HANDBOOK FOR REVIEW OF NATIONAL GHG INVENTORIES

CHAPTER V : AGRICULTURE SECTOR ISSUES

Introduction

1. This chapter provides specific guidance to assist in the review of the estimation of emissions of the agriculture sector. The guidance is for use by experts during an annual technical review. The overall aim is to help review experts in performing their tasks, avoid duplication of efforts, and promote consistency in the different types of reviews of national greenhouse gas (GHG) inventories (desk, centralized and in-country review teams) for the technical review of GHG inventories.

2. The guidance presented in this document for the review of emissions is independent of which review approach is taken (i.e., desk, centralized or in-country).

3. The guidance presented in the tables in this handbook is not intended as a checklist where the team must complete all the questions but rather as reference manual for the reviewers. Each of the tables and to a large extent the questions may be used independently. Questions relevant for checking cross cutting issues like choice of Tier, uncertainty and QA/QC are provided once in the Chapter III general review tables.

4. Agricultural greenhouse gas emissions are mainly methane and nitrous oxide. (Carbon dioxide emissions from agriculture are covered in the Land-Use Change and Forestry section) The main sources of nitrous oxide emissions include manure management, savannah burning, residue burning, direct emissions from agricultural soils, and indirect emissions from agricultural soils. The main sources of methane emissions are enteric fermentation in domestic livestock, manure management, savannah burning, residue burning, and rice production.

Livestock Population Characterization

5. The methods for estimating methane and nitrous oxide emissions from livestock related source categories all require information on livestock sub-category definitions, annual populations and feed intake estimates. To ensure that these definitions and data are used consistently across the source categories a single "characterisation" should be developed for each species. A coordinated livestock characterisation ensures consistency across the different source categories

6. In performing the characterization according to the appropriate level of detail, the livestock species common to multiple source emissions must first be identified. Subsequently, the emission estimation methods for each of the pertinent source categories must be reviewed and the most detailed characterisation required for each livestock species must be identified. Characterization may be achieved on either a basic or enhanced level.

Enteric Fermentation

7. Enteric fermentation is a major source of methane from livestock such as cattle, buffalo, sheep, goats, camels, mules/asses, and swine. In domestic livestock methane is produced in the rumen, by methanogenic bacteria, and emitted to the air through belching.

8. If significant country specific data are available with which to estimate emissions for each sub-source category, the methodology must account for nutrient requirements, feed intake, and methane conversion rates for specific feed types. (Tier 2 Estimate) If significant data are unavailable, a more simplified approach, which relies on default emission factors, must be employed. (Tier 1 Estimate)

Manure Management

9. Background: With increasing animal numbers and increasing density of livestock the manure is stored in anaerobic silos or lagoons. In these anaerobic environments when the manure is stored over the winter fermentation starts and methane emissions occur. Especially in the intensive agriculture in Western Europe methane emissions from manure are increasing. Methane emissions can be reduced by storage outside the stable in cold environments. Methane emissions can also be reduced by a shorter storage period. Another possibility is to stimulate the fermentation and to capture the methane for energy purposes. This seems to be profitable only in the larger farms and when the storage is specifically designed for methane capture and use.

10. Livestock manure is composed of organic material that produces methane during decomposition in an anaerobic environment and nitrous oxide during the storage and application to land.

11. Methane emissions from manure management are assessed first, by collecting Livestock Population Characterization data and dividing species into those with “basic” and “enhanced” characterization. Next, emission factors must be developed for each relevant livestock population and manure management system using either IPCC default values or those developed on the basis of manure characteristics (Methane Conversion Factor (MCF), Maximum Methane Producing Capacity (Bo), and Volatile Solid Excretion Rates (VS)).

12. Factors that influence the amount of methane produced from manure management include 1) ambient temperature and moisture, 2) residency time, and 3) moisture content.

13. First collecting Livestock Population Characterization data and dividing species into those with “basic” and “enhanced” characterization must assess nitrous oxide emissions from manure management. Then, the annual average nitrogen excretion rate per head (Nex(T)) and the fraction of total annual excretion must be determined for each defined livestock species. If adequate country specific data exists for these and for manure management usage, emissions must be estimated using country-specific emission factors. If country specific data does not exist, IPCC default values must be used.

