated.

20. For project areas involving dairy farms that began to engage in dairy production only upon or after the start of project activities and where the dairy farm stratum to which the project area can be allocated is represented in the baseline survey, the baseline emission intensity shall be estimated using the standardized baseline regression equation and a weighted average of the baseline stratum (weighted by fat and protein corrected milk yield in the same stratum as the project area), estimated by applying the following procedures.

21. Divide all the farms surveyed in the baseline survey into strata based on the type of feeding or grazing practices, housing, breed or other factors (e.g. agroecological zone) that affect the emissions intensity of milk production. For each identified stratum, calculate a yield-weighted average of the mean emission intensity for all farms included in that stratum:

$$\mathbf{BEI_{B,k,t} = \frac{\sum_j (BEI_{B,k,j,t} \times FPCM_{B,k,j,t})}{\sum_j FPCM_{B,k,j,t}}} \qquad \textbf{(Equation 24)}$$

22. For all dairy farms that began to engage in dairy production only upon or after the start of project activities and that can be allocated to a dairy farm stratum that is represented in the baseline survey, the baseline emission intensity of milk production (i.e. $BEI_{B,j,t}$) is to be taken as the average emission intensity for dairy animals in the relevant stratum (i.e. $BEI_{B,k,t}$).

23. For project areas involving dairy farms that began to engage in dairy production only upon or after the start of project activities and where the project area cannot be allocated to a dairy farm stratum represented in the baseline survey (e.g. due to significant difference in feed management or other factors used to define each dairy farm stratum), the baseline emission intensity shall be estimated using the standardized baseline regression equation and a yield-weighted average of the all baseline strata:

$$\mathbf{BEI_{B,new,t}} = \frac{\sum_{k}(\mathbf{BEI_{B,k,t}} \times \mathbf{FPCM_{B,k,t}})}{\sum_{k} \mathbf{FPCM_{B.k.t}}} \qquad \textbf{(Equation 25)}$$

Where:

$BEI_{BS,new,t}$ = baseline emission intensity of project areas adopting dairy farming only at or after the beginning of the project and that cannot be allocated to a dairy farm stratum represented in the baseline survey (kg CO_2e * kg FPCM $^{-1}$)

5. Quantifying Project Emission Intensity

1. For dairy farms that can be allocated to dairy farm strata identified in the baseline survey, it can be assumed that the standardized baseline also applies to the estimation of emissions intensity in the project scenario for project areas in the project region during the crediting period. Project emission intensity can therefore be estimated using the regression equation from the standardized baseline that established a relationship between milk yield and emission intensity:

$$\mathbf{PEI_{P,j,t}} = \mathbf{f}(\mathbf{FPCM_{P,j,t}}, \boldsymbol{\beta}) \qquad \textbf{(Equation 16)}$$

Where:

$PEI_{P,I,t}$ = Project emission intensity estimated using regression equation and project monitoring data on milk yields specific to each project area (kg CO_2e * kg FPCM $^{-1}$)
FPCM $_{P,I,t}$ = Project fat and protein corrected milk yield on the jth farm from project monitoring data specific to each project area (kg FPCM * farm^{-1} * year^{-1})
P = index of project scenario
j = index of farms
β = the vector of parameters to be estimated.

2. For project areas that in the project scenario cannot be allocated to a dairy farm stratum represented in the baseline survey (e.g. due to significant difference in feed management or other factors used to define each dairy farm stratum), in the current crediting period in which these dairy farms are first enrolled to participate in the project, it shall be assumed that the relationship in the project scenario between milk yield and GHG emission intensity for these farms can be estimated using the regression equation from the standardized baseline (Equation 21). Before the beginning of the subsequent crediting period, the distribution of performance in the project region shall be reassessed, including the performance of a sample of dairy farms representing the new dairy farm strata, and related emission factors shall be revised.

Determining Milk Yield in the Project

3. Monitoring of milk yield during project implementation may use any data collection method that produces unbiased and reliable estimates of average per cow milk production per farm per year. If the milk yield data collection method used for milk yield monitoring during project implementation is different from the method used to characterize the standardized baseline, then it shall be demonstrated that the change in method does not lead to a bias in estimated milk yields that would tend to overstate emission reductions due to project activities. Data on annual milk yields shall be converted to estimates of FPCM using Equation 2.

