Provincial Guidance for Measurement, Reporting and Verification of Greenhouse Gas Inventory in China's livestock based on IPCC Tier 2 method —— Dairy cattle and Swine

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CHAPTER 1 INTRODUCTION

1. INTRODUCTION

Greenhouse gas (GHG) inventory monitoring, reporting and verification (MRV) is the basis for dealing with climate change globally, assessment of the status of GHG emissions and the effectiveness of mitigation actions. To this end, the United Nations Climate Change Conference has adopted a series of agreements and decisions on GHG monitoring, reporting and certification, as shown in table 1-1. The United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992, requires that all Parties, taking into account their common but differentiated responsibilities and their specific national and regional priorities, objective , and circumstance, develop , and communicate the conference of parties, through the secretariat, a national inventory of anthropogenic emissions by sources and removals by sinks, to the extent its capabilities prime, using comparable methodologies to be promoted and agreed upon the Conference of Parties (COP). The Cancun Agreement, reached at the Sixteenth Conference of the Parties (2010) to UNFCCC, proposed that non-Annex I countries should submit a biennial update report (BUR), including a national GHG inventory. The guidelines for the BUR, agreed at the Seventeenth Conference of the Parties (2011), suggested that developing countries should submit relevant information including mitigation actions and effects, methodology and assumptions adopted. The Twenty-First Conference of the Parties adopted the Paris Agreement (2015), inviting developing countries to report regularly their national inventories and progress on national mitigation actions. The requirements for the submission of national GHG inventories and biennial transparency reports (BTR) were further clarified at the First Conference of the Parties to the Paris Agreement (2018) through the Modalities, Procedures and Guidelines for the Transparency Framework. China attaches great importance to climate change, green and low-carbon development of agriculture, and explicitly proposes the development of low-carbon agriculture in its nationally determined contribution (NDC) submitted to the UNFCCC.

Livestock is an important emissions source of GHG emissions. Major livestock, such as dairy and swine, inevitably cause produce GHG emissions during production and waste management. Scientific measurement, reporting and verification of GHG emissions from livestock are important to

increase transparency of GHG emission, account effects of mitigation actions, integrate mitigation action with improving livestock productivity and animal manure utilization, and achieve sustainable development.

Supported by the CGIAR's Climate Change, Agriculture and Food Security program (CCAFS) and the Global Research Alliance on Agricultural Greenhouse Gases (GRA), the Institute of Environment and Sustainable Development in Agriculture, e Chinese Academy of Agricultural Sciences, in collaboration with the National Center for Climate Change Strategy and International Cooperation, and the Hebei Provincial Livestock Station, took dairy and swine as examples and proposed Provincial Guidance for Measurement, Reporting and Verification of GHG Inventories in China based on the IPCC Tier 2 method. These guidelines are expected to provide experience for China and other countries in monitoring, measurement, reporting and verification of GHG emissions from livestock, and to support efforts to tackle climate change and realize green and low-carbon development of livestock.

This Guidance includes 5 parts: introduction, Methodologies of estimation, Data requirement and Monitoring methods, Requirements and formats for reporting, Verification methods. This Guidance is expected to guide provinces, counties and cities to compile GHG inventories and evaluate the effects of mitigation actions.

In this guidance, the following terms indicate different requirements:

“shall” indicates that it is an obligatory requirement;

“should” indicates a recommendation that users are encouraged to adopt;

“may” indicates an option that users may decide to adopt.

Table 1- 1 The development of the MRV framework for developing country Parties

1992	The Convention establishes reporting obligations for all Parties and timelines for the initial national communications from developing country Parties.
2002 (COP8)	COP 8 adopted the revised guidelines for the preparation of national communications

	(decision 17/CP.8).
2010 (COP16)	COP 16 defined the frequency of national communications as every four years, and introduced additional elements of MRV (decision 1/CP.16): enhanced reporting in national communications, including inventories, on mitigation actions and their effects, and support received; biennial update reports (BURs) every two years; international consultation and analysis (ICA) of BURs; and domestic MRV of domestically supported mitigation actions.
2011 (COP17）	COP 17 adopted the guidelines for the preparation of BURs and the guidelines and modalities for ICA: the first BUR to be submitted by December 2014, consistent with the capabilities and the level of support provided for reporting; least developed country Parties and small island developing States may submit this report at their discretion; the first BUR is to cover, at a minimum, the inventory for the calendar year no more than four years prior to the date of submission; ICA will commence within six months of the submission of the first round of BURs; ICA will include a two-part technical analysis and facilitative sharing of views
2015（COP21）	The Paris agreement established a transparency framework that requires developing countries to report regularly :1) national GHG inventories; 2) tracking the progress of national emission reduction actions.
2018 (CMA1)	Developed the transparency framework patterns, procedures and guidelines. mandatory requirements: 1) Each Party shall use the 2006 IPCC Guidelines, and shall use any subsequent version or refinement of the IPCC guidelines agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA). 2) Each Party shall identify the indicator(s) that it has selected to track progress towards the implementation and achievement of its NDC. Each Party shall provide an

assessment of whether it has achieved the target(s) for its NDC

3) Decides that Parties shall submit their first biennial transparency report (BTR) and national inventory report, if submitted as a stand-alone report, in accordance with the modalities, procedures and guidelines, at the latest by 31 December 2024.

2. TERMINOLOGY AND DEFINITIONS

1) **Accuracy:** Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they neither are systematically neither over- nor under-estimate true emissions or removals, so far as can be judged, and that uncertainties are reduced so far as is practicable. Appropriate methodologies conforming to guidance on good practices should be used to promote accuracy in inventories.

2) **Activity data:** Data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time. Data on the livestock sector refers to annual average animal population.

3) **Carbon dioxide equivalent:** A measure used to compare different GHG based on their contribution to radiative forcing.

4) **Climate change:** Climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which that is in addition to natural climate variability observed over comparable time periods.

5) **Comparability:** Comparability means that estimates of emissions and removals reported by countries in inventories should be comparable among countries. For this purpose, countries should use agreed methodologies and formats for estimating and reporting inventories.

6) **Completeness:** Completeness means that an inventory covers all sources and sinks and gases included in the IPCC Guidelines for the full geographic coverage in addition to other existing relevant source/sink categories which are specific to individual countries (and therefore may not be included in the IPCC Guidelines).

7) **Consistency:** Consistency means that an inventory should be internally consistent in all its elements over a period of years. An inventory is consistent if the same methodologies are used for the base year and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. An inventory using different methodologies for different years can be considered to be consistent if it has been estimated in a transparent manner taking into account the guidance in Volume 1 of the 2006 IPCC Guidelines on good practice in time series consistency.

8) **Emission factor:** A coefficient that quantifies the emissions or removals of a gas per unit of activity. Emission factors in this Guideline are refers to annual methane (CH_4) emissions per head of livestock from enteric fermentation of one head dairy, and annual CH_4 and nitrous oxide (N_2O) emissions from manure management systems of per head of livestock.

9) **Global warming potential:** Global Warming Potentials (GWP) are calculated as the ratio of the radiative forcing of one kilogram of GHG emitted to the atmosphere to that from one kilogram of CO_2 over a period of time.

10) **GHG:** means those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation.

11) **Key category:** An emission source that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of GHG in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions or removals. Whenever the term key category is used, it includes both source and sink categories.

12) **Measurement:** In this guideline, it refers to the collection of activity data, calculation of emission factor and emissions.

13) **CH_4 emissions from enteric fermentation**: refers to CH_4 emissions during normal metabolism of animals and the digestive process by which feed are fermented by animal intestinal micro-organisms.

14) **CH_4 emissions from manure management systems:** refers to the CH_4 emissions during the

storage and treatment of manure, in which CH_4 is produced by fermentation of organic matter under the action of anaerobic micro-organisms. The emissions accounted as livestock emissions do not include CH_4 emissions after livestock manure has been applied to cropland or other soils as organic amendments, or that has been deposited directly onto pasture land during grazing.

15) **MRV：** In this Guideline, the M refers to “measurement”, R refers to reporting, V refers to verification.

16) **N_2O emissions from manure management:** refers to N_2O emissions from nitrogen-containing substances in the process of nitrification or denitrification during the storage and treatment manure (excluding N_2O emissions after livestock manure has been applied to cropland or other soils as organic amendments, or that has been deposited directly onto pasture land during grazing). N_2O emissions from livestock manure management include direct and indirect emissions.

17) **Quality assurance:** Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process to verify that data quality objectives were met, ensure that the inventory represents the best possible estimate of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the quality control (QC) programmer.

18) **Quality control:** Quality Control (QC) is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed carried out by those directly involved in the compilation/development process of the inventory. QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardized procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. More detailed QC activities include technical reviews of source categories, activity and emission factor data, and methods.

19) **Reporting:** The process of providing the GHG emission results.

20) **Transparency:** Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by

users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of information.

21) **Uncertainty:** Lack of knowledge of the true value of a variable that can be described as a probability density function characterizing the range and likelihood of possible values. Uncertainty depends on the analyst's state of knowledge, which in turn depends on the quality and quantity of applicable data as well as knowledge of underlying processes and inference methods.

22) **Verification:** Verification refers to the collection of activities and procedures that can be followed during the planning and development, or after completion of an inventory that can help to establish its reliability for the intended applications of that inventory.

CHAPTER 2 PROVINCIAL GUIDEANCE FOR MEASUREMENT, REPORTING AND VERIFICATION OF GHG INVENTORIES FOR LIVESTOCK BASED ON IPCC TIER 2 APPROACH

1. THE NECESSITY OF ADOPTING THE 2006 IPCC GUIDELINES TIER 2 APPROACH

Animal husbandry is an important source of GHG emissions. With the development of society and the increase of people's demand for animal products, GHG emissions from animal husbandry production will continue to increase. In addition, although total livestock GHG emissions in developing countries have increased, their GHG intensity (carbon dioxide equivalent per unit of livestock product) has been declining due to the improvement of productivity in animal husbandry. Therefore, the improvement of livestock production efficiency and the utilization of manure are important ways to meet the growing demand for livestock products and to control GHG emissions to mitigate further global climate change. These issues draw attention to the importance of methods for livestock GHG emission measurement.

The 2006 IPCC Guidelines for National GHG Inventories (hereinafter referred to as 2006 IPCC Guidelines), compiled by the Intergovernmental Panel on Climate Change (IPCC), provide alternative methods for estimating GHG emissions from livestock husbandry.

The Tier 1 method is a simplified approach that relies on default emission factors drawn from the literature. Users of the Tier 1 method multiply the activity data by the IPCC default emission factors to estimate emissions per source, and sum across subcategories to estimate total emissions. The 2006 IPCC Guidelines provide annual CH_4 emission factors per animal for enteric fermentation and manure management, with emission factors differentiated by climate zone and livestock species. In the Tier 1 approach, the emission factors do not change over time, so Tier 1 method cannot reflect the effects of changes in herd structure, productivity and manure management, or the effect of mitigation policies and measures. The IPCC Guidelines provide Tier 1 default values for emissions per animal per year, which are applicable to broad continental regions, and do not reflect specific circumstances within

countries. With a Tier 1 approach, emission reductions in livestock sector can only be reflected if total animal numbers decrease. Therefore, the application of a Tier 1 approach to policy makers is limited.

The Tier 2 method uses a more complex approach. The emission factors for enteric fermentation and manure management in a region are determined using input parameters that reflect local animal performance, feed type and quality, feed intake, digestibility, manure N excretion, and manure management system. Tier 2 method require more detailed information on different subcategories of livestock in a country or region, and activity data on management practices and animal performance for each subcategory. These data are used to estimate feed intake (either as dry matter or as gross energy) required by the animals to maintain the specified level of performance. Intake is then converted to CH_4 emissions by multiplying energy intake by a CH_4 conversion factor (CH_4 emissions per unit of energy intake). Therefore, the Tier 2 method is better able to reflect management practices, diets and animal productivity in different production systems or regions of a country. Emissions per animal estimated using the Tier 2 method can also change over time if data on management practices or productivity are updated. The Tier 2 method is therefore essential for capturing the effects of livestock development and climate change mitigation policies on emissions from the sector. Tier 2 method are therefore useful for measuring and reporting progress in achievement of NDCs. Where livestock emissions are key sources in a national inventory, Tier 2 method can more accurately estimate emissions from the livestock sector.