14. Factors that influence the amount of nitrous oxide produced from manure include the composition of the manure and urine, the type of bacteria involved, and the amount of oxygen and liquid present in the manure system.

Savanna Burning

15. Savanna burning is a source of both methane and nitrous oxide emissions. Country specific activity data or IPCC default values must account for 1) the fraction of area burned, 2) aboveground biomass density, 3) aboveground biomass burned, and 4) aboveground biomass that is living, or combustion efficiency.

Agricultural Residue Burning

16. Agricultural residue burning is a source of both methane and nitrous oxide emissions. Country specific activity data or IPCC default values must account for 1) the fraction of area burned, 2) aboveground biomass density, 3) aboveground biomass that is living, or combustion efficiency.

Direct Emissions from Agricultural Soils

17. Nitrous oxide emissions from agricultural soils are directly related to the application of synthetic fertilizers and manure, the cultivation of nitrogen fixing crops, the incorporation of crop residues into soils, and soil nitrogen mineralisation due to cultivation of organic soils. They also result from unmanaged animal manure, such as that deposited by animals on pasture, range, and paddock, and land application of sewage sludge. Injection of manure in the soil as a means to reduce ammonia emissions results in higher nitrous oxide emissions.

Indirect Emissions from Agricultural Soils

18. Nitrous oxide is emitted indirectly from agricultural soil management via five pathways: 1) the atmospheric deposition of NO_X and ammonia on the soils1, as well as combustion and industrial process sources; 2) leaching and runoff of nitrogen from synthetic fertilizer and manure application; 3) leaching of land application of sewage; 4) formation of nitrous oxide in the atmosphere from the oxidation of anthropogenic NH3 emissions; and 5) the leaching and runoff of nitrogen from land application from food processing effluents.

Rice Production

19. Methane emissions from rice production occur when organic material in flooded rice fields decomposes anaerobically. Factors that influence the amount of methane emitted include the number and duration of crops grown, soil type and temperature, water management practices, and the use of fertilisers and other organic/inorganic additions.

[1] Potential atmospheric sources of nitrous oxide include combustion, industrial processes, and re-volatilization on nitrogen inputs to soils.

Table 4: Livestock Population Characterization

Source Category	4 Livestock Population Characterization - Overview
Definition	Livestock population characterization includes descriptive information on all livestock subcategories, annual populations, and feed intake in order to estimate GHG emissions in this sector. A coordinated livestock characterization ensures consistency across the following source categories: Methane emissions from enteric fermentation in domestic livestock (IPCC good practice guidance [GPG] Section 4.2) Methane emissions from manure management (Section 4.3) Nitrous oxide from manure management (Section 4.4) Direct nitrous oxide emissions from agricultural soils (Section 4.7) Indirect nitrous oxide emissions from nitrogen used in agriculture (Section 4.8)
Potential Key Issues:	Incomplete or erroneous animal population statistics due to different treatment of young animals between countries. Inconsistencies across sector and in levels of detail between countries can lead to difficulties with comparability of estimates.
General References	GPG Chapter 4.1, page 4.8 IPCC Guidelines Chapter 4 Reference manual page 4.7. Workbook not treated.

Source Category		4 Livestock Population Characterization - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology		Is Tier 2 methodology (enhanced characterization) used for any of the source categories? Identify which source categories utilize enhanced characterization. For those source categories that used tier 1, does the IPCC good practice guidance indicate the use of a higher tier?	Not using an enhanced characterization throughout the different source categories may lead to inconsistent time series. (IPCC GPG page 4.8). If an enhanced population characterization is used, it is important to check the consistency of the estimation method used.
		If the animal performance data are used to calculate feed intake, is the performance data complete?	The detailed livestock characterization includes information per livestock species and age class for estimating the EF, such as type, weight (kg), weight gain (kg/day), feeding situation, milk (kg/day), work (hrs/day), % pregnant, digestibility of feed (%), CH_4 conversion (%), day weighted population mix (%), EF (kg/hd/yr).
		Is the feed intake calculated based on the updated equations from the IPCC good practice guidance?	Refer to equations 4.1 to 4.11, good practice guidance Chapter 4. Tables 4.1 to 4.7 list default assumptions.
		Is it based on other IPCC recommended methodology or based on country specific methodology?	If a country specific method is used it is important to know whether the results are comparable to other countries. Therefore the results per animal class could be compared across countries.
		What is the source of milk production data and other data	For milk production data it is important to know whether total milk production is simply