4. Total milk yield in a given year on the jth farm in the project is to be estimated as the sum of average FPCM yield per ith cow:

$$\mathbf{FPCM_{total,P,j,t} = \sum_{i=1}^{I} FPCM_{P,i,j,t}} \qquad \textbf{(Equation 27)}$$

Where:
$FPCM_{total,P,j,t}$ = total fat and protein corrected milk yield of all individual cows on the jth farm in project year t (kg FPCM * farm^{-1} * year^{-1})
FPCM $_{P,I,j,t}$ = Project fat and protein corrected milk yield for the ith cow on the jth farm from project monitoring data specific to each project area (kg FPCM * head^{-1} * year^{-1})
P = index of project scenario
j = index of farms
t = index of project year

6. Leakage Due to Land Use Change

1. There is potential leakage due to land use change induced by demand for feed by project participants. All projects using this methodology shall assess the risk of leakage, and shall account for leakage using the following procedures.

2. Changing demand of project participants for feed resources may cause land use change (e.g. deforestation, conversion of native pasture to cropland) that emits GHG emissions into the atmosphere. While estimates of the occurrence of land use change in a region (particularly deforestation) are facilitated by freely available global datasets,[39] attribution of land use change to the demand of dairy producers for feed is not straightforward.

3. In theory, demand for feed may cause land use change through direct and indirect impacts. Direct land use change is conversion of land, which was not previously used for crop production, into land for the production of dairy cattle feeds (either from deforestation or from conversion of grasslands). The emissions caused by the conversion process can potentially be directly linked to the level of demand for dairy cattle feed, and thus allocated to the specific impact of dairy development in the project region on emissions due to land use change. Recognizing the need to reduce emissions from deforestation and forest degradation (REDD)

[39] For example, http://earthenginepartners.appspot.com/google.com/science-2013-global-forest

caused in part by agricultural expansion, a number of countries have initiated national REDD+ programmes in collaboration with the international community to reduce emissions deforestation and forest degradation, and promote conservation, sustainable management of forests and enhancement of forest carbon stocks. Major international initiatives supporting national REDD+ initiatives include UN REDD[40], The Forest Carbon Partnership Initiative and Forest Investment Program of the World Bank[41], and the REDD+ Early Movers Programme of the German government[42]. If the geographic regions providing feed to the project are not covered by a domestic or internationally-supported REDD+ programme, an assessment of direct land use change due to increased demand for dairy feed in the country in which the project region is located is required, and shall be conducted following the general guidance set out below.

4. Indirect land use change is a market effect resulting from the production of feed crops on land that was previously used to produce food crops. If all other factors remain the same, this reduces the area available for food crop production, and leads to a reduction in food supply, and may cause food prices to rise due to the reduced supply. The price increase provides an incentive to convert formerly unused areas for food production. There are no established research approaches for quantifying the indirect land use change effects of dairy feed demand, and an explicit assessment is not required due to the lack of a robust methodological basis.

5. Leakage due to direct land use change caused by the project activities shall be assessed as follows:

   i. Recognizing the need to reduce emissions from deforestation and forest degradation (REDD) caused in part by agricultural expansion, a number of countries have initiated national REDD+ programmes in collaboration with the international community to reduce emissions deforestation and forest degradation, and promote conservation, sustainable management of forests and enhancement of forest carbon stocks. If the geographic regions providing feed to the project region are within a country that is a UN REDD programme partner country,[43] or a participant country to the Forest Carbon Partnership Initiative and Forest Investment Program of the World Bank[44], or covered by any other domestic or international REDD+ programme, an assessment of direct land use change due to increased demand for dairy feed in the project region is not required.

      Geographic regions providing feed to the project region shall be identified in the Project Design Document (PDD). Transparent data and methods shall be presented to justify the identification of supplying regions and their participation in REDD+ programmes.

   ii. If the geographic regions are not covered by a REDD+ programme, the project proponents shall assess the risk of deforestation or conversion of grassland to cropland caused by