2. SCOPE OF PROVINCIAL GHG INVENTORY IN CHINA

Following the scope the 2006 IPCC Guidelines and China's national GHG inventory, the scope of provincial GHG inventories in China include CH_4 emissions from enteric fermentation, CH_4 emissions from manure management, and N_2O emissions from manure management.

Dairy cattle is a major source of CH_4 emissions from enteric fermentation. The amount of CH_4 that is released is greatly affected by feeding systems, animal growth performance and other related factors. Swine and dairy cattle are both important sources of CH_4 and N_2O emissions from manure management, and GHG emissions are affected by a variety of factors, including climatic regions, feeding systems, digestibility, manure nitrogen excretion and management systems. There are great

differences in livestock production performance and manure management systems in different provinces. Therefore, in order to reflect the actual GHG emissions of each province, the use of more detailed calculation Tier 2 methods is encouraged.

3. CH4 EMISSIONS FROM ENTERIC FERMENTATION OF DAIRY CATTLE

In last 10 years, dairy sector has keeping transformation and upgrading, milk production per cow has increased from 4.6 t per year to 7.6 t per year, while the total daily population has been stable. In 2017, there were about 10.80 million dairy cattle a in stock in China, 63% of dairy housed intensive system. .

CH_4 emissions from enteric fermentation include only CH_4 excreted from the animal's mouth, nose and rectum, not emissions from manure. The amount of CH_4 that is released depends on the type of animal, age, and weight of the animal, the quality and quantity of the feed consumed, growth rate, and production level, among which feed intake and the quality of feed are the most important influencing factors. Dairy cattle have a large rumen volume and a large number of parasitic micro-organisms, which can decompose cellulose. Therefore, dairy cattle are a major source of CH_4.

Total CH_4 emissions from enteric fermentation of dairy cattle is equal to the sum of CH_4 emissions from dairy cows managed under different feeding situations and growth stages in the province, and can be calculated using Equation 1:

$$\boldsymbol{E_{CH4\_EN}} = \sum_{T,P} \boldsymbol{EF_{CH4\_EN\ (T,P)}} \cdot \left(\frac{\boldsymbol{N_{(T,P)}}}{\boldsymbol{10^3}}\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where:

E_{CH4_EN} : CH_4 emissions from enteric fermentation in the province, t CH_4 yr^{-1};

$E_{CH4\_EN(T,P)}$: CH_4 emission factor from in feeding situation P in growth stage T, kg CH_4 $head^{-1}$ yr^{-1};

$N_{(T,P)}$: activity data, the number of head of livestock in the feeding situation P in growth stage T, average annual animal population in stock, head;

P : index for feeding situation (intensive, backyard, grazing);

T : index for growth stage (calves, other cattle, mature dairy cattle).

The emission factors for enteric fermentation from dairy cattle are calculated using Equation 2:

$$EF_{CH_4\_EN\ (T,P)} = \left(GE_{\ (T,P\ )} \cdot \frac{Y_{m(T,P)}}{100} \cdot 365\right) / 55.65 \ldots\ldots (1)$$

Where:

$EF_{CH4\_EN(T,\ P)}$: CH_4 emission factor from enteric fermentation in feeding situation P in growth stage T, kg CH_4 head^{-1} yr^{-1};

$GE_{(T,\ P)}$: gross energy intake of dairy cattle in feeding situation P in growth stage T; MJ head^{-1} day^{-1};

$Y_{m(T,\ P)}$: CH_4 conversion factor for dairy cattle in feeding situation P in growth stage T, percent of gross energy in feed converted to CH_4, %;

365 : total days in a year, day year^{-1};

55.65 : the energy content of CH_4, MJ kg^{-1} CH_4.

3.1 GROSS ENERGY (GE) INTAKE FROM FEED BY DAIRY CATTLE

Gross energy (GE) intake by livestock is related to a variety of factors including livestock type, growth performance and feed characteristics. Two methods for estimating the GE are presented in the IPCC Guidelines. The first method is based on animal performance data, and the second method directly estimates total dry matter intake of different animals at different growth stages. Provinces are encouraged to use animal performance parameters to calculate GE, and the dry matter intake method may be used to calculate GE if relevant data on animal performance are not available.

The GE intake for dairy cattle can be determined based on the formula provided by the IPCC Guidelines and dairy cattle production performance. The calculation using Equation 3 is as follows:

$$GE = \left[\frac{NE_m+NE_a+NE_l+NE_{work}+NE_p}{REM} + \frac{NE_g}{REG}\right] / (DE \cdot 0.01) \ldots\ldots (3)$$

Where:

GE : gross energy of dairy cattle feed intake, MJ $head^{-1}$ day^{-1};

NE_m : net energy required by dairy cattle for maintenance, MJ $head^{-1}$ day^{-1};

NE_a : net energy for dairy cattle activity, MJ $head^{-1}$ day^{-1};

NE_g : net energy required for dairy cattle growth, MJ $head^{-1}$ day^{-1};

NE_l : net energy required for dairy cattle lactation, MJ $head^{-1}$ day^{-1};

NE_{work} : net energy required for work by dairy cattle, MJ $head^{-1}$ day^{-1};

NE_p : net energy required for dairy cattle pregnancy, MJ $head^{-1}$ day^{-1};

REM : ratio of net energy available in a diet for maintenance to digestible energy consumed;

REG : ratio of net energy available for growth in a diet to digestible energy consumed;

DE : digestible energy expressed as a percentage of gross energy, %; Table 2-1 lists the IPCC recommended feed digestibility default values for swine and dairy cattle.

Table 2- 1 Representative feed digestibility for swine and dairy cattle

Main categories	Class	Digestibility (DE as %)
Swine	Mature Swine – confinement	70 -80%
	Growing Swine - confinement	80 -90%
	Swine – free range	50 -70%
Dairy	Feedlot animals fed with > 90% concentrate or high-grain diet	75 -85%
	Pasture / mixed-diet fed animals	55 -75%
	Animals fed – low quality forage	45- 55%

Note: Dairy feed can always be calculated by feeding situation and growth stage. The above formulas and main parameters are not marked with animal feeding situation(P) and growth stage (T). The following net energy calculations are not marked with subclass codes.

3.1.1 Net energy for maintenance (NE_m)

Net energy for maintenance is the net energy required for maintenance, which is the amount of energy needed to keep the animal in equilibrium where body energy is neither gained nor lost. NE_m is mainly determined by animal weight. The equation used to calculate NE_m is as follows:

$$NE_m = Cf_i\,(BW)^{0.75} \qquad (4)$$

Where:

NE_m : net energy required by the animal for maintenance, MJ $head^{-1}\,day^{-1}$;

Cf_i : a coefficient which varies for each animal category as shown in Table 2-2;

BW : live-weight of the animal, kg.

Table 2- 2 Coefficients for calculating NE_m (IPCC,2006)

Animal category	Cf_i（$MJ\ kg^{-1}\ day^{-1}$）
Dry cattle in mature dairy cowa Calves, other cattle	0.322
Lactating cows in mature dairy cows	0.386

3.1.2 Net energy for activity (NE_a)

Net energy for activity (NE_a) is the net energy required for animals to obtain their food, water and shelter. It is based on the feeding situation rather than characteristics of the feed itself. The equation for estimating NE_a for dairy cattle is as follows:

$$NE_a = C_a \cdot NE_m \qquad (5)$$

Where:

NE_a : net energy for dairy cattle activity, MJ $head^{-1}\,day^{-1}$;

NE_m : net energy required of dairy cattle for maintenance, MJ $head^{-1}\,day^{-1}$;

C_a : a coefficient corresponding to a dairy cattle's feeding situation as shown in Table 2-3;

Table 2- 3 Activity coefficients corresponding to dairy cow's feeding situation (IPCC,2006)

Situation		Definition	C_a
Stall	Intensive	Animals are confined to a small area (i.e., tethered, pen, barn) with the result that they expend very little or no energy to acquire feed.	0
	Backyard		

Grazing	Pasture grazing	Animals are confined in areas with sufficient forage requiring modest energy expense to acquire feed.	0.17
	Free grazing	Animals graze in open range land or hilly terrain and expend significant energy to acquire feed.	0.36

3.1.3 Net energy for growth (NE_g)

Net energy for growth (NE_g) is the net energy required for growth (i.e., weight gain). This term is not used in the calculation of GE for animals that have reached their maximum weight and are no longer growing i.e. adult cattle. The equation for estimating NE_g for dairy cattle is as follows:

$$NE_g = 22.02 \cdot \left(\frac{BW}{C \cdot MW}\right)^{0.75} \cdot WG^{1.097} \qquad (6)$$

Where:

NE_g : net energy needed for growth, MJ day^{-1};

BW : the average live body weight (BW) of dairy cattle, kg;

C :a coefficient with a value of 0.8 for dairy cattle;

MW : the mature live body weight of an adult female in moderate body condition, kg;

WG : the average daily weight gain of dairy cattle, kg day^{-1}.

3.1.4 Net energy for lactation (NE_l)

Net energy for lactation (NE_l) is the net energy required for lactation. For dairy cattle the net energy required for lactation is expressed as a function of the amount of milk produced and its fat content expressed as a percentage. This term is not included in calculating the calculation of GE for non-lactating female cattle. The equation for estimating NE_l for dairy is as follows:

$$NE_l = Milk \cdot (1.47 + 0.40 \cdot F_{fat}) \qquad （2）$$

Where:

NE_l : net energy for lactation, MJ day^{-1};

M_{milk} : amount of milk produced, kg day^{-1};

F_{fat} : fat content of milk, % by weight.

3.1.5 Net energy for work (NE_{work})

Net energy for work is the net energy required for work. In some provinces, dairy cows raised by farmers will have labor production activities, which requires energy consumption. This term is not included for the calculation of GE in animals that do not have a labor production activity. The equation for estimating NE_{work} for dairy cattle is as follows:

$$NE_{work} = 0.10 \cdot NE_m \cdot H \quad (3)$$

Where:

NE_{work} : net energy for work, MJ day^{-1};

NE_m : net energy required by dairy cattle for maintenance, MJ head^{-1} day^{-1};

H : number of hours of work per day, hour.

3.1.6 Net energy for pregnancy (NE_p)

Net energy for pregnancy is the energy required for pregnancy. For dairy cattle, the total energy requirement for pregnancy for a 281-day gestation period averaged over an entire year is calculated as 10% of NE_m. The equation for estimating NE_p for dairy cattle is as follows:

$$NE_p = C_{pregnancy} \cdot NE_m \cdot R_{pregnancy}/100 \quad (4)$$

Where:

NE_p : net energy required for pregnancy, MJ day^{-1};

NE_m : net energy required by dairy cattle for maintenance (Equation 4), MJ head^{-1} day^{-1};

$C_{pregnancy}$: pregnancy coefficient with a value of 0.10 for dairy cattle.

$R_{pregnancy}$: percentage of dairy pregnancy, %.

When using NE_p to calculate GE for dairy, the NE_p estimate must be weighted by the portion of adult females that actually go through gestation ($R_{pregnancy}$) in a year in the province. For example, if 80% of the adult females in the animal category give birth in a year, then 80% of the NE_p value would be used in the GE equation.

3.1.7 Ratio of net energy available in diet for maintenance to digestible energy consumed (REM)

For dairy cattle, the ratio of net energy available in a diet for maintenance to digestible energy (REM) is estimated using Equation 10:

$$REM = \left\{\left[1.123 - (4.092 \cdot 10^{-3} \cdot DE) + \left[1.126 \cdot 10^{-5} \cdot (DE)^2\right]\right] - \frac{25.4}{DE}\right\} \quad (5)$$

Where:

REM : ratio of net energy available in a diet for maintenance to digestible energy consumed;

DE : feed digestibility, %.

3.1.8 Ratio of net energy available for growth in a diet to digestible energy consumed (REG)

For dairy cattle, the ratio of net energy available for growth in a diet to digestible energy consumed (REG) is estimated using Equation 11:

$$REG = \left\{\left[1.164 - (5.160 \cdot 10^{-3} \cdot DE) + \left[1.308 \cdot 10^{-5} \cdot (DE)^2\right]\right] - \frac{37.4}{DE}\right\} \quad (6)$$

Where:

REG : ratio of net energy available for growth in a diet to digestible energy consumed;

DE : feed digestibility, %.