		that is needed?	divided by the number of animals in a country or the milk production is based on the actual production, using measurements from a sample of the dairy cows. These can be widely different, leading to inconsistencies.
Emission Factor		What emission factors are used?	National inventories should document key assumptions and emission factors used.
Activity Data		What activity data has been used? National statistics or other? Are these activity data comparable to FAO statistics? Has the country used animal classes in addition to those listed in the GPG? What is the documentation of data and methods used for these additional animal categories? Have annual population statistics taken into account seasonal births or slaughters? Has migration of livestock within or between countries lead to double counting or under counting of animals?	Normally national statistics are comparable to FAO statistics. Differences should be explained. Some countries manipulate the agricultural census data. (E.g. seasonal births and slaughters are included or excluded, sometimes three years averages are used). Some countries may have domesticated animals for which there are currently no IPCC tier 1 or 2 estimation methods (llamas, alpacas, wapiti, deer, emus, elks, and ostriches). Please include reference. In some countries for example the lambs are not counted, in other countries they have been included or added for a fraction of the year e.g. 40%. Differences >5% should be explained.
Parameters relevant to determine activity data		Is the feed intake calculated each year or is it based on assumptions? Is average weight increase estimated? Is it comparable to other countries from the region? Have the sources for the data clearly been cited? What is the sample size?	Some countries when estimating feed intake have estimated an average weight increase of 1% over the years for some animal categories. See IPCC GPG page 4.12 and 4.13. When the animals become more efficient they can produce more milk from the same amount of food. More often the food intake increases over the years and changes in character. The detailed livestock characterization includes information per livestock species and age class for estimating the EF, such as type, weight (kg), weight gain (kg/day), feeding situation, milk (kg/day), work (hrs/day), % pregnant, digestibility of feed (%), CH_4 conversion (%), day weighted population mix (%), EF (kg/hd/yr).
Completeness		Are all possible livestock classes covered?	E.g. compare with other similar countries and country specific FAO data. The review team may make a table with the animal classes that have been used by the country if a more detailed classification has been used than in the CRF.

Recalculations/ Consistent time series		Check whether different climate region classification leads to fluctuations in the emission trends. Have rapid changes in livestock population taken place as a result of economic restructuring and changing market conditions? If so, is it ensured that an adequate time series is developed?	For some large countries livestock may be managed in regions with different climates. For each livestock category, the percentage of animals in each climate region should be estimated. According to IPCC Guidelines three climate regions are defined in terms of average annual temperature: cool (<15^0 Celsius), temperate ($15\text{-}25^0$ C) and warm (>25^0C). In some countries the climate regions are redefined each year leading to varying percentages of livestock classified in each climate over the years because of differences in average temperature over the years. Normally key-attributes do not change rapidly and can be obtained by back-estimating ongoing trends. However, if structural changes have taken place further investigation may be needed. The review team may investigate the uncertainty of the animal statistics. IPCC GPG page 4.21 specifically asks for adequate and consistent time series under changing market conditions.
Uncertainty		What is the uncertainty in the animal statistics? What is the uncertainty in the other key attributes for the intake estimates? Is an uncertainty assessment performed for each data element in the livestock characterization? Is an uncertainty assessment performed for livestock population data? Is the uncertainty propagated through to the final estimates of feed intake and population data? IPCC GPG page 4.21.	The factors that contribute most to the sensitivity of the feed intake estimates should be identified in order to improve on the estimates.
Reporting and documentation		Has information on detailed livestock characterization been provided? Is the method to estimate the annual population fully documented? o Please provide references on, e.g., animal population by category and region o Full reference of all AD	The new CRF reporting tables provide a mechanism for reporting detailed livestock statistics. Refer to Table 4.A and the additional information table that is used for tier 2 livestock characterization data.