[40] http://www.un-redd.org/aboutredd/tabid/102614/default.aspx
[41] https://www.forestcarbonpartnership.org/redd-country-participants and http://www.climatefundsupdate.org/listing/forest-investment-program
[42] http://www.bmz.de/en/publications/topics/international_cooperation/FlyerREDD_lang.pdf
[43] http://www.un-redd.org/aboutredd/tabid/102614/default.aspx
[44] https://www.forestcarbonpartnership.org/redd-country-participants

changing feed demand from the project area and estimate the emissions caused by deforestation or conversion of grasslands to cropland due to changing feed demand from project activities. The approach to assessing whether leakage takes place and to the estimation of leakage emissions shall be transparent and conservative. The leakage estimation approach may be based on land use change emission factors or on the approach presented in Step 5 of the CDM EB approved tool for "Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity",[45] or on any other approach that uses transparent data and methods that support a justifiably conservative estimate of leakage emissions. Where possible, information used to support the assessment and estimation of leakage due to land use change should draw on peer reviewed studies related to the project region, and published studies from authoritative organizations or NGOs. Where such information is not available, project proponents may conduct specific studies using data collection methods and research approaches that reflect IPCC guidance on data collection.[46] Where it is not possible to use such methods, project participants may submit a written testimony based on the results of a Participatory Rural Appraisal (PRA) as practised in the host country.

iii. The result of estimation shall be the quantification of the parameter $LK_{LUC,t}$

Where:
$LK_{LUC,t}$ = leakage due to land use change due to change in demand for feedstuffs due to project implementation in project year t ($tCO2e * year^{-1}$).

7. Quantification of Net Emission Reductions

1. The emission reductions achieved by each farm in project year t in tonnes of CO_2e are calculated as follows:

$$\mathbf{ER_{P,j,t}} = \left[\frac{(\mathbf{BEI_{BS,j}} \times \mathbf{Total\ Milk\ Yield_{P,j,.t}}) - (\mathbf{PEI_{P,j}} \times \mathbf{Total\ Milk\ Yield_{P,j,t}})}{\mathbf{1000}}\right] \qquad \textbf{(Equation 28)}$$

Where:
$ER_{P,j,t}$ = Emission reductions for the jth farm in project year t (tonnes CO_2e)
$BEI_{B,j}$ = Baseline emission intensity for the jth farm (kg^{-1} CO_2e * kg $FPCM^{-1}$)
$PEI_{P,j}$ = Project emission intensity for the jth farm (kg^{-1} CO_2e * kg $FPCM^{-1}$)
Total Milk $Yield_{P,j,t}$ = total fat and protein corrected milk yield of all individual cows on the jth farm in project year t
1000 = Conversion from kg^{-1} to $tonnes^{-1}$ of FPCM
BS = index of baseline scenario
P = index of project scenario
j= index of individual farms

[45] https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-09-v2.pdf
[46] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_2_Ch2_DataCollection.pdf

2. The total emission reductions achieved by all farms participating in the project in project year t is the sum of emission reductions by each farm, calculated as in Equation 28:

$$\mathbf{ER_t = \sum_{j=1}^{J\ farms} ER_{P,j,t}}$$ **(Equation 9)**

Where:
ER_t= total emission reductions of the project in year t; tCO_2e.
j = index of farms
t = index of project years
P = index indicating project scenario

3. Net emission reductions due to project implementation in year t are calculated as follows:

$$\mathbf{NER_t = ER_t - LK_{LUC,t}}$$ **(Equation 30)**

Where:
NER_t= net emission reductions due to project implementation in year t (tonnes CO_2e)
LK_{LUCt} = leakage due to land use change due to change in demand for feedstuffs due to project implementation in project year t (tonnes CO_2e)
t = index year

8. Monitoring Methodology

1. The following baseline information on each project area (i.e., dairy farm) within the project region shall be provided in the PDD (or at the time of verification where the number of project areas increases gradually over time):
   a) Unique numerical identifier for each project area (i.e., dairy farm)
   b) Name of household head
   c) Physical address or other marker of location (e.g. GPS coordinates)
   d) A statement of the dairy farm stratum to which the project area was allocated before dairy management changes took place in the project.
   e) A statement clarifying the ownership of emission reductions.

2. During project implementation, the parameters indicated in Section 8.1 shall be monitored. In addition, the following general requirements should be adhered to. Project proponents shall:
(a) Electronically archive all data collected as part of monitoring for a period lasting until 2 years after the end of the crediting period; and
(b) Measuring equipment should be certified to national or international standards and calibrated according to the national standards and reference points or international standards and recalibrated at appropriate intervals according to manufacturer specifications.