3.2 ESTIMATING GE WITH DRY MATTER INTAKE (DMI)

The 2006 IPCC Guidelines provide a simplified method to calculate GE. Considering the capacity of provincial GHG inventory compilation agencies, the average feed intake and dry matter intake parameters can be investigated without obtaining relevant production performance parameters. GE intake can be calculated using Equation 12:

$$GE_{(T,P)} = DMI_{(T,P)} \times 18.45 \quad (7)$$

Where:

$GE_{(T,P)}$: gross energy intake of dairy cattle in feeding situation P in growth stage T; MJ $head^{-1}$ day^{-1};

$DMI_{(T,P)}$: dry matter intake by dairy cattle in feeding situation P in growth stage T, kg $head^{-1}$ day^{-1};

18.45 : default conversion coefficient of dry matter and gross energy, MJ kg^{-1};

P : index for feeding situation;

T : index for growth stage.

3.3 OBTAINING THE CH4 CONVERSION FACTOR (Y_M)

The CH4 conversion factor (Y_m) is directly related to the quality of feed and feed intake. At present, there is no systematic experimental data on Y_m for dairy cattle enteric fermentation in China, so the default value (6.5 ±1.0) , given in the 2006 IPCC Guidelines, is adopted in these guidelines.

4. INVENTORY COMPILATION METHOD FOR CH_4 EMISSIONS FROM LIVESTOCK MANURE MANAGEMENT

CH_4 emission from manure management is produced during the storage and treatment of manure before it is applied to land. The term 'manure' is used here collectively to include both dung and urine (i.e., the solids and the liquids) produced by livestock. CH_4 emission factors during storage and treatment of manure depends on manure characteristics, the fraction managed in different manure management systems, and local climate. Swine and dairy cattle are bred in large quantities in various provinces and regions in China, and a large amount of liquid manure generated in the process. Liquid storage and treatment of livestock manure is the most important process of manure management.

Thirteen manure management systems are presented, include pasture/range/paddock, daily spread, solid storage, dry lot, liquid/slurry, uncovered anaerobic lagoon, pit storage below animal confinements, anaerobic digester, burned for fuel, deep bedding, composting, poultry manure with litter and aerobic treatment. For manure sold or entrusted to a third party, the final management of manure should be traced back and classified according to the final treatment.

4.1 CH_4 EMISSIONS FROM MANURE MANAGEMENT OF SWINE AND DAIRY CATTLE

The calculation of CH_4 emissions from manure management of swine and dairy cattle uses Equation 13:

$$E_{CH_4\_MM} = \sum_{T,P} \frac{\left(EF_{CH4\_MM(T,P)} \cdot N_{(T,P)}\right)}{10^3} \quad (13)$$

Where:

E_{CH4_MM} :CH_4 emissions from manure management for swine and dairy cattle in the province, t CH_4 yr^{-1};

$EF_{CH4\_MM(T,P)}$: emission factor for animals in feeding situation P in growth stage T, kg CH_4 $head^{-1}$ yr^{-1};

$N_{(T,P)}$: activity data, the number of head of livestock in feeding situation *P*

in growth stage *T*, average annual animal population in stock, head;

P : index for feeding situation;

T : index for feeding stage.

4.2 CH4 EMISSION FACTORS FOR MANURE MANAGEMENT

Consistent with enteric fermentation, growth stages are classified for swine and dairy cattle. The calculation of CH_4 emission factors using the Tier 2 method uses Equation 14:

$$EF_{CH_4\_MM\ (T,P)} = \left(VS_{(T,P)} \cdot 365\right)\left[B_{0(T,P)} \cdot 0.67 \cdot \sum_{(S,K)} \frac{MCF_{(S,K)}}{100} \cdot \frac{MS_{(T,P,S)}}{100}\right] \quad (14)$$

Where:

$EF_{CH4\_MM(T,P)}$: CH_4 emission factor from manure management for animals in feeding situation P in growth stage T, kg CH_4 head^{-1} yr^{-1};

$VS_{(T,P)}$: daily volatile solids excreted in feeding situation P in growth stage T, kg VS day^{-1};

$B_{0(T,P)}$: CH_4 production capacity for manure produced by animal in feeding situation P in growth stage T, m^3 CH_4 kg^{-1} of VS;

$MCF_{(S,K)}$: CH_4 conversion factors for each manure management system *S* by climate region *K*, %;

$MS_{(T,P,S)}$: fraction of manure handled using manure management system *S* in feeding situation P in growth stage T, %;

0.67 : density of CH_4, kg m^{-3};

S : index for manure management system;

K : index for climate region.

The value of $VS_{(T,P)}$ is calculated using Equation 15 based on the estimated gross energy (GE) intake and its fractional digestibility, and should be the same value for GE as used for CH_4 from enteric fermentation; if specific animals (such as swine) do not need to calculate CH_4 emissions from enteric fermentation, there may be no calculated gross energy, or no parameters for calculation of gross energy, you can directly use the VS default value recommended by the regional literature or IPCC. $B_{0(T,P)}$ uses

the IPCC Guidelines default values; $MCF_{(S,K)}$ is determined from among the default values given in the IPCC Guidelines by investigating manure management and annual average temperatures in different regions; $MS_{(T,P,S)}$ refers to the fraction of manure from animals in different feeding situations and of different animal categories that is handled using different manure management system.

4.2.1 VS excretion rates

The VS excretion rate is estimated as:

$$\boldsymbol{VS} = \left[\boldsymbol{GE} \cdot \left(\mathbf{1} - \frac{\boldsymbol{DE}}{\mathbf{100}}\right) + (\boldsymbol{UE} \cdot \boldsymbol{GE})\right] \cdot \left(\frac{\mathbf{1} - \boldsymbol{ASH}}{\mathbf{18.45}}\right) \qquad (8)$$

Where:

VS : volatile solid excretion per day on a dry matter basis, kg VS day^{-1};

GE : gross energy intake, MJ day^{-1} (from equation 3 or 12);

DE : feed digestibility, %.

UE · DE : urinary energy expressed as fraction of GE. Typically, 0.04 GE can be considered urinary energy excretion by most ruminants (reduced to 0.02 for ruminants fed with 85% or more grain in the diet or swine). Use country -specific values or province specific values where available.

ASH : the ash content of manure, %.

18.45 : conversion factor for dietary GE per kg of dry matter, MJ kg^{-1}.

Note: The volatile solids excreted by dairy cattle or swine should be calculated by feeding situation and feeding stage. The above formula and main parameters are not marked with indexes for feeding situation (*P*) or growth stage (*T*).

The GE intake values of dairy cattle in different feeding situations and stages must be consistent with the GE values used in estimating enteric fermentation emissions. The GE intake values of swine are determined by collecting data on DMI. *DE* values are determined by surveys. The default value recommended by the IPCC Guidelines is applicable to the value for ash content, which is 8%.

4.2.2 Maximum CH_4 producing capacity (B_0)

The maximum CH4-producing capacity of manure (B_0) varies by species and diet. As there are no research results in China, B_0 uses the default values recommended in the 2006 IPCC Guidelines. In particular, the default values for developed countries are used for large-scale animal operations (intensive feeding) and the default values for developing countries are used for smallholder farms (backyard feeding) and animals raised in grazing systems (Table 2-4).

Table 2- 4 CH4 production potential of manure in different feeding systems (IPCC,2006)

Animal category	**CH4 Production Potential (m^3 CH_4 kg^{-1} VS)**		
	Intensive feeding	Backyard feeding	Grazing
Dairy cattle	0.24	0.13	0.13
Swine	0.45	0.29	

4.2.3 Fraction of manure handled using different manure management systems

The IPCC Guidelines list 17 livestock manure management systems and give the definition of each, we combined different composting, cattle and swine deep bedding, poultry manure with or without litter, so total 13 manure management systems was recommended in this guidance. The Provincial Guidance is based on these manure management systems to ensure that the CH_4 emission factors are available. The inventory compilation agencies should obtain data on use of manure management systems and the fraction of animal managed in different feeding situations based on surveys in typical counties. The questionnaires tables in annex table A1-4 are recommend to applied in the surveys in typical counties

4.2.4 CH4 Conversion Factor（MCF）

MCFs are determined for each specific manure management system and reflect the portion of B_0 that is achieved. IPCC default CH_4 conversion factors (MCFs) are provided in Table 2-5 for manure management systems by climatic zone. The inventory compilers can select the appropriate IPCC default values based on local annual average temperature.

Table 2- 5 Default MCFs by climatic zone for manure management systems (%) (IPCC, 2006)

System		Cool (℃)					Temperate(℃)											Warm(℃)		
		≤10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥28
Pasture/Range/Paddock		1.0					1.5											2.0		
Daily spread		0.1					0.5											1.0		
Burned for fuel		10.0					10.0											10.0		
Solid storage		2.0					4.0											5.0		
Dry lot		1.0					1.5											2.0		
Composting	In-vessel or static pile	0.5					0.5											0.5		
	Intensive or passive windrow	0.5					1.0											1.5		
Cattle and swine deep bedding	< 1 month	3					3											30		
	>1 month	17	19	20	22	25	27	29	32	35	39	42	46	50	55	60	65	71	78	80
Pit storage below animal confinements	< 1 month	3					3											30		
	>1month	17	19	20	22	25	27	29	32	35	39	42	46	50	55	60	65	71	78	80
Liquid /slurry	With natural crust cover	10	11	13	14	15	17	18	20	22	24	26	29	31	34	37	41	44	48	50
	Without natural crust cover	17	19	20	22	25	27	29	32	35	39	42	46	50	55	60	65	71	78	80
Uncovered anaerobic lagoon		66	68	70	71	73	74	75	76	77	77	78	78	78	79	79	79	79	80	80
Anaerobic digester		10					10											10		
Poultry manure with litter		1.5					1.5											1.5		
Aerobic treatment		0					0											0		
Others		1.0					1.0											1.0		

5. INVENTORY COMPILATION METHOD FOR N_2O EMISSIONS FROM LIVESTOCK MANURE MANAGEMENT

5.1 INVENTORY COMPILATION METHOD FOR DIRECT N_2O EMISSIONS FROM LIVESTOCK MANURE MANAGEMENT

Direct N_2O emissions from manure management are produced directly during the storage and treatment of manure before it is applied to land. The emission of N_2O from manure during storage and treatment depends on the nitrogen content of daily excreted manure and the fraction of manure managed in different manure management systems for each livestock category. The activity data and manure management usage data for estimating direct N_2O emissions from manure management of swine and dairy cattle must be consistent with that used for estimating CH_4 emissions from manure management.

The calculation of direct N_2O emissions from manure management of swine and dairy cattle is based on the Equation 16:

$$\boldsymbol{E_{N_2O\_D,MM}} = \left[\sum_{S}\left[\sum_{(T,P)}\left(\left(\boldsymbol{N}_{(T,P)} \cdot \boldsymbol{Nex}_{(T,P)}\right) \cdot \frac{\boldsymbol{MS}_{(T,P,S)}}{\boldsymbol{100}}\right)\right] \cdot \boldsymbol{EF}_{3(S)}\right] \cdot \frac{\boldsymbol{44}}{\boldsymbol{28}} \quad \text{........ (16)}$$

Where:

$E_{N2O\_D,MM}$: direct N_2O emissions from manure management, kg N_2O year^{-1};

$N_{(T,P))}$: activity data for the number of head of livestock population in feeding situation P in growth stage T, head;

$Nex_{(T,P)}$: annual average N excretion in feeding situation P in growth stage T, kg N year^{-1};

$MS_{(T,P,S)}$: fraction of manure handled using manure management system *S*, from animals in feeding situation P in growth stage T, %;

$EF_{3(S)}$: emission factor for direct N_2O emissions from manure management system *S*, kg N_2O-N kg^{-1}N.

S : index for manure management system;

T : index for growth stage;

P : index for feeding situation;

44/28 : conversion of N_2O-N emissions to N_2O emissions, kg N_2O (kg N_2O-N)$^{-1}$

5.1.1 N_2O-N emission factors from manure management

Based on Equation 16, the key parameters involved in direct N_2O emissions from animal manure management include nitrogen excretion rates, the types of manure management systems, the portion of manure managed in each manure management system, and N_2O-N emission factors (EF_3). There are no systematic measurements of N_2O-N emission factors for various manure management systems in China. The default values of N_2O-N emission factors for manure management systems recommended by the IPCC Guidelines are adopted in this guideline (Table 2-6).