		o Frequency of data collection o Values for methane conversion rate o Gross energy intake	
QA/QC		Are QA/QC checks performed on the data by the inventory agency? Has external expert peer review been conducted on the livestock characterization data and population data? Has the inventory agency cross-checked the data with FAO statistics and other data sources?	IPCC GPG page 4.22 suggests enacting various quality control checks. Reviewers could ask for peer reviewed journal articles on the livestock characterization and livestock animal statistics and include the references in the review report. The inventory agency could cross check activity data with FAO statistics and with other data sources. Feed intake estimates should be checked for reasonableness. For ruminant animals the feed intake in dry matter per day (kg/day) should be on the order of 1-3% of the weight of the animals. According to the IPCC GPG the inventory agency should conduct expert peer review on the livestock characterization data.

Table 4.A: Methane Emissions from Enteric Fermentation in Domestic Livestock

Source Category	**4.A Methane Emissions from Enteric Fermentation in Domestic Livestock - Overview**		
Definition	Enteric fermentation occurs in the rumen of livestock and is a significant source of global methane emissions. The number of animals and type of digestive system primarily drive the amount of methane, and the type and amount of feed consumed. Cattle, buffalo and sheep are the largest sources of enteric methane emissions in the world.		
Potential Key Issues:	Statistics that may have been corrected for young animals. Emission factors that are held constant while the animal production in terms of milk and beef has been growing. Emission factors that are insensitive to changes in diet.		
General References	IPCC Guidelines. Workbook section 4.2, page 4.3 and Reference Manual section 4.2, page 4.3 and further IPCC good practice guidance (GPG) chapter 4.2, page 4.23 and further.		
Source Category		**4.A Methane Emissions from Enteric Fermentation in Domestic Livestock - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology		For animal classes not included in the IPCC Guidelines and GPG, are estimates developed using the same principles as for developing Tier 2 AD and EF? If a country specific method is used how does this compare to the IPCC methods?	Often Tier 2 is used for dairy cattle and sheep. Tier 1 is often used for the other animal categories. Some of those however may be key sources.

Emission Factor		If tier 2 is used, how is the emission factor derived for cattle, buffalo and sheep? If a country specific method has been used, how is the emission factor derived? Is the gross energy intake value taken from the livestock characterization? Which methane conversion rate is used for dairy cattle and sheep? How is the emission factor derived for other livestock categories? What are the differences with the IPCC defaults? Are the data developed through the livestock characterization been used for developing EF?	The methane conversion rate for cattle varies from 4-7% depending on the digestibility of the feeds. Less methane is formed when good feeds are used with high protein content. When only roughage is fed methane is 7%. IPCC GPG gives default rates. (See table 4.8 and 4.9 from IPCC GPG). In some countries the emission factors per adult animal are higher because of an assumption about accompanying young animals that are otherwise not in the statistics. Table 4.8 in the IPCC good practice guidance indicates a default value of Y_m 0.06 +/- 0.005.
Activity Data		Has a single livestock characterization been followed for all sources? Is the herd improved recently by changing to other types with higher milk production per cow? (E.g. from Holstein to American Friesian Holstein)	The activity data should be collected following the guidance from the Livestock Population Characterization (IPCC GPG section 4.1) to ensure consistency. When improved breeds used the methane conversion factor may be different from defaults
Completeness		Are all animals covered by the method used in the country? Are time series complete? Are deer included?	Reviewers might want to compare with other countries. In many countries today deer are held on farms as domestic livestock.