3. Project proponents shall provide the following monitoring data for each year in the project crediting period:
   - Unique numerical identifier for each dairy animal in each project area (for each project area, all dairy animals in the farm shall be registered – it is not permitted to register only particular breeding-age cows);
   - Total fat and protein corrected milk yield for farm;
   - Number of mature lactating and dry cows per farm;
   - For each animal leaving the farm (e.g. due to mortality, sale, gift, theft or other reason), record of the reason;
   - A statement of the dairy farm stratum to which each project area is allocated at each monitoring event;
   - Documentary evidence of the implementation of the plan for capacity building and other support to farmers to improve animal welfare.

For project areas participating in the project after the first year of the project, the information in paragraph 56 should be provided, and if a project area involves a farm that was not producing milk prior to the start of participation in the project, the dairy farm stratum to which the newly participating project area is allocated shall be recorded and justified.

8.1 Data and parameters monitored

1. In order to quantify emission reductions, the parameters in this section shall be monitored, and data recorded and stored for presentation at verification. In addition, the project proponent shall ensure that each project implements a Sustainability Monitoring Plan in accordance with the Gold Standard Agriculture Requirements.

Data Parameter	Dairy farm stratum
Data Unit:	unitless
Description:	The project proponents shall identify the dairy farm stratum (e.g. grazing, stall & grazing or zero-grazing) to which each project area can be allocated.
Source of Data:	Project proponents
Measurement Procedures (if any):	To be determined on the basis of a site-inspection of the dairy farm and surveys conducted by the project proponent for the baseline survey, as well as during the project.
Comment:	Each project shall, based on circumstances in the project region, draw up its own list of dairy farm strata. These may be distinguished on the basis of feed system, agroecological zone or other factors, as appropriate.

Data Parameter	Annual total milk yield per farm
Data Unit:	kg milk * $farm^{-1}$ * $year^{-1}$
Description:	Total uncorrected volume of milk produced per farm per year
Source of Data:	Farmer reported value
Measurement Procedures (if any):	Milk yield may be estimated using any survey method that produces unbiased and reliable estimates of milk production per cow per year. Such methods may include direct measurement of consecutive milk yields, or estimation of milk yields based on a validated lactation curve models and farmer self-reporting. Guidance can be found in the ICAR guidelines for dairy production recording (http://www.icar.org/documents/Rules%20and%20regulations/Guidelines/Guidelines_2012.pdf) and justifications for adjustment of specific procedures to the project context shall be given in the monitoring plan. Where milk yield is estimated on the basis of farmer self-reporting and lactation modelling, estimation will require data on the breed, date of calving, date dry (i.e. end of lactation), milk off-take (i.e. milk obtained, excluding calf suckling) and presence and duration of calf feeding. Milk off-take and suckling presence shall be recorded monthly from the time of calving to end of lactation, unless published literature supports the use of fewer observations in lactation modelling. Where farmer self-reporting is the main source of data, recall periods shall be sufficiently short to ensure reliable and unbiased estimates of each parameter. Farmers shall be equipped with or trained in a method of providing accurate estimates of milk off-take. Annual milk yield will be estimated following a published lactation modelling methodology, suited to the project context. If a cow has been purchased mid-lactation and previous details required for milk yield estimation are not documented, quantification using lactation models of milk yield from that cow shall begin from the start of the next lactation. Milk yield estimates based on lactation models will be based on data from the start of each calving and extend for at least 10 months. Where lactation periods do not coincide with the calendar year used for quantification of project emissions, milk yield reported in any given calendar year shall only include milk yield during that calendar year.
Comment:	If raw data are collected as volumes (liters), this can be converted to weight (kg) by assuming that 1 litre of milk averages 1.031 kg.[47]

[47] http://www.fao.org/docrep/007/y3548e/y3548e06.htm

Data Parameter	Number of mature lactating and dry cows per farm (HS_j)
Data Unit:	Head
Description:	The number of mature lactating and dry cows in each farm in each year
Source of Data:	Farmer reported value
Measurement Procedures (if any):	
Comment:	This is needed to determine the gap between current on-farm animal numbers and replacement animals and may also be needed if average milk yields per cow are calculated from total farm yields.

Data Parameter	Number of bulls maintained per farm (CB_j)
Data Unit:	Head
Description:	The number of bulls maintained on the jth farm in each year
Source of Data:	Farmer reported value
Measurement Procedures (if any):	
Comment:	This is needed to determine the gap between current on-farm bull numbers and replacement bulls.