Table 2- 6 N_2O emission factors for manure management systems (IPCC, 2006)

System		EF_3 kg N_2O-N （kg N excreted）$^{-1}$
Pasture/Range/Paddock		0.02
Daily spread		0.0
Burned for fuel		0.007
Solid storage		0.005
Dry lot		0.02
Composting	In-vessel or static pile	0.006
	Intensive windrow	0.1
	Passive windrow	0.01
Cattle and swine deep bedding	No mixing	0.01
	Active mixing	0.07
Pit storage below animal confinements		0.002
Liquid /slurry	With natural crust cover	0.005
	Without natural crust cover	0.0
Uncovered anaerobic lagoon		0.0

Anaerobic digester		0.0
Poultry manure with litter		0.001
Aerobic treatment	Natural aeration systems	0.01
	Forced aeration systems	0.005
Others		0.001

5.1.2 Annual average nitrogen excretion rates

Annual average N excretion rates of animals is a key parameter for estimating N_2O emissions. In Tier 2 method, local data parameters should be used as much as possible, two methods are recommended in this guide, the first is based on food intake, and the second is based on existing experimental or research data in China.

When data are available on animal feed intake, Equation 17 can be used.

$$Nex_{(T)} = N_{intake(T)} \cdot (1 - N_{retention(T)}) \ldots\ldots\ldots\ldots\ldots \quad (17)$$

Where:

$Nex_{(T)}$: annual average N excretion in growth stage T, kg N $year^{-1}$;

$N_{intake(T)}$: annual average N intake in growth stage T, kg N $year^{-1}$;

$N_{retention(T)}$: annual average N intake that is retained by animal in growth stage T, kg N $year^{-1}$; The nitrogen retention rate recommended by IPCC is shown in table 2-7

Table 2- 7 The nitrogen retention rate of livestock

Livestock category	Nitrogen retention rate (kg N/ kg N intake)
Mature dairy cattle	0.2
Calves, other mature cattle	0.07
Swine	0.3

Nitrogen intake can also be calculated according to the following formula (18) during the compilation of dairy cattle or swine inventory.

$$N_{intake(T)} = \frac{GE}{18.45} \cdot \left(\frac{\frac{CP}{100}}{6.25} \right) \cdot 365 \qquad (18)$$

Where:

$N_{intake(T)}$: annual average N intake in growth stage T, kg N $year^{-1}$;

GE : gross energy intake of the animal, MJ $head^{-1}$ day^{-1}; in enteric model, based on digestible energy, milk production, pregnancy, current weight, mature weight, rate of weight gain, and IPCC constants;

18.45 : conversion factor for dietary GE per kg of dry matter, MJ kg^{-1}. This value is relatively constant across a wide range of forage and grain-based feeds commonly consumed by livestock.

CP : percent crude protein in dry matter of diet, %;

6.25 : conversion from kg of dietary protein to kg of dietary N, kg feed protein $(kg\ N)^{-1}$

Based on data availability, the N excretion data used in this guidance for swine and dairy cattle is provided by the Handbook for the Second National Pollution Source Census on Emission Coefficient of Livestock Industry, in which the national average values were obtained from monitoring results of nearly 100 monitoring farms (Table 2-8).

Table 2- 8 Annual average N excretion rates of dairy cattle and swine （kg $head^{-1}$ yr^{-1}）

Animal category	Swine			Dairy cattle		
	Nursery	Growing-Finishing	Sows	Calves	Other cattle	Mature dairy cows
Nitrogen excretion	4.5	7.5	11.5	14.4	58.8	96.9

5.2 INVENTORY COMPILATION METHOD FOR INDIRECT N_2O EMISSIONS FROM LIVESTOCK MANURE MANAGEMENT

Indirect N_2O emissions from manure management include the emission due to the deposit of NH_3 and NO_x volatilization indirectly during the storage and treatment of manure before it is applied to land, as well as the nitrogen lost due to leaching and runoff . Indirect emissions can be calculated using Equation 19:

$$E_{N_2O\_ID,MM} = N_2O_{volatilization,MM} + N_2O_{leach,MM} \cdots\cdots (19)$$

Where:

$E_{N2O\_ID, MM}$: indirect N_2O emissions from manure management, kg N_2O yr^{-1};

$N_2O_{volatilization, MM}$: indirect N_2O emissions due to volatilization of N from manure management, kg N_2O yr^{-1}

$N_2O_{Leach, MM}$: indirect N_2O emissions due to leaching and runoff from manure management, kg N_2O yr^{-1}

5.2.1 Calculation of indirect N_2O emissions due to volatilization of N

The indirect N_2O emissions due to volatilization of NH_3 from manure management system are estimated using Equation 20:

$$N_2O_{volatilization,MM} = (N_{volatilization,MM} \cdot EF_4) \cdot \frac{44}{28} \cdots\cdots (20)$$

Where:

$N_2O_{volatilization, MM}$: indirect N_2O emissions due to volatilization of N from Manure Management in the country, kg N_2O yr^{-1};

EF_4 : emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg N_2O-N (kg NH_3-N + NO_x-N volatilized)$^{-1}$. The IPCC recommended default values adopted in this guidance are shown in Table 2-9.

$N_{volatilization,MM}$ amount of manure nitrogen that is lost due to volatilization of NH_3 and NO_x, kg N yr^{-1}

Table 2- 9 Default emission, volatilization and leaching factors for indirect soil N_2O emissions

Factor	Default value	Uncertainty range
EF_4 [N volatilization and re-deposition]， kg N_2O-N (kg NH_3-N + NO_x-N volatilized)$^{-1}$	0.010	0.002-0.05
EF_5[leaching/runoff]，kg N_2O-N (kg N leaching/runoff)$^{-1}$	0.0075	0.0005-0.025
$Frac_{GASM}$ [Volatilization from all organic N fertilisers applied, and dung and urine deposited by grazing animals], (kg NH_3-N + NO_x-N) (kg N applied or deposited)$^{-1}$	0.20	0.05-0.5
$Frac_{LEACH-(H)}$ [N loss by leaching/runoff for regions where Σ(rainy in rainy season] – Σ(PE in same period) > soil water holding capacity, or where irrigation (except drip irrigation) is employed , kg N(kg N additions or deposition by grazing animals)$^{-1}$	0.30	0.1-0.8

The emission factor mainly depends on the nitrogen content in the manure excretion of different animals and ammonia volatilization. The nitrogen volatilization is calculated as shown in formula 21:

$$\boldsymbol{N_{volatilization,MM}} = \sum_{S}\left[\sum_{T,P}\left[\left(\left(\left(\boldsymbol{N}_{(T,P)} \cdot \boldsymbol{Nex}_{(T,P)}\right) \cdot \frac{\boldsymbol{MS}_{(T,P,S)}}{100}\right) \cdot \left(\frac{\boldsymbol{Frac}_{GasMS(T,S)}}{100}\right)\right)\right]\right] \ldots\ldots (21)$$

Where：

$N_{volatilization,MM}$: amount of manure nitrogen that is lost due to volatilization of NH_3 and NO_x, kg N yr^{-1}

$N_{(T,P)}$: number of animal s in growth stage T in feeding situation P, head;

$Nex_{(T,P)}$: annual average N excretion per head of animals in growth stage T in feeding situation P, kg N head^{-1} yr^{-1};

$MS_{(T,P,S)}$: fraction of manure handled using manure management system *S*, from animals in feeding situation P in growth stage T, %;

P : index for feeding situation;

$Frac_{GasMS}$: percent of managed manure nitrogen for animals in growth stage T that volatilizes as NH_3 and NO_x in the manure management system *S*, %; Refer to Table 2-10 for the recommended values of some manure management systems.

For manure management systems not included in the table, the unified value is 20%.

Table 2- 10 Default values for nitrogen loss due to volatilization of NH_3 and NO_x from manure management.

Animal type	Manure management system (MMS)	N loss from MMS due to volatilization of N-NH_3 and N-NO_x (%) $Frac_{GasMS}$（Range of $Frac_{GasMS}$）
Swine	Anaerobic lagoon	40%（25-75）
	Pit storage	25%（15-30）
	Deep bedding	40%（10-60）
	Liquid/slurry	48%（15-60）
	Solid storage	45%（10-65）
Dairy cow	Anaerobic lagoon	35%（20-80）
	Liquid/Slurry	40%（15-45）
	Pit storage	28%（10-40）
	Dry lot	20%（10-35）
	Solid storage	30%（10-40）
	Daily spread	7%（5-60）

[a] Manure Management System here includes associated N losses at housing and final storage system.
[b] Volatilization rates based on judgement of IPCC Expert Group and following sources: Rotz (2003), Hutchings *et al.* (2001), and U.S EPA (2004).

5.2.2 Calculation of indirect N_2O emissions due to leaching and runoff.

The indirect N_2O emissions due to leaching and runoff from manure management system are estimated using Equation 22:

$$N_2O_{Leach,MM} = (N_{Leach,MM} \cdot EF_5) \cdot \frac{44}{28} \quad (22)$$

Where:

$N_2O_{Leach,\ MM}$: indirect N_2O emissions due to leaching and runoff from Manure Management in the country, kg N_2O yr^{-1};

$N_{Leach,\ MM}$: amount of manure nitrogen that is lost due to leaching, kg N yr^{-1}

EF_5 : emission factor for N_2O emissions from nitrogen leaching and runoff, kg N_2O-N/kg N leached and runoff, This guide uses the IPCC recommended default values as shown in Table 2-8.

The emission factor mainly depends on the nitrogen that is lost due to leaching and runoff, calculated as Equation 23:

$$N_{leach,MM} = \sum_S \left[\sum_{T,P} \left[\left(\left(\left(N_{(T,P)} \cdot Nex_{(T,P)}\right) \cdot \frac{MS_{(T,P,S)}}{100}\right) \cdot \left(\frac{Frac_{Leach,MS(T,P,S)}}{100}\right)\right)\right]\right] \quad (23)$$

Where:

$N_2O_{Leach,\ MM}$: indirect N_2O emissions due to leaching and runoff from Manure Management in the country, kg N_2O yr^{-1};

$N_{(T,P)}$: number of animals in growth stage T in feeding situation P, head;

$Nex_{(T,P)}$: annual average N excretion per head of animals in growth stage T in feeding situation P, kg N $head^{-1}$ yr^{-1};

$MS_{(T,\ P,\ S)}$: fraction of manure handled using different management system *S*, from animals in feeding situation P in growth stage T, %;

$Frac_{Leach,\ MS(T,P,S)}$: percent of managed manure nitrogen for animals in growth stage T that is leached from the manure management system *S*, %; This guide directly takes the IPCC default value of 30, but in provinces where evaporation is greater than precipitation, this value is 0. See Table 2-9 for details.

CHAPTER 3 DATA REQUIREMENTS, MONITORING , COLLECTION METHODS

1. STEPS TO DEFINE CATEGORIES AND SUBCATEGORIES OF LIVESTOCK

According to the 2006 IPCC Guidelines, taking into account the large population of swine and dairy cattle production in China, the differences in local varieties and production levels, and the variety of feed, the animals should be further classified into subcategories. According to the production characteristics of animal husbandry in China, animals are classified into three feed situations: intensive feeding, backyard feeding and grazing. The effects of different age / growth stages of animals on CH_4 emission from enteric fermentation, CH_4 and N_2O emissions from manure management systems are also considered.

1.1 FEEDING SITUATION CATEGORIES

Swine are divided into intensive feeding and backyard feeding. Dairy cattle are divided into intensive feeding, backyard feeding and grazing.

- Intensive feeding refers to individual farms (zones) where the stock of dairy cattle ≥ 100 head, or the annual amount of fattening pigs ≥ 500 head.
- Grazing refers to dairy cattle raised in 266 pastoral and semi-pastoral districts and counties in 13 provinces (autonomous regions) designated by the administrative ministries of China, excluding the intensive feeding cattle in those regions.
- Backyard feeding refers to livestock raised by a single family. In this guidance, farm with animal population which is smaller scale than the standard for intensive feeding, is included in backyard feeding.

1.2 GROWTH STAGE CATEGORIES

- Dairy cattle are divided into mature dairy cattle, calves and other cattle.
- Swine are divided into three feeding stages: nursery, growing-finishing(including boars), and sows

2. PARAMETERS THAT NEED TO BE COLLECTED

According to the methodology, the parameters that need to be collected to apply the Tier 2 method are shown in Table 3-1, including parameters on animal populations, production, feed, and manure management.