Recalculations/ Consistent time series		Is a consistent time series found for cattle, buffalo and sheep? If the livestock population characterization is updated each year is the methane conversion rate also updated each year? Is the set for the methane conversion rate consistent over time? If rates have been modified due to mitigation measures or changes in agricultural practices (e.g. feed conditions): Do the rates reflect the changes in data and methods, and are they thoroughly explained and documented?	Feeding practices in a country are shifting over time with availability on the farms and through imports. Feeding practices are changing with improved efficiency of the animals. In high production dairy farming more concentrates are fed (e.g. soybean cake, line seed cake). Especially over the last decades changes have been particularly fast. Sometimes the herds are changing to more efficient types.
Uncertainty		Has an uncertainty estimate been made for methane from enteric fermentation for all categories?	The typical uncertainty in the tier 2 emission factors is 20%. An uncertainty analysis can help find the most uncertain parameters for future improvement.
Reporting and documentation		Check the adequacy by reviewing the transparency of the estimates. Are the reviewers able to reproduce the estimates based on the information provided?	It is not enough to simply make a reference to a background document that is not available during the review. In the IPCC good practice guidance the information that should be documented is given on page 4.28. References of recent research results are preferable to improve the emission factors and activity data. To improve transparency, emission estimates from this source category should be reported together with the activity data and emission factors used to determine the estimates.
QA/QC		Are QA/QC checks performed on the data? Are country specific factors compared to IPCC default values? Is an external expert peer review carried out on the country results? Did the review team see results from earlier external expert peer reviews?	It is important to maintain internal documentation on review results obtained from external reviewers.

Table 4.B (a): Methane Emissions from Manure Management

Source Category	4. B (a) Methane Emissions from Manure Management - Overview
Definition	Livestock manure is composed of organic material. When this material decomposes without oxygen methanogenic bacteria produce methane. These conditions often occur when large numbers of animals are managed in confined areas and the manure is stored under the stable, in covered silos or open lagoons.
Potential Key Issues:	Poor statistics on manure management systems in a country and the percentage distribution. Calculation of amount of manure produced by the animals that differs from one country to the other. Uncertainty in the amounts and times in the storage. Difficulties with the classification of manure management types over the climate regions in a country.
General References	IPCC Guidelines Reference manual chapter 4.2 and workbook chapter 4.2 IPCC good practice guidance (GPG) chapter 4.3

Source Category		4.B (a) Methane Emissions from Manure Management - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CH_4	Are the calculations based on the total herd instead of only a portion of the herd?	Some countries may have omitted parts of the herd.
Emission Factor		Are the VS, Bo and MCF factors country specific or default IPCC? Are country specific emission factors based on recent research results within the country? If the emission factors are specified for different climate regions in the country is this done consistently?	Different MCF values are given by the IPCC good practice guidance for three climate regions (cool, temperate, warm). Some large countries have livestock in different climate regions. The review team should check whether variations in the emissions over the years are the result of variations in livestock numbers assigned to these different climate regions. Some countries define the climate regions each year, based on the average yearly temperatures. This can lead to strange variations in the trends.
Activity Data		Is the calculation based on the same animal population characterization as in methane from enteric fermentation? Is the manure management system usage based on proper statistics or based on assumptions? What portion is kept in the stables in warm conditions?	Animal population data should be from the population characterization. Manure management statistics in most countries are poor. Please provide a reference when assumptions are made. In some countries part of the year manure is kept under the stable in warm conditions. This leads to particularly high emissions of methane as well as ammonia.

Completeness		Are all manure systems and animal species included?	Compare with other countries from the region.
Recalculations/ Consistent time series		Have changes taken place in activity data and manure management statistics? What are the effects on the time series? Have changes taken place in manure management practices?	Difficulties may arise when manure management systems over the time series have changed or when manure management statistics have improved over the time series.
Uncertainty		Has an uncertainty assessment been carried out? What are the uncertainties in the assumptions?	The main uncertainties are in the emission factors, the animal population statistics and in the statistics on manure management. An uncertainty assessment can help in finding the most uncertain parameters for improvement.
Reporting and documentation		Are emission factors, activity data and other parameters properly documented? Ask for reference.	It is good practice to document and archive all information required to produce the estimates of methane from manure management. To improve transparency emission estimates should be reported along with the activity data and emission factors. IPCC GPG page 4.38 gives an overview of data to be documented. It is not enough to simply make a reference to a background document that is not available during the review.
QA/QC		Have QA/QC checks been applied by the inventory agency? Has an external review been applied on the assumptions within the methodology?	If using the Tier 2 methodology, the inventory agency should provide a proper justification for country-specific emission factors through peer reviewed documentation.