8.2 Data and Parameters not monitored

The parameters in this section are required for quantification of emission reductions, but values used do not need to be derived from monitored data. Parameters that are derived through calculations are not included in these tables.

Data Parameter	$Milk_{fat}$
Data Unit:	%/kg milk
Description:	Fat content of milk
Source of Data:	Local or regional value, if available. If not the default value specified in IPCC 2006 Vol 4 Ch 10 can be used (4%).
Measurement Procedures (if any):	
Comment:	

Data Parameter	$Milk_{protein}$
Data Unit:	%/kg milk
Description:	Protein content of milk
Source of Data:	Local or regional value, if available. If not the default value specified in IPCC 2006 Vol 4 Ch 10 can be used (3.3%).
Measurement Procedures (if any):	
Comment:	

Data Parameter	DE%
Data Unit:	proportion
Description:	Digestible energy expressed as a proportion of gross energy
Source of Data:	Estimates of DE% for each type of fodder, feed or supplement component of the total mixed ration may derive from values reported in published scientific literature or feed nutritional tables published by an authoritative organization. Where no literature values are available, measurements may be made to determine the value of DE%.
Measurement Procedures (if any):	Where measurements are made, standard procedures for measurement and calculation should be followed as outlined in ILCA (1990) Livestock Systems Research Manual Volume 1, Section 1, Module 7.[48]
Comment:	

[48] http://www.fao.org/wairdocs/ilri/x5469e/x5469e0a.htm

Data Parameter	Y_M
Data Unit:	%
Description:	Methane Conversion Factor
Source of Data:	IPCC default factor for dairy cattle = 6.5% ±1.0%[49]
Measurement Procedures (if any):	The methane conversion factor (Y_m) is estimated based on IPCC (2006) and a Tier 2 approach is applied for the calculation of enteric CH_4 emissions due to the sensitivity of emissions to diet composition and the relative importance of enteric CH_4 to the overall GHG emissions profile in ruminant production. IPCC (2006) defines the CH_4 conversion factor (Y_m) as 6.5 ±1 percent, indicating that Y_m is at the high end of the range when digestibility of feed is low and vice versa.
Comment:	The extent to which feed energy is converted to CH_4 depends on several interacting feed and animal factors. For further guidance on this factor see IPCC 2006 Vol 4 Ch 10 page 10.30.

Data Parameter	Cf_i
Data Unit:	MJ * $head^{-1}$ * day^{-}
Description:	Coefficient for each animal category used in determining net energy for maintenance
Source of Data:	IPCC 2006 Vol 4 Ch 10 Table 10.4
Measurement Procedures (if any):	
Comment:	Selection of the appropriate value from the data source should be justified

Data Parameter	C_a
Data Unit:	unitless
Description:	Coefficient corresponding to animal's feeding situation used in determining net energy for activity
Source of Data:	IPCC 2006 Vol 4 Ch 10 Table 10.5
Measurement Procedures (if any):	
Comment:	Selection of the appropriate value from the data source should be justified

[49] IPCC – Chapter 10 – Emissions from Livestock and Manure Management, Table 10.2

Data Parameter	$Hours_i$
Data Unit:	$Hours^{-1} * head^{-1} * day^{-1}$
Description:	Number of hours of work per day for the ith animal
Source of Data:	Average regional values obtained from peer reviewed scientific literature, statistical databases of authoritative organizations or from sample surveys in the project region conducted on behalf of the project proponent
Measurement Procedures (if any):	Where sample surveys are used to determine this parameter, guidance in UNFCCC Standard for sampling and surveys in CDM project activities and programme of activities should be followed.[50]
Comment:	

Data Parameter	$C_{pregnancy}$
Data Unit:	unitless
Description:	Coefficient used in calculating net energy for pregnancy
Source of Data:	IPCC 2006 Vol 4 Ch 10 Table 10.7
Measurement Procedures (if any):	
Comment:	