Table 3- 1 Technical definitions of activity data parameters

Number	Parameter	Units	Description / definition
1. livestock activity data			
1.1	Population	head	Annual average population in stock of each livestock sub-category.
1.2	Number of mature females	head	Annual average population of mature females.
1.3	Number of weaned piglets/calves	head	Annual average population of weaned piglets/calves.
1.4	Number of other livestock	head	Annual average population of other livestock not included in mature females and weaned piglets/calves .
1.5	Ratio of intensive feeding	%	Ratio of animal number in intensive feeding to total animal number
1.6	Ratio of backyard feeding	%	Ratio of animal number in backyard feeding to total animal number
1.7	Ratio of grazing	%	Ratio of animal number in grazing to total animal number
2. Production performance			
2.1	Body weight	kg	Average live weight of each animal sub-category (kg)
2.2	Mature females weight	kg	Average live weight of mature females (kg).
2.3	Birth weight	kg	Average live weight of birth (kg).
2.4	Weaning weight	kg	Average live weight of weaning (kg).
2.5	Other livestock weight	kg	Average live weight during growth(kg).
2.6	Weight gain	kg day^{-1}	Average daily weight gain (kg per day). May be applied only to growing animals.
2.7	Milk yield	kg day^{-1}	Annual average daily milk yield (kg per day). This is the average per calendar day, not per lactation day.

2.8	Fat content of milk	%	Average fat content of milk (%). Applied to lactating females only.
2.9	Protein content of milk	%	Average protein content of milk (%). Applied to lactating females only.
2.10	Fraction of mature females giving birth	%	Fraction of mature females giving birth in a calendar year. Applied to lactating females only.
2.11	Hours worked	hours day^{-1}	Annual average number of hours of work per day. Applied to mature cattle only.
3. Feed			
3.1	Feed digestibility	%	Digestible energy as a percent of gross energy (%). For further guidance see **错误!未找到引用源。**.
3.2	Crude protein content of the diet	%	Average crude protein content (%) of the diet.
3.3	Feed composition	%	Ratio of concentrate and roughage feed, including concentrate composition and roughage composition.
3.4	Feed intake	kg	Average daily feed intake of dairy cattle and swine at different growth stages.
4. Manure			
4.1	N excretion	kg	Refers to the annual nitrogen excretion of swine or dairy cattle
4.2	VS production	kg	Refers to the annual VS production from manure of swine and dairy cattle
4.3	Fraction of manure managed in different systems	%	Fraction of manure from each type of livestock managed in different manure management system in different regions. See Table 3-2 for definitions of manure management systems.

Table 3- 2 Definitions of manure management systems

System	Definition
Pasture/Range/Paddock	The manure from pasture and range grazing animals is allowed to lie as deposited, and is not managed.

Daily spread		Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.
Solid storage	Solid storage	The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation. Solid stores can be covered or compacted. In some cases, bulking agent or additives are added.
	Covered/compacted	Similar to solid storage, but the manure pile is a) covered with a plastic sheet to reduce the surface of manure exposed to air and/or b) compacted to increase the density and reduce the free air space within the material.
	Bulking agent addition	Specific materials (bulking agents) are mixed with the manure to provide structural support. This allows the natural aeration of the pile, thus enhancing decomposition. (e.g. sawdust, straw, coffee husks, maize stover)
	Additives	The addition of specific substances to the pile in order to reduce gaseous emissions. Addition of certain compounds such as attapulgite, dicyandiamide or mature compost have shown to reduce N_2O emissions; while phosphonyls reduce CH_4 emissions
Dry lot		A paved or unpaved open confinement area without any significant vegetative cover. Dry lots do not require the addition of bedding to control moisture. Manure may be removed periodically and spread on fields.
Liquid/Slurry		Manure is stored as excreted or with some minimal addition of water or bedding material in tanks or ponds outside the animal housing. Manure is removed and spread on fields once or more in a calendar year. Manure is agitated before removal from the tank/ponds to ensure that most of the VS are removed from the tank.
Pit storage below animal confinements		Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods less than one year. Manure may be pumped out of the storage to a secondary storage tank multiple times in one year, or stored and applied

		directly to fields. It is assumed that VS removal rates on tank emptying are >90%.
Anaerobic digester		Animal manure with and without straw are collected and anaerobically digested in a containment vessel.
Burned for fuel		The dung and urine are excreted on fields. The sun dried dung cakes are burned for fuel.
Deep bedding		As manure accumulates, bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months. This manure management system also is known as a bedded pack manure management system and may be combined with a dry lot or pasture. Manure may undergo periods where animals are present and are actively mixing the manure, or periods in which the pack is undisturbed.
Composting	In-vessel	Composting, typically in an enclosed channel, with forced aeration and continuous mixing.
	Static pile	Composting in piles with forced aeration but no mixing, with runoff/leaching containment.
		Composting in piles with forced aeration but no mixing, without runoff/leaching containment.
	Intensive windrow	Composting in windrows with regular (at least daily) turning for mixing and aeration, runoff/leaching containment
		Composting in windrows with regular (at least daily) turning for mixing and aeration, no runoff/leaching containment
	Composting - Passive windrow	Composting in windrows with infrequent turning for mixing and aeration, with runoff/leaching.
		Composting in windrows with infrequent turning for mixing and aeration, no runoff/leaching.
Poultry manure with litter		Similar to cattle and swine deep bedding except usually not combined with a dry lot or pasture. Typically used for all poultry breeder flocks, for alternative systems for layers and for the production of meat type chickens (broilers) and other fowl. Litter and manure are left in place with added bedding

	during the poultry production cycle and cleaned between poultry cycles, typically 5 to 9 weeks in productive systems and greater in lower productivity systems.
Uncovered anaerobic lagoon	A type of liquid storage system designed and operated to combine waste stabilization and storage. Lagoons have a lower depth and a much larger surface compared to liquid slurry stores. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The supernatant water from the lagoon may be recycled as flush water or used to irrigate and fertilise fields.
Aerobic treatment	The biological oxidation of manure collected as a liquid with either forced or natural aeration. Natural aeration is limited to aerobic and facultative ponds and wetland systems and is due primarily to photosynthesis. Hence, these systems typically become anoxic during periods without sunlight.
Other	Refers to manure management systems that are not included in the above-mentioned systems.

3. COLLECTION OF ACTIVITY DATA

The activity data (i.e. annual number of livestock) used in the provincial livestock GHG emission inventory mainly comes from the livestock statistical data in the Provincial Statistical Yearbook and statistical data on animal industry at provincial level. The year-end stock of swine and dairy cattle need to be compared with the data in the Yearbook of Animal Husbandry and Veterinary Medicine in China for the same year. The major sources of livestock activity are listed in Table 3-3.

Table 3- 3 Major sources of livestock activity data

Source of livestock activity data	Description
China Statistical Yearbook	• Number of head of dairy cattle, swine and other livestock at the end of the year at national level
China Animal Husbandry and Veterinary Medicine Yearbook / China Animal Husbandry Yearbook	• Number of head of dairy cattle, swine and other livestock at the end of the year at provincial level • Number of head of dairy cattle and other livestock at the end of the year in pastoral and semi-pastoral areas
Provincial Statistical Yearbook	• Number of head of dairy cattle, swine and other livestock in counties and cities of the inventory provinces
Statistical data of animal industry at provincial level	• The proportion of dairy cattle, swine and other livestock at different growth stage • The proportion of dairy cattle, swine and other livestock raised in farms of different scale
Nationally/Provinces representative agriculture survey	• Number of head of dairy cattle, swine and other livestock at the end of the year at provincial level • The proportion of dairy cattle, swine and other livestock raised in farms of different scale
Nationally/Provinces representative pollution survey	• Number of head of dairy cattle, swine and other livestock at the end of the year at provincial level • The proportion of dairy cattle, swine and other livestock raised in farms of different scale
Direct collecting and direct reporting system	• Number of head of dairy cattle, swine and other livestock at the end of the year at national, provinces, cities and counties level • Number of head of dairy cattle, swine and other livestock raised in backyard at the end of the year at national, provinces, cities and counties level • Proportion of manure utilization from large-scale dairy cattle, pig and

	other livestock farms in intensive feeding system at national, provincial, cities and counties level • Data on average milk yield of large-scale dairy cattle in intensive feeding system at national, provincial, cities and counties level
Expert opinion	• Proportion of manure utilization from large-scale dairy cattle, swine and other livestock farms in intensive feeding system at national, provincial, cities and counties level

The activity data on dairy cattle and swine needed are the annual average number of livestock in different feeding situations and growth stages. The calculation methods are as follows:

1） Estimation of Year-end population in stock of dairy cattle and swine

The year-end population in stock of dairy cattle and swine may directly use the year-end population data provided in the Provincial Statistical Yearbook of the given inventory year. If no year-end population data are available, the activity data should be obtained by referring to the China Statistical Yearbook or the China Animal Husbandry and Veterinary Medicine Yearbook for the given inventory year.

2）Estimation of Year-end population in stock in different feeding situations

- **Dairy cattle population in grazing system**

If the statistical data on the dairy cattle population in grazing system in a province are available, inventory compilers can directly use the statistics to obtain an estimate of the population of grazing dairy cattle. If not, the population in stock of grazing dairy cattle can be estimated by subtracting the number of dairy cattle in intensive feeding from the total number of dairy cattle raised in the corresponding pastoral and semi-pastoral areas. The number of livestock raised in pastoral and semi-pastoral areas can be obtained from the China Animal Husbandry and Veterinary Medicine Yearbook for the given inventory year, and the corresponding data on dairy cattle in intensive feeding comes from the Direct Collecting and Direct Reporting System.

- **Dairy cattle population in intensive feeding stock**

The population in stock of dairy cattle in intensive feeding stock = (the total population in stock of dairy cattle –population in stock of dairy cattle in grazing system) ×the ratio of dairy cattle raised in intensive feeding system, which is provided by the statistical data on animal industry in the province (county);

The population in stock of swine in intensive feeding = the population in stock of swine × the population ratio of swine raised in intensive feeding, which is provided by the statistical data on animal industry in the province (county).

- **Dairy cattle population in backyard feeding system**

Population in stock of dairy cattle in backyard feeding system = total population in stock of dairy cattle – population in stock of dairy cattle in intensive feeding stock – population in stock of dairy cattle in grazing system

Population in stock of swine in backyard feeding system = total population in stocks of swine – Population in stock of swine in intensive feeding system

3）Estimation of Year-end population in stock of different growth stages

Year-end population in stocks of dairy cattle or swine in different feeding situations and growth stages = year-end population in stock of different feeding situations× the ratio of livestock populations in different growth stages. The ratio values in different growth stages are provided in statistical data on herd structure.

4）Estimating annual average populations for growing populations which are alive for less than one year

In addition to calculating the annual average populations according to the above method, estimating annual average populations for growing populations requires more evaluation. Most animals in growing populations are alive for only part of a complete year. Animals should be included in the populations regardless of whether they were slaughtered for human consumption or died of natural causes. Equation 18 estimates the annual average livestock population.

$$\mathbf{N = Days\_alive \cdot \frac{\textit{NAPA}}{365}} \quad (9)$$

Where:

N : annual average population, head;

NAPA : number of animals produced annually, head;

$Days_{\_alive}$: alive days, day.

4. THE DATA COLLECTION OF RELATED PARAMETERS FOR EMISSION FACTORS

Three classes of key parameters are needed to calculate the emission factors of GHG emissions, including CH_4 emissions from enteric fermentation, CH_4 and N_2O emissions from manure management. The collection methods for these parameters are listed in Table 3-4 to Table 3-6.