Table 4.B (b): Nitrous Oxide Emissions from Manure Management

Source Category	4.B (b) Nitrous Oxide Emissions from Manure Management - Overview
Definition	Nitrous oxide from manure is produced during the storage and treatment of manure before it is applied to land. Manure includes both dung and urine. The emission of nitrous oxide from manure during storage and treatment depends on the nitrogen and carbon content of manure, and on the duration of the storage and type of treatment.
Potential Key Issues:	Poor statistics on manure management. Calculation of N-excretion that differs from one country to the other and from IPCC defaults. Reporting under the wrong sub-category.
General References	IPCC Guidelines Reference manual 4.5.3. Workbook 4.2.3 step 4. IPCC good practice guidance (GPG) chapter 4.4

Source Category		4.B (b) Nitrous Oxide Emissions from Manure Management - Details	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	N_2O	Are emissions of ammonia and/or other substances subtracted before calculation of nitrous oxide emissions from manure management?	The method is based on the multiplying of the total amount of N excretion from all animal species and categories by an emission factor for each type of manure management system.
Emission Factor		Are the emission factors specific or default IPCC? Are country specific emission factors based on recent peer reviewed research results within the country? Are emission factors identified for deep litter stables?	Default emission factors are given in the IPCC GPG table 4.12 and 4.13 on page 4.43 and 4.44. Deep litter stables have high N_2O emissions.
Activity Data		Is the manure management system usage the same as used in methane from manure management? Is it based on proper statistics or based on assumptions? Is the calculation based on the animal population characterization as in methane from enteric fermentation? Is an enhanced characterization applied? Are adjustment factors applied?	It is good practice to multiply the default N excretion rates with adjustment factors for young animals from IPCC GPG table 4.14. If country specific N-excretion per animal category is used, is this comparable to other countries. An enhanced characterization is needed to estimate N_2O emissions using calculated nitrogen excretion rates. For IPCC default values see Reference Manual table 4.20.
Completeness		Are all systems and animal categories covered?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.

Recalculations/ Consistent time series		Have changes taken place in activity data and manure management statistics? What are the effects on the time series?	Difficulties arise when manure management over the time series have changed or when manure management statistics have improved over the time series.
Uncertainty		Has an uncertainty assessment been performed? What are the uncertainties in the assumptions?	An uncertainty assessment helps to find the most uncertain parameters.
Reporting and documentation		Is all information documented and archived and available for review? Check if reference is provided for details on N-excretion assumptions. Check if reference is provided	It is good practice to document and archive all information required to produce the estimates of nitrous oxide from manure management. To improve transparency emission estimates should be reported along with the activity data and emission factors. It is not enough to simply make a reference to a background document that is not available during the review.
QA/QC		Have QA/QC checks been applied by the inventory agency? Has an external review been applied on the assumptions within the methodology?	If using the Tier 2 methodology, the inventory agency should provide a proper justification for country-specific emission factors through peer reviewed documentation.

Table 4.D: Direct Nitrous Oxide Emissions from Agricultural Soils

Source Category	**4.D Direct Nitrous Oxide Emissions from Agricultural Soils - Overview**		
Definition	N_2O emissions from agricultural soils occur directly from anthropogenic inputs to the soil. The IPCC Guidelines method for estimating direct N_2O emissions from soils has two parts. The first is the estimation of emissions due to N inputs to the soil (excluding animals on pasture, range and paddock). The second is the estimation of emissions from animal manure directly dropped in pasture, range and paddock.		
Potential Key Issues:	Inconsistencies with calculation of N excretion Calculation of N in stable and storage Missing sub-sources of N to the soils Reporting under the wrong sub-categories		
General References	IPCC 1996 Revised Guidelines Reference manual chapter 4.5.1. to 4.5.3. Workbook 4.6 IPCC good practice guidance (GPG) chapter 4.4 and 4.7		
Source Category		**4.D Direct Nitrous Oxide Emissions from Agricultural Soils - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	N_2O	Is Tier 1a or Tier 1b chosen by the country? If Tier 1b is chosen, compare important differences with Tier 1a. Are emissions of ammonia and/or other substances	The terms Tier 1a and Tier 1 b have been used throughout the IPCC good practice guidance in the subsections 4.7 and 4.8, to differentiate between the equations in the IPCC Guidelines (Tier 1a) and new equations (Tier 1b). The Tier 1b equations give increased precision due to expansion in the terms in the equations. If activity data are available in a country Tier 1b is preferred. The approach in the IPCC Guidelines accounts for anthropogenic nitrogen inputs from the application of synthetic fertilizers (F_{SN}) and