[50] https://cdm.unfccc.int/Reference/Standards/meth/meth_stan05.pdf

Data Parameter	BW
Data Unit:	kg/animal
Description:	Live weight of the animals in the population
Source of Data:	Average regional values appropriate to each animal may be obtained from peer reviewed scientific literature, statistical databases of authoritative organizations or from sample surveys in the project region conducted on behalf of the project proponent.
Measurement Procedures (if any):	Where sample surveys are used to measure live weight, any scientifically validated method for estimating live weight using linear body measurements may be used.
Comment:	For further guidance see IPCC 2006 Vol 4 Ch 10 pp. 10.12-10.13

Data Parameter	MW
Data Unit:	kg/animal
Description:	Mature body weight of an adult female in moderate body condition
Source of Data:	Average regional values appropriate to each animal may be obtained from peer reviewed scientific literature, statistical databases of authoritative organizations or from sample surveys in the project region conducted on behalf of the project proponent.
Measurement Procedures (if any):	Where sample surveys are used to measure live weight, any scientifically validated method for estimating live weight using linear body measurements may be used.
Comment:	The mature weight of the adult animal of the inventoried group is required to define a growth pattern, including the feed and energy required for growth. The mature weight will vary among breeds and should reflect the animal's weight when in moderate body condition. For further guidance see IPCC 2006 Vol 4 Ch 10 Page 10.13

Data Parameter	WG
Data Unit:	kg day^{-1}
Description:	Average daily weight gain of the animals in the population
Source of Data:	Average regional values appropriate to each animal may be obtained from peer reviewed scientific literature, statistical databases of authoritative organizations or from sample surveys in the project region conducted on behalf of the project proponent.
Measurement Procedures (if any):	Where sample surveys are used to measure live weight, any scientifically validated method for estimating live weight using linear body measurements may be used.
Comment:	Mature animals are assumed to have no net weight gain or loss over an entire year. Mature animals may lose weight during the dry season and gain weight during the following season, but the effect of this is assumed to be negligible. For further guidance, see IPCC 2006 Vol 4 Ch 10 Page 10.13

Data Parameter	C_g
Data Unit:	Unitless
Description:	Coefficient used in calculating net energy for growth
Source of Data:	IPCC 2006 Vol 4 Ch 10 Table 10.7
Measurement Procedures (if any):	
Comment:	The source of data specifies a value of 0.8 for females, 1.0 for castrates and 1.2 for bulls

Data Parameter	EF_{FEED}
Data Unit:	kg CO2e/ kg feed
Description:	Emission factor for embodied emissions in each feed type
Source of Data:	Where available, local business as usual fertilizer and/or manure application rates and energy for processing feed should be used in the LCA analysis. If local data is not available, country specific or regional data may be used in the LCA analysis. Local data used for the LCA analysis should be sourced from surveys in the project region, peer-reviewed published values and/or publications of authoritative organizations. Where possible LCAs should report the standard error of the mean, since this will aid in quantification of uncertainty
Measurement Procedures (if any):	LCA procedures should be consistent with ISO 14040 and ISO 14044
Comment:	

Data Parameter	Feed
Data Unit:	kg feed (each type) * $year^{-1}$
Description:	Quantity of each type of feed (roughage, concentrate and organic or inorganic supplements) consumed by the animals
Source of Data:	Farmer reported value
Measurement Procedures (if any):	Where feed quantities are reported in local measurement units, justification for the conversion of raw data into kg shall be given.
Comment:	Included in the baseline survey for baseline estimation

Data Parameter	VS_i
Data Unit:	(kg dry matter * $head^{-1}$ * day^{-1})
Description:	Daily Volatile Solids excreted per animal
Source of Data:	Volatile solids may be calculated using the main Tier 2 method specified in IPCC 2006 Vol.4 Ch. 10, equation 10.24
Measurement Procedures (if any):	
Comment:	Volatile solids (VS) are the organic material in livestock manure and consist of both biodegradable and non-biodegradable fractions. The VS content of manure equals the fraction of the diet consumed that is not digested and thus excreted as fecal material which, when combined with urinary excretions, constitutes manure.

Data Parameter	$B_{O,i}$
Data Unit:	(m^3 CH_4 * kg^{-1} of VS excreted)
Description:	Maximum methane producing capacity
Source of Data:	Default values for the maximum methane producing capacity can be found in Table 10A-4 of IPCC 2006 Vol.4 Ch. 10, Annex 10A.2, page 10.77
Measurement Procedures (if any):	
Comment:	The maximum methane-producing capacity of the manure (Bo) varies by species and diet.