Table 3- 4 Animal production data , data sources and collection

	Parameters	Unit	China Statistical Yearbook	Statistical data of animal industry	Data of Industry Association	Typical survey	Data from Literature	Default of National inventory	IPCC default	Field / laboratory measures
2.1	Body	head			√	√	√	√		√

	weight									
2.2	Body weight of Mature females	kg			√	√	√	√		√
2.3	Body weight at birth	kg			√	√	√	√		√
2.4	Body weight at weaning	kg			√	√	√	√		√
2.5	Body weight of other livestock	kg			√	√	√	√		√
2.6	Weight gain	$kg\ day^{-1}$			√	√	√	√		√
2.7	Milk yield	$kg\ day^{-1}$	√	√	√	√	√	√		√
2.8	Fat content of milk	%	√	√	√	√	√	√		√
2.9	Protein content of milk	%	√	√	√	√	√	√		√
2.10	Fraction of adult females giving birth	%	√	√	√	√	√	√		√
2.11	Hours worked	$Hours\ day^{-1}$				√	√	√		√

Table 3- 5 Feed data, data sources and collection

	Parameters	Unit	China Statistical Yearbook	Statistical data of animal industr	Data of Industry Association	Typical survey	Data from Literature	Default of National invento	IPCC default	Field / laboratory measures

				y				ry		
3. 1	Feed digestibility	%		√	√	√	√	√	√	√
3. 2	Crude protein content of the diet	%			√	√	√	√		√
3. 3	Feed composition	%			√	√	√	√		√
3. 4	Feed intake	kg			√	√	√	√		√

Table 3- 6 Manure data, data sources and collection

	Parameters	Unit	China Statistical Yearbook	Statistical data of animal industry	Data of Industry Association	Typical survey	Data from Literature	Default of National inventory	IPCC default	Field / laboratory measures
4.1	N excretion	kg	√	√	√	√	√	√	√	√
4.2	VS production	kg	√	√	√	√	√	√	√	√
4.3	Fraction of manure managed in different systems	%	√	√	√	√		√		

For animal production and feed data, considering the general parameters in the current statistical yearbook, it is recommended that the data of relevant industry associations be consulted first. On the basis of confirming that there is no industry association data, typical surveys, literature data, default of national inventory or default values of the IPCC guidelines should be adopted.

For livestock manure characteristics data, in addition to the above methods, it can also use the national direct reporting system or pollution census data.

The order of priority for collecting the three classes of parameters is as follows: Typical surveys/measurement > Literature data > Default values in national inventories > Default values in 2006 IPCC Guidelines.

4.1 TYPICAL SURVEY

Typical survey refers to obtain relevant data based on field questionnaires for key parameters, the selected farms for survey should be representative of common practice of animal production in the typical counties in the provinces. General requirements for the typical survey are as following:

1) Sample surveys should be conducted in at least five counties in each province; The characteristic parameters of intensive feeding system and backyard feeding system should investigated in selected each county, respectively.

2) The proportion of sample dairy cattle or swine farms surveyed in intensive feeding system in each county should be not less than 1% of the total, and the number of farms surveyed is not less than 10..

3) The proportion of sample dairy cattle or swine farms surveyed in backyard feeding system should be not less than one thousandth of the total, and the number of swine or dairy cattle farmers surveyed should be not less than 10.

4) Fill in Annex Tables A1-1 to A1-4 for questionnaires of the survey.

4.2 LITERATURE DATA

In the case that the relevant parameters of typical surveys cannot be obtained, inventory compilation agencies may consult domestic and foreign literature, selecting the relevant parameters of the province or neighboring provinces which have been reported in the literature. These parameters include growth performance, feed characteristics, manure management systems and their proportions, etc. Literature data need to be screened to ensure that they basically reflect the typical production situation of local dairy cattle or swine production. The original literature of the values selected should be attached to the inventory report.

4.3 DEFAULT VALUES IN NATIONAL INVENTORIES

In the case that above two methods cannot provide the relevant parameters, inventory compilation agencies can choose the characteristic parameters selected in the Report of China's National Livestock GHG Inventory for the relevant year, and select the relevant characteristic parameters of the region in which the province is located.

4.4 DEFAULT VALUES IN 2006 IPCC GUIDELINES

In the case that the relevant parameters cannot be obtained from the national inventories, inventory compilation agencies can select the default values of production characteristics, feed characteristics and N excretion characteristics provided in the 2006 IPCC Guidelines. In choosing characteristic parameters, priority should be given to the recommended parameters for developing countries and the Asia region, and at the same time, a comparison of their production performance with provincial data should be made, such

as milk yield of dairy cattle. In recent years, domestic dairy cattle are mainly imported foreign varieties, with milk yield per head is much higher than 1650 kg/head. When choosing the parameters, inventory compilation agencies can choose the characteristic parameters whose average yield per head is close to that in the province.

5. QUESTIONNAIRE FOR CHARACTERISTIC PARAMETERS

In order to better reflect the actual production and management situation of the province, it is suggested that inventory compilation agencies conduct typical surveys to obtain localized characteristic parameters. This guidance has formulated questionnaires on characteristic parameters, including animal population structure questionnaire, dairy cattle and swine production characteristic parameter questionnaire, and animal manure management questionnaire. Detailed tables can be found in Annex Tables A1-1 to A1-4.

CHAPTER 4 REPORT ON PROVINCIAL GHG INVENTORIES FOR DAIRY CATTLE AND SWINE

The provincial GHG inventory report includes two parts, one is the inventory report, and the other is the inventory report form. The requirements and templates for the inventory compilation report and form are as follows.

1. REQUIREMENTS FOR INVENTORY REPORTING

The inventory compilation report includes summary, overview, institutional arrangement, description of the measurement and accounting process of three types of emissions (CH_4 emission from enteric fermentation, CH_4 and N_2O emission from manure management systems), uncertainty assessment, detailed description of the verification process for quality assurance and quality control.

1.1 ABSTRACT

Brief introduce the sources, applied methodology, emissions, reported forms , and uncertainty of GHG inventory from livestock sector in province .

1.2 OVERVIEW

Describe basic information of provincial GHG inventory from livestock sector, including applied guideline, reporting scope and GHG, sources of activity data, sources of emission factors and parameters, GHG emissions, uncertainty, and verification process.

1.3 INVENTORY COMPILATION AGENCY

This part should include the information on coordinating body, inventory compilation institutions, data providers and the division of tasks, verification process of quality control and quality assurance.

1.4 DESCRIPTION OF METHODS APPLIED IN GHG INVENTORY

Inventory compilation agencies should describe the methods used to calculate CH_4 emissions from enteric fermentation, CH_4 and N_2O emissions from manure management, Provide the basic contents and equations of the methods applied for each emission source, as well as default values used in each method or equation.

1.5 DESCRIPTION OF ACTIVITY DATA AND DATA SOURCES

Inventory compilation agencies should describe the activity data and its sources, including the year-end population of livestock in the reporting year, and the fraction of animals in different feeding situations and different growth stages. The comparison between the activity data in the provincial inventory and data in China's Animal Husbandry and Veterinary Yearbook and China Statistical Yearbook for the inventory year, and analysis of reasons for any differences should be described.

1.6 DESCRIPTION OF EMISSION FACTORS AND DATA SOURCES

Inventory compilation agencies should report the calculation process for emission factors, values and data sources of each relevant parameters, including feed intake for each livestock categories, dry matter intake , feed digestibility, manure management systems and their proportions of use, the climatic zone and temperature, etc. Inventory compilation agencies should describe the selection and reason of emission factors for different sources if the emission factors or relevant parameters are selected from this guidance.

1.7 GHG EMISSIONS OF LIVESTOCK

Total GHG emissions from livestock in the reporting year should be reported in the unit of carbon dioxide equivalent. The CH_4 emissions from enteric fermentation, CH_4 emissions from manure management, and N_2O emissions from manure management should be reported in their respective units.

1.8 UNCERTAINTY ASSESSMENT

The uncertainty of CH_4 emissions from enteric fermentation, CH_4 and N_2O emissions from manure management should be calculated and reported according the method recommend of IPCC guideline, respectively. The overall uncertainties of livestock emissions should be reported based on the emissions and uncertainties of different emission sources.

1.9 VERFICATION OF QUALITY CONTROL OF INVENTORY

The process, methods and contents of quality control and verification inside and outside the inventory compilation agencies should be reported.

2 TEMPLATE FOR PROVINCIAL INVENTORY REPORT

2.0 ABSTRACT

The GHG inventory of livestock sector in province includes the CH_4 emission from enteric fermentation, CH4 and N_2O emission from manure management systems, and related uncertainty assessments. In order to ensure the transparency, consistency, comparability, completeness and accuracy of the inventory, the inventory compilation agency calculated livestock GHG emissions in according to Provincial Guidance for Measurement, Reporting and Verification of GHG Inventories , and fill in the relevant report forms as shown in Table 4-1 to Table 4-7 for details. The GHG emissions in 20XX are XXX tons of carbon dioxide equivalent, and the uncertainty of GHG emissions in 20XX husbandry is XX%.

2.1 OVERVIEW

(1) Guideline: Provincial Guidance for Measurement, Reporting and Verification of GHG Inventories:

(2) Emission sources:

(3) Data collection and parameter survey:

(4) Emission of GHG:

(5) Uncertainty:

(6) Brief description of the verification process:

2.2 INVENTORY COMPILATION AGENCY ARRANGEMENT

2.3 MEASUREMENT AND CALCULATION OF CH_4 EMISSIONS FROM ENTERIC FERMENTATION

2.3.1 Activity data

2.3.2 Monitoring and calculation of emission factors and key parameters

2.3.2.1 Gross energy in feed intake (GE)

2.3.2.2 CH_4 conversion factor (Y_m)

2.3.2.3 CH_4 emission factor

2.3.3 Estimation of CH_4 emissions from enteric fermentation

2.4 MEASUREMENT AND CALCULATION OF CH_4 EMISSIONS FROM MANURE MANAGEMENT

2.4.1 Activity data

2.4.2 Monitoring and calculation of emission factors and key parameters

2.4.2.1 Calculation of volatile solids excreted in manure (VS)

2.4.2.2 Determination of CH_4 production capacity for manure (B_0)

2.4.2.3 Determination of the proportion of manure management systems

2.4.2.4 CH_4 emission factor for manure management systems

2.4.3 Estimation of CH_4 emission in manure management systems

2.5 MEASUREMENT AND CALCULATION OF N_2O EMISSIONS FROM MANURE MANAGEMENT OF DAIRY COWS

2.5.1 Activity data

2.5.2 Monitoring and calculation of direct N_2O emission factors for manure management systems

2.5.2.1 Determination of the proportion of manure management systems

2.5.2.2 Determination of Nitrogen Excretion of animal in different growth stage

2.5.2.3 Direct N_2O emission factor for manure management systems

2.5.3 Estimation of direct N_2O emission in manure management systems

2.5.4 Monitoring and calculation of indirect N_2O emission factors for manure management systems

2.5.5 Estimation of indirect N_2O emission in manure management systems

2.5.6 Calculation of total N_2O emission

2.6 PROVINCIAL GHGES EMISSION

2.7 UNCERTAINTY ANALYSIS

2.8 VERFICATION OF GHG INVENTORY

2.9 INVENTORY REPORT FORM (SEE TABLES 4-1 TO 4-7)

2.10 APPENDIX

Project Leader(sign):

Inventory compilation agency（seal）

Date:

Table 4- 1 Summary of GHG emissions from dairy cows or swine

source categories	CH_4 emissions (ton)	N_2O emissions (ton)	Emissions (ton CO_2e)
CH_4 emissions from enteric fermentation		______	
CH_4 emissions from manure management		______	
N_2O emissions from manure management	______		
Total			

Table 4- 2 Major livestock activity data in feeding situations and in different growth stages

Livestock	Feed situation	population in stock at the end of the year (10^4 heads)	Proportion of different growth stages		
			Calf/Nursery	other cattle /growing-Finishing	Mature dairy cattle cows/Sow
Dairy cattle	Intensive feeding				
	Backyard feeding				
	Grazing				
	Total				
Swine	Intensive feeding				
	Backyard feeding				
	Total				

Table 4- 3 Activity data and key parameters for determination of CH_4 emissions from enteric fermentation of dairy cattle

Feeding situation	Growth stages	population in stock at the end of the year (ten thousand heads)	Average gross energy intake（MJ/head/day)	Average CH_4 conversion factors（Ym）%	CH_4 emission factors ($kgCH_4$/head/day)	CH_4 emissions（ten thousand ton）
Intensive	Calf					
	Other cattle					
	Mature dairy cow					
Backyard	Calf					
	Other cattle					
	Mature dairy cow					
Grazing	Calf					
	Other cattle					
	Mature dairy cow					

Table 4- 4 Data for determining CH_4 emission factors from enteric fermentation of dairy cattle

Feeding situation	Growth stages	**Weight (kg)**	**weight gain (kg/d)**	**Milk (kg/d)**	**Fat(%)**	**Work (hr/d)**	**pregnant (%)**	**Feed intake (kg dm/d)**	**Feed digestibility (%)**	**Gross Energy intake (MJ/head/year)**	**CH_4 emission factors (kg CH_4/head/year)**
Intensive	Calf										
	Other cattle										
	Mature dairy cow										
Backyard	Calf										
	Other cattle										
	Mature dairy cow										
Grazing	Calf										
	Other cattle										
	Mature dairy cow										

Table 4- 5 Activity data and key parameters for determining CH_4 emission from manure management