		subtracted before calculation of nitrous oxide emissions?	animal manure (F_{AM}); the cultivation of biologically N-fixing crops (N_{BN}); incorporation of crop residues in the soils (F_{CR}); and soil mineralisation due to cultivation of organic soils (F_{OS}). As the IPCC Guidelines treat indirect and direct emissions separately, the portion that volatilizes is subtracted from the amounts applied, and the N_2O that is eventually emitted from this volatilized N is included as part of the indirect emissions.
Emission Factor		Are the emission factors country specific or default IPCC? Are country specific emission factors based on recent research results within the country? Are these factors used consistently? Are updated default values for EF2 used for organic soils? Does the country have a research program in place to update and document emission factors? Are countries coordinating their efforts? Do measurements take place over periods of one year or longer? What is the good practice derivation of country specific emission factors according to the country?	IPCC EF1 = 1.25%. IPCC Mid-latitude EF2 = 5 kgN/ha/yr, Updated IPCC EF2 = 8 kgN/ha/yr; IPCC Tropical EF2 = 10 kgN/ha/yr, Updated IPCC Tropical EF2 = 16 kgN/ha/yr. See IPCC GPG table 4.17 Default emission factors from IPCC are based on a database with many measurement results from experiments that lasted at least a year or longer. Emission measurements that lasted less than a year are less reliable because of the large seasonal variations. Please provide a reference for country specific emission factors derivation so that other countries could learn from these research results. Compare with Box 4-1 in IPCC GPG.
Activity Data		Is the fertilizer consumption N_{FERT} disaggregated? Is the loss rate by volatilization ($Frac_{GASF}$) country specific or default 10% (IPCC Guidelines Reference Manual Table 4-19)? Are animal N excretion rates country specific or default?	It is good practice to collect detailed activity data as far as possible. This will allow for a more accurate revision of previously constructed inventories once country or crop-specific emission factors become available. The review experts should compare the country synthetic fertilizer consumption to international statistics like IFA and FAO. If possible N_{FERT} should be disaggregated by fertilizer type, crop type and climatic regime for major crops. (IPCC Guidelines Reference Manual Table 4-20) Please provide a reference to the documentation if the country uses specific methodology and assumptions.

		How are data on animal manure application derived? Is it consistent with estimates in the section on methane from manure? Is it properly documented? Is the loss rate by volatilization ($Frac_{GASM}$) country specific or default 20%? What is the source for country specific assumptions?	(IPCC Guidelines Reference Manual Table 4-19)
Completeness		Are all emissions from anthropogenic inputs and activities covered? Compare with completeness of other countries in the region.	Currently IPCC does not explicitly address some activities that may enhance N_2O emissions, like other organic fertilizers, N-fixing forage crops like alfalfa, cover crops, catch crops, ploughing of pasture land, plastic sheeting of horticultural soils, N-deposition onto agricultural land from industrial sources, manure injection into the soils. Does the country address some of these? Please provide a reference with documentation.
Recalculations/ Consistent time series		How consistent is the time series for the country under review? Are the results of policy measures reflected in the time series? Does the review team think that the explanations of the reasons for the changes in emissions through time are transparent enough?	The same method should be used throughout the entire time series. Emission estimates however may improve over time with the availability of improved statistic information and improved emission factors. In agriculture various technical and policy measures can be taken to reduce emissions. It is important that the methods reflect the results of the actions. The inventory report should explain the effects of policies on the input data. Please provide a reference to documentation of the country specific methods.
Uncertainty		Did the country perform an uncertainty assessment on the input data and the results? What kind of uncertainty assessment was performed? Have Monte-Carlo or other methods been used? Has the uncertainty assessment been compared with results from the literature?	The uncertainty in the emissions estimates in agriculture is rather large. An uncertainty assessment can help a country to find the parameters that are most uncertain. Priorities can be set to improve these.
Reporting and documentation		Is reporting and documentation according to good practice? According to IPCC the following is necessary to document the estimate:	It is not enough to simply refer to a background document that may or may not be available during the review. The review experts may decide to make a table of deviations from good practice. Please provide a reference to documentation of