Data Parameter	$MCF_{S,i}$
Data Unit:	unitless
Description:	Methane conversion factor specific to manure management systems
Source of Data:	MCF can be found in Table 10.17, IPCC 2006 Vol.4 Ch. 10.
Measurement Procedures (if any):	
Comment:	The value appropriate to the climate region must be selected.

Data Parameter	$MS_{S,i}$
Data Unit:	Unitless
Description:	Fraction of the manure handled using the manure management system
Source of Data:	The value of $MS_{S,i}$ may be taken from peer reviewed scientific literature, statistical databases of authoritative organizations or from sample surveys in the project region conducted on behalf of the project proponent.
Measurement Procedures (if any):	Where sample surveys are used to determine this parameter, guidance in UNFCCC Standard for sampling and surveys in CDM project activities and programme of activities should be followed.[51]
Comment:	

[51] https://cdm.unfccc.int/Reference/Standards/meth/meth_stan05.pdf

Data Parameter	AFC_k
Data Unit:	$Months^{-1}$
Description:	Average age at first calving of cows in stratum k
Source of Data:	Farmer reported value
Measurement Procedures (if any):	
Comment:	Included in the baseline survey for baseline estimation

Data Parameter	AE_k
Data Unit:	Head
Description:	Number of mature females exiting farms in stratum k due to culling, sales, gifts or other reasons in the year prior to the baseline survey
Source of Data:	Farmer reported value
Measurement Procedures (if any):	
Comment:	Included in the baseline survey for baseline estimation

Data Parameter	CE_k
Data Unit:	Head
Description:	Number of calves and heifers exiting farms in stratum k due to culling, sales, gifts or other reasons in the year prior to the baseline survey
Source of Data:	Farmer reported value
Measurement Procedures (if any):	
Comment:	Included in the baseline survey for baseline estimation

Data Parameter	CH_k
Data Unit:	Head
Description:	Number of calves and heifers on farms in stratum k in the baseline survey
Source of Data:	Farmer reported value
Measurement Procedures (if any):	
Comment:	Included in the baseline survey for baseline estimation

Data Parameter	SR_k
Data Unit:	Ratio
Description:	Sex ratio of calves born in stratum k in the baseline survey
Source of Data:	The value of this parameter may be taken from peer reviewed scientific literature, statistical databases of authoritative organizations or from sample surveys in the project region conducted on behalf of the project proponent.
Measurement Procedures (if any):	
Comment:	

Data Parameter	CD_k
Data Unit:	Head
Description:	The number of calves on farms in stratum k that died in the year prior to the baseline survey
Source of Data:	Farmer reported value
Measurement Procedures (if any):	
Comment:	Included in the baseline survey for baseline estimation

Data Parameter	CB_k
Data Unit:	Head
Description:	The number of calves born on farms in stratum k in the year prior to the baseline survey
Source of Data:	Farmer reported value
Measurement Procedures (if any):	
Comment:	Included in the baseline survey for baseline estimation

Data Parameter	BL_k
Data Unit:	Years
Description:	Average working lifetime of a bull in stratum k
Source of Data:	Baseline survey
Measurement Procedures (if any):	
Comment:	Included in the baseline survey for baseline estimation

Data Parameter	NCB_k
Data Unit:	%
Description:	Average non-completion rate for bull replacements on farms in stratum k in the baseline survey
Source of Data:	Baseline survey
Measurement Procedures (if any):	
Comment:	Included in the baseline survey for baseline estimation

Data Parameter	REDD+ Programme
Data Unit:	Unitless
Description:	Existence and extent of a REDD+ programme in the geographic region related to feed for the project
Source of Data:	Government agencies
Measurement Procedures (if any):	
Comment:	

Data Parameter	$LK_{LUC,t}$
Data Unit:	tCO_2e * $year^{-1}$
Description:	Leakage due to land use change due to changing demand for feedstuffs due to project implementation in project year t
Source of Data:	Project proponent
Measurement Procedures (if any):	Leakage may be calculated using land use change emission factors and estimates of deforestation activity driven by feed demand from the project, or methods based on those outlined in Step 5 of the CDM A/R methodological tool[52]), or using other approach that uses transparent data and methods that support a justifiably conservative estimate of leakage emissions
Comment:	

[52] https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-09-v2.pdf

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ISBN 978-92-5-109457-0
9 789251 094570
I6280En/1/10.16