Livestock	Growth situation	Feeding stages	population at the end of the year (ten thousand heads)	Ratio of climaticzones(%)			Average annual temperature (℃)	Average animal weight (kg)	Average VS excretion (kg DM/head/day)	Average maximum CH_4 producing capacity (B_0)(m^3CH_4/kg VS)	CH_4 emission factors (kgCH_4/head/day)	CH_4 emissions (ten thousand ton)
				Cool	Temperate	Warm						
Dairy cattle	Intensive	Calf										
		Other cattle										
		Mature dairy cow										
	Backyard	Calf										
		Other cattle										
		Mature dairy cow										
	Grazing	Calf										
		Other cattle										
		Mature dairy cow										
Swine	Intensive	Nursery										
		Finishing										
		Breeding sows										
	Backyard	Nursery										
		Finishing										
		Breeding sows										

Table 4- 6 Manure management systems and corresponding CH_4 conversion factor (%)

Animal category	Feeding situation	Psature /Range /Paddock	Daily spread	Burned for fuel	Solid storage	Dry lot	Composting	Deep bedding	Pit storage	Liquid storage	Lagoon	biogas digester	Aerobic treatment	Other
Dairy cattle	Intensive													
	Backyard													
	Grazing													
	MCF （%）													
Swine	Intensive													
	Backyard													
	MCF （%）													

Table 4- 7 Parameters related to dairy cattle and swine manure management and N_2O emissions

Animal category	Feeding situation	Growth stages	popolation (ten thousand heads)	body weight (kg)	N excretion rate (kg/head/year)	Nitrogen content in different manure management systems (kg N/year)													Total N (kg N/year)	Total amount of volatilized ammonia (kg N/year)	Total amount of leaching and runoff nitrogen (kg N/year)	Emission factors			Emissions (t N_2O)		
						Pasture/Range/Paddock	Daily spread	Burned for fuel	Solid storage	Dry lot	Composting	Deep bedding	Pit storage	Liquid storage	Lagoon	Biogas digester	Aerobic treatment	Other				Direct emissions (kg N_2O/head/year)	N deposition (kg N_2O-N/kg N)	Runoff and leakage (kg N_2O-N/kg N)	Direct emissions	N deposition	Runoff and leaching
Dairy cows	Intensive	Calves																									
		other cattle																									
		mature dairy cow																									
	Backyard	Calves																									
		other cattle																									
		mature dairy cattle																									
	Grazing	Calves																									
		other cattle																									
		mature dairy cow																									
Swine	Intensive	Nursery																									
		Finishing																									
		Breeding sows																									
	Backyard	Nursery																									
		Finishing																									
		Breeding sows																									
Total nitrogen in manure management systems (kg N/year)																											
Direct emission factors EF_3(kg N_2O-N/kg N)																											
EF_4（%）																											
EF_5（%）																											
The amount of direct emissions（kgN_2O)																											

The amount of indirect emissions （kg N_2O）																						

CHAPTER 5 PROVINCIAL GUIDANCE FOR VERIFICATION OF GHG INVENTORIES

1. OUTLINE

GHG inventories are the basis for estimating emissions and identify mitigation measures. In order to ensure transparency, accuracy, consistency, comparability, and completeness (TACCC) of the inventory, the coordinating authority and the authority of inventory compilation agency will require the verification of the inventory through the establishment and implementation of quality control and quality assurance system.

2. VERFICATION OF QUALITY CONTROL AND QUALITY ASSURANCE

Quality Control and Quality Assurance (QC/QA) are important to ensure the quality and the accuracy of reported GHG inventory. Quality control (QC) and quality assurance (QA) measures can improve the quality of the whole process of data collection, accounting, measurement, reporting and verification， enhance the effective connection with the statistical office , and other the relevant national agencies, and guide the invited experts to conduct consultation and inspection. Development of a QC/QA plan for livestock GHG inventory can improve the transparency, consistency, comparability, and completeness, and accuracy of emission estimates.

2.1 QUALITY CONTROL

Quality control refers to the self-inspection of report quality on the GHG inventory by the inventory compilation agency, including whether the calculation formulas are from the MRV guidance for livestock sector? Are activity data sources description clear and consistent across emission sources? Are emission factors and related key parameters obtained in accordance with MRV guidance, are the values of relevant parameters consistent for each emission source? Were the calculations correctly implemented in accordance with these guidance? Whether the report format is correct, whether the report content and emission source are complete and transparent, and whether calculated variables have been accurately and completely recorded in the report?

2.2 QUALITY ASSURANCE

The inventory compiling agency should invite national or international experts to review emissions calculation and reporting. The inventory compiling agency should provide provincial inventory report, reporting forms and calculation sheets for GHG emission, etc. External review should review whether format of provincial inventory report follows the MRV guidance for GHG inventory; whether provincial inventory report are transparent and complete; whether the activity data is correct and consistent, whether the activity data is consistent with data from the country's existing statistics, national direct report, and the consistency of animal number between different sources; whether the calculation of emission factors is transparent, whether the key parameter values are reasonable, the correctness of calculation results, etc. Are

the calculated emission factors comparable to IPCC defaults, national inventory data, factors of other provinces inventory, values reported in previous year?

The internal quality control and external expert review of the inventory report can be implemented based on checklist of verification for GHG inventory to improve the quality of the inventory, see Table 5-1.

Table 5- 1 Checklist of Verification for GHG inventory

NUMBER	VERIFIED CONTENT	DETAILED LIST OF VERIFICATION	CONCLUSION OF VERIFICATION	COMMENTS / SUGGESTIONS	STATUS ON IMPROVE OR MODIFICATION
1. METHODOLOGICAL CHOICE					
1.1	Methodological choice	● Whether according to the methodology of the MRV guidelines?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Are the level of the methodology applied for CH_4 emissions from enteric fermentation appropriate?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Are the level of the methodology applied for CH4 from manure management CH_4 appropriate?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Are the level of the methodology applied for N_2O emissions from manure management appropriate?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
2. ACTIVITY DATA					
2.1	The source of activity data	● Is the animal population data source clearly described?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Is the population data correct?	Yes ☐	comments:	Solved ☐

			No ☐ issues:		Partly ☐ Unsolved ☐
2.2	Detailed classification description and animal population data	● Have the detailed livestock categories/subcategories classification data and reasons been transparently documented?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● whether the detailed animal feeding situation in accordance with the classification of MRV guidance? Is there a evidences for detailed classification of grazing and backyard feeding situation , and is it correct?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Is the animal growth stage classification appropriate?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Is the method of obtaining data on animal population of detailed classification correct?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
2.3	Calculation of animal population in stock based on numbers of animal produced	If the stocks is calculated based on the output, ● Are the calculation methods of animal population in stock clearly described? ● Are numbers of animal produced correct? ● Are the hypothesis of alive of animals days appropriate?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
2.4	Cross-checking of animal population in stock	● Are of total animal population in stock of the livestock categories/subcategories equal to the total amount of livestock population?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Are animal population among each emission sources consistent?	Yes ☐ No ☐	comments:	Solved ☐ Partly ☐

			issues：		Unsolved ☐
		● Are the activity data comparable to previous years？ ● Are there detailed explanation in inventory if there is a significant change?	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
		● Are animal population data comparable with that in China Statistical Yearbook, Yearbook of Animal Husbandry and Veterinary in China, Statistical Yearbook of Provincial, Statistical Yearbook of County , and Statistical Yearbook of City?	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
3. EMISSION FACTORS					
3.1	Implied emission factor（IEF ）	● Are the estimated implied emission factors of CH_4 from enteric fermentation comparable with the default values of IPCC, the values of the national inventory and inventories of other provinces？	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
		● Are the estimated implied emission factors of CH_4 from manure management comparable with the default values of IPCC, the values of the national inventory and inventories of other provinces？	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
		● Are the estimated implied emission factors of N_2O from dairy cows and swine manure management comparable with the default values of IPCC, the values of the national inventory and inventories of other provinces？	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
3.2	Calculation method of CH_4 emission	● Does the calculation equations and units of net energy to determine maintenance, net energy for activity, net	Yes ☐ No ☐	comments：	Solved ☐ Partly ☐

	factors from enteric fermentation	energy for growth, net energy for lactation, net energy for work, net energy for pregnancy correctly be applied? are the ratio of net energy for maintenance to digestible energy in a diet, ratio of net energy for growth to digestible energy in a diet, gross energy, emission factors, etc. correctly applied ?	issues:		Unsolved ☐
		● Does the evidences be provided to identify the parameters for calculating net energy for maintenance, net energy for activity, net energy for growth, net energy for lactation, net energy for work, net energy for pregnancy. is there description of the selection of parameters for ratio of net energy for maintenance to digestible energy in a diet, ratio of net energy for growth to digestible energy in a diet, gross energy, emission factors?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
3.3	Method of obtaining key parameters to determine CH_4 emission factors from enteric fermentation	● Have the characteristics on animal production and feed applied in the calculation of CH_4 emission factors been clearly described, such as dairy cows weight, mature dairy weight, weight gain per day, feed intake, feed digestibility, milk production etc?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Are the survey methods clearly described if the characteristics on animal production and feed are obtained through the survey? ● Have the representativeness of survey methods and results been demonstrated?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● If the characteristics on animal production and feed are obtained through the literature, have the references been provided?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐

		● Have the representativeness and applicability of the literature results been demonstrated?			
3.4	The comparability of key parameters to determine CH_4 emission factors form enteric fermentation	● Are the parameters such as dairy cattle weight, mature dairy weight, feed intake, weight gain per day, milk production, feed consumption, feed digestibility comparable with the default values of IPCC Guidelines, values applied in national inventory and other similar provinces?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Whether the calculated results of net energy for maintenance, net energy for activity, net energy for growth, net energy for lactation, net energy for work, the ratio of net energy for maintenance to digestible energy in a diet, the ratio of net energy for growth to digestible energy in a diet, gross energy, emission factors, are comparable with the default values of IPCC Guidelines, values applied in national inventory and other similar provinces?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Are the milk yield per lactating dairy cows comparable with that of FAO, national statistical yearbook and other data?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
3.5	Calculation methods of CH_4 emission factors from manure management	● Does the equations and unit of volatile solid excretion and emission factor correctly be applied?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Does the evidences be provided to identify the parameters in the formula of volatile solid excretion and emission factors?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐

		● Are the values of gross energy intake and feed digestibility of dairy cows used in calculation of CH_4 emission factors from enteric fermentation and manure management consistent?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
3.6	Methods of obtaining key parameters to determine CH_4 emission factors of manure management	● Have the classification and description of manure management systems been clear and correct?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Are the survey methods on the usage of different manure management systems clearly described?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Are the data on the usage of different manure management systems comparable to that in the national guidance, neighboring provinces, IPCC defaults, Nationally/Provinces representative pollution survey, direct collecting and Direct reporting system?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Are the survey methods and values of local temperature clearly described?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
3.7	Method for obtaining key parameters to determine CH4 emission factor of manure management	● Are the values of volatile solid content comparable to IPCC defaults, applied values in national inventory and other province?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Are values of CH_4 potential comparable to IPCC defaults, applied values in national inventory and other province?	Yes ☐ No ☐ issues:	comments:	Solved ☐ Partly ☐ Unsolved ☐
		● Are values of CH_4 conversion coefficients comparable to IPCC defaults, applied values in national inventory and other	Yes ☐ No ☐	comments:	Solved ☐ Partly ☐

		province?	issues：		Unsolved ☐
3.8	Calculation method of N2O emission factor from manure management	● Are the calculation equations and unit to determine the direct and indirect N_2O emission from manure management correctly applied?	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
		● Are the calculation equations and unit to determine manure nitrogen excretion, volatile nitrogen, runoff and leaching nitrogen correctly applied ?	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
		● Does the evidences be provided to identify direct and indirect N_2O emission factors from manure management?	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
		● Have the nitrogen excretion, methods and data sources for determining various coefficients been clearly described?	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
		● Are the nitrogen excretion, coefficients of direct emissions and indirect emissions comparable to IPCC default values and related literature data?	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
		● Are the fraction of manure management systems used to calculate the direct N_2O emission from manure management consistent with that used to calculate CH_4 emissions from enteric fermentation?	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
4. EMISSION CALCULATION					
4.1	emission calculation	● Are the emissions calculation repeatable and correct?	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
4.2	Uncertainty	● Have uncertainties been reported? ● Is the uncertainty calculation method	Yes ☐	comments：	Solved ☐

	analysis	appropriate?	No ☐		Partly ☐
		● Have the data source and evidence to determine the parameters for the calculation of uncertainty been clearly described?	issues：		Unsolved ☐
5. Reporting on GHG emissions					
5.1	Reporting on GHG emissions	● Have the reports been compiled in line with the requirements of MRV Guidance？ ● Have the emission sources been fully reported？	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐
5.2	General report form（Excel）	● Are the date in reporting forms consistent with the inventory reporting data？ ● Have the data unreported been noted?	Yes ☐ No ☐ issues：	comments：	Solved ☐ Partly ☐ Unsolved ☐

CHAPTER 6 INSTITUTIONAL ARRANGEMENTS FOR INVENTORY COMPILATION

Suitable institutional arrangements are one of the key factors in determining a GHG inventory's monitoring, reporting and verification capabilities. This may involve, if appropriate, building on existing institutions and/ or establishing new arrangements, and may also require a transition from temporary operations to more permanent institutional arrangements to facilitate a sustained operation of GHG compilation teams to enhance the quality of inventory .

The Chinese government attaches great importance to the institutional arrangements for addressing climate change. China has built institutional frameworks for addressing climate change on national, local and relevant departmental levels, and is constantly improving according to needs from daily work.

Preparing and submitting National Communications and Biennial Update Reports, including National GHG Inventories, is a continuous, deepening task requirement. The Chinese government has established a national system for the preparation and reporting of National Communications on Climate Change and formed a relatively stable team for the preparation of National GHG Inventories, National Communications on Climate Change and Biennial Update Reports. The Institute of Environmental and Sustainable Development in Agriculture (IEDA), Chinese Academy of Agriculture Sciences (CAAS) is responsible for the GHG inventory of livestock sector

With the deepening of the work on climate change, the work plan for controlling GHG emissions in the 12th five-year plan and the 13th five-year plan clearly put forward the "regular compilation of provincial-level GHG inventories". China's Development and Reform Commission issued the "Notice on issuance of provincial GHG inventory compilation guidelines (trial)" in 2011, and the "Notice on the compilation of provincial GHG inventory next stage" in 2015. As of 2019, 31 provinces, municipalities and Xinjiang Construction Corps nationwide have initially established provincial inventory compilation teams and compiled provincial inventory of different frequencies and years.

The GHG inventory from livestock sector is the core of the provincial inventory, in order to further strengthen the capacity building of the provincial inventory preparation team, it is suggested to set up a livestock inventory preparation institution and formulate a plan for the inventory preparation process. This guidance proposes the following requirements for the compilation system and arrangement of provincial GHG inventory from livestock sector.

1. ESTABLISHMENT OF THE PROVINCE INVENTORY SYSTEM ON LIVESTOCK SECTOR

Inventory compilation is a systematic program. In order to have high-quality GHG inventory of livestock sector, it is recommended that provincial inventory system should consist of coordinating agencies, steering committees and inventory compilation team.

Provincial coordinating agencies: the environmental protection bureau or the provincial climate change leadership office is generally responsible for climate change issues. Make clear the preparation arrangement of the inventory, including responsibilities and obligations of each ministries, time line, set up

inventory compilation team , and invite the experts formulation of Steering committee , check progress regularly, carry out internal review and approval, and submit the inventory to the national coordinating agencies on climate change .

Provincial Steering committee: committee members include official of environmental protection, statistics, agriculture, finance, experts from university and research organizations. The steering committee is responsible for determining the inventory compilation team, and coordinating access to the data sources, providing overall guidance to the inventory compilation process, determining the inventory improvement plan, organizing expert review and approving the inventory report.

Provincial inventory compilation team : it is suggested that the provincial animal husbandry extension station takes the lead, and collaborates with the provincial statistical department and institute on agriculture research. The inventory compilation team is responsible for methodology selection, data collection, data analysis, determination of emission factor and GHG emissions, uncertainty assessment, inventory report and preparation and implementation of quality control activities.

2. PLAN FOR THE INVENTORY PREPARATION PROCESS.

Table 6-1 shows the key steps and timeline needed to prepare a GHG inventory on a regular basis. From planning, method selection, data collection and report compilation, external reviews, review and revisions, and approval by coordinating agencies. It is important to identify inventory compilation team and organizations, establish coordination mechanisms, and establish procedures to ensure systematic documentation and archiving of information, in order to enhance transparency and ensure the sustainability of the process.

Table 6- 1 Key elements of institutional arrangements for MRV

Step	What to do	Who is Responsible	Deadline
PLANNING	• Appointing inventory compilation team • Identifying contributing ministries • Establishing coordination mechanisms • Planning funding and its allocation	Provincial Ecology and Environment Agency	January
PREPARATION	• Holding first coordination meeting • Consulting the preparation plan • Agreeing milestones and timelines	Lead organization of Inventory compilation team	March
METHODOLOGY	• Identify key categories • Choice of methodology • Define data needs	Inventory compilation team	March – April
DATA	• Develop / improve data spreadsheet	Inventory compilation	May-July

COLLECTION	• Identify data sources and providers • Collect data • Data analysis • QA/QC check for data collection	team Provincial Ecology and Environment Agency , Statistics bureau Department of Agriculture and Rural Affairs in province	
GHG ESTIMATION	• Determination of activity data • Calculate emission factors • Estimate emissions and uncertainty • QA/QC check and data comparison with that of national inventory and other province	Inventory compilation team	August
REPORTING	• Compilation of inventory report • Fill in the inventory report format • Check first version of inventory report • QC check • Revision and improve inventory report	Inventory compilation team	September
DOCUMENTING AND ARCHIVING	• Establishing procedures to ensure regular and systematic documentation and archiving • Enhance transparency and sustainability of process	Inventory compilation team	September
EVALUATION AND CONSULTATION	• QA/QC check • External expert review • Plan for improvement • Correct, revise and improve inventory report • Approval by Provincial Steering committee:	Provincial Ecology and Environment Agency Provincial Steering committee: Inventory compilation team Provincial Statistics bureau Department of Agriculture and Rural Affairs	October
APPROVAL AND SUBMISSION	Approval by relevant approving government authority and submitting it to the national coordinating agencies on climate change .	Provincial Ecology and Environment Agency Department of Agriculture and Rural Affairs	November

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ANNEX QUESTIONNAIRE OF FIELD SURVEY FOR LIVESTOCK GHG EMISSION INVENTORY

Table A1- 1 Investigation on the Population Structure of Dairy Cows and Swine

Provence： County： Year of Investigation：

Data source: Investigator： Survey Date：

Livestock	Feeding situation	Total amount of livestock population in the province (10^4 heads)	Total amount of livestock population in sample county (10^4 heads)	proportion of growth stages(%)		
				Calf/ Nursery	Other cattle/ Growing-finishing	Mature dairy cow/ sows
Dairy cattle	Intensive					
	Backyard					
	Grazing					
Swine	Intensive				—	—
	Backyard				—	—

Intensive feeding: refers to individual farms (zones) where the stock of dairy cattle ≥ 100 heads, or the annual output of swine ≥ 500 heads.

Grazing: refers to dairy cattle raised in 266 pastoral and semi-pastoral districts and counties in 13 provinces (autonomous regions) designated by the administrative divisions of China.

Backyard feeding: refers to livestock raised by a single family. In this guideline, farm feeding, which is smaller than the standard for intensive feeding, is included in backyard feeding.

Table A1- 2 Production characteristic parameters—Dairy cattle

Province: County: Investigator: Survey Date:

Feeding Situation			Intensive				Backyard				Grazing			
Subject			Births	Calves	Other cattle	Mature dairy cow	Births	Calves	Other cattle	Mature dairy cow	Births	Calves	Other cattle	Mature dairy cow
Age（day）			—				—				—			
Average weight（kg）														
Daily weight gain（kg/day）			—				—				—			
Lactation milk production（kg/day/head）			—	—	—		—	—	—		—	—	—	
Lactation days（day/year）			—	—	—		—	—	—		—	—	—	
Milk fat content（%）			—	—	—		—	—	—		—	—	—	
Lactation rate of mature cows（%）			—	—	—		—	—	—		—	—	—	
Pregnancy rate of mantrecows（%）			—	—	—		—	—	—		—	—	—	
Calving number（heads）			—	—	—		—	—	—		—	—	—	
Feed composition	TMR feed（kg/day）		—				—				—			
	concentrates（kg/day）													
	Roughage（kg/day）		—				—				—			
	Roughage（kg/day）	Silage	—				—				—			
		Hay, Alfalfa hay	—				—				—			
		Ammoniated straw	—				—				—			
		Dried Stover	—				—				—			
		Juicy feedstuff for root tubers, Green forage	—				—				—			
	Distiller's grains, wheat bran		—				—				—			
Gross energy intake（MJ/day）			—				—				—			
Feed digestibility（%）			—				—				—			

Table A1- 3 Production characteristic parameters —Swine

Province: County: Investigator: Survey Date:

<table>
<tr><td colspan="3">Feeding Situation</td><td colspan="4">Intensive</td><td colspan="4">Backyard</td></tr>
<tr><td colspan="3">Subject</td><td>Births</td><td>Nursery</td><td>Finishing/Growing</td><td>sows</td><td>Births</td><td>Nursery</td><td>Finishing/Growing</td><td>Sows</td></tr>
<tr><td colspan="3">Age（day）</td><td>—</td><td></td><td></td><td></td><td>—</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Average weight（kg）</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Daily weight gain（kg/day）</td><td>—</td><td></td><td></td><td></td><td>—</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Number of give birth（heads）</td><td>—</td><td>—</td><td>—</td><td></td><td>—</td><td>—</td><td>—</td><td></td></tr>
<tr><td colspan="3">Survival rate（%）</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td rowspan="5">Feed composition</td><td colspan="2">Complete feed（kg/day）</td><td>—</td><td></td><td></td><td></td><td>—</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Concentrates（kg/day）</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Roughage（kg/day）</td><td>—</td><td></td><td></td><td></td><td>—</td><td></td><td></td><td></td></tr>
<tr><td>Roughage（kg/day）</td><td>Juicy feedstuff for root tubers,（Carrot, cabbage, sweet potato）</td><td>—</td><td></td><td></td><td></td><td>—</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Distiller's grains, wheat bran</td><td>—</td><td></td><td></td><td></td><td>—</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Gross Energy intake（MJ/day）</td><td>—</td><td></td><td></td><td></td><td>—</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Feed digestibility（%）</td><td>—</td><td></td><td></td><td></td><td>—</td><td></td><td></td><td></td></tr>
</table>

Table A1- 4 Questionnaire on manure management systems of swine and dairy cows

Province: County: Investigator: Survey Date:

Livestock	Feeding situation	Ratio of manure treatment（%）													
		Grazing /Range /Paddock	Daily spread	Burned for fuel	Solid storage	Dry lot	Composting	Deep bedding	Pit storage	Liquid storage	Lagoon	Biogas digester	Aerobic treatment	poultry manure with litter	Other
Dairy cattle	Intensive feeding														
	Backyard feeding														
	Grazing														
Swine	Intensive feeding														
	Backyard feeding														

Grazing------ The manure from pasture and range grazing animals is allowed to lie as deposited, and is not managed.

Daily spread------ Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.

Burned for fuel------ The dung and urine are excreted on fields. The sun dried dung cakes are burned for fuel.

Solid storage------ The storage of manure, typically for a period of several months, in unconfined piles or stacks.

Dry lot------ A paved or unpaved open confinement area without any significant vegetative cover. Dry lots do not require the addition of bedding to control moisture. Manure may be removed periodically and spread on fields.

Composting------Aerobic fermentation of livestock solid manure by silo, batch, tank agitation or static ventilation after collection.

Deep bedding------As manure accumulates, bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months.

Pit storage------Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods less than one year.

Liquid storage------Manure is stored as excreted or with some minimal addition of water or bedding material in tanks or ponds outside the animal housing, and removed periodically.

Lagoon-----A type of liquid storage system designed and operated to combine waste stabilization and storage. The supernatant water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields.

Anaerobic digester------ Animal manure with and without straw are collected and anaerobically digested in a containment vessel or in covered lagoon. CH_4 and CO_2 are produced during the anaerobic fermentation process, Biogas is captured and used as a fuel.

Aerobic treatment------The biological oxidation of manure collected as a liquid with either forced or natural aeration (e.g. wetland).

Poultry manure with litter------Using the bedding material for poultry, and the manure and litter cleaning out together..