		o Activity data: Sources, frequency of data collection and estimation, accuracy and precision. o Emission factors: Sources, full documentation and description of methods to derive country specific emission factors and sources and magnitudes of uncertainties. o Emission results: Explanation of significant fluctuations in emissions between years, changes in activity levels and emission factors, reasons for these changes.	country specific methods. If different emission factors are used for different years, the reasons should be explained and documented.
QA/QC		It is good practice to implement quality control checks. Have QA/QC checks been applied by the inventory agency? Has external review been applied to the research results leading to country specific emission factors?	Please provide a reference to QA/QC checks.

Table 4.D.3: Indirect Nitrous Oxide Emissions from Nitrogen used in Agriculture

Source Category	4.D.3 Indirect Nitrous Oxide Emissions from Nitrogen used in Agriculture - Overview
Definition	Nitrous oxide is produced naturally in soils and aquatic systems through the microbial processes of nitrification and denitrification. A number of agricultural and other anthropogenic activities add nitrogen to soils and aquatic systems, increasing the amount of N available for nitrification and denitrification. This increases the N_2O emissions from these systems. Indirect N_2O emissions occur from leaching and runoff of applied soil N to aquatic systems. Another indirect emission is the volatilization of applied N as ammonia (NH_3) and oxides of nitrogen (NO_X) subsequently followed by the deposition as ammonium (NH_4) and NO_X on soils and water. The IPCC Guidelines describe five separate pathways by which anthropogenic inputs of N become available for formation of N_2O: Atmospheric deposition on soils of NO_X and NH_4 with the sources of N including volatilization of N inputs to soils, as well as combustion and industrial processes (only N_2O from agricultural N should be reported under this category); Leaching and runoff of N that is applied to or deposited on soils; Disposal of human sewage N in rivers and estuaries (N_2O to be reported under Waste); Formation of N_2O in the atmosphere from NH_3 emissions from anthropogenic activities (No IPCC method available yet); Disposal of processing effluents from food processing and other operations (N_2O to be reported under Waste).

Potential Key Issues:	Reporting in the wrong category. Incomplete coverage of all indirect sources of emissions. Assumptions on human sewage N, industrial wastewater N and agricultural N from leaching and runoff to the surface waters.		
General References	IPCC Guidelines Reference manual chapter 4.5.4 Workbook 4.6 Agricultural soils IPCC good practice guidance GPG) chapter 4.8		
Source Category		**4.D.3 Indirect N_2O Emissions from Nitrogen Used in Agriculture - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	N_2O	Has a country specific methodology or IPCC Tier 1a or 1b been chosen? If a country specific method is chosen is the result reported in the right reporting categories? How have the human sewage N, the industrial wastewater N and the agricultural N been distinguished?	The terms Tier 1a and Tier 1b have been used throughout the IPCC good practice guidance in the subsections 4.7 and 4.8, to differentiate between the equations in the IPCC 1996 Guidelines (Tier 1a) and new equations in the IPCC good practice guidance (Tier 1b). Some countries have estimated indirect emissions from the total N-load of the surface waters. The emissions from sewage N and industrial wastewater N effluent should be reported under waste and the emissions from agricultural N should be reported here.
Emission Factor		Are the emission factors country-specific or default IPCC?	Very little information exists even on a global scale to specify the emission factors. IPCC Defaults are: EF4 = 1 kg N/kg N deposited, EF5 = 0.025 kg N/kg N leached, EF6 = 0.01 kg N/kg effluent N.
Activity Data		Is the good practice followed in the choice of activity data? Is the activity data consistent with the calculations in the direct emissions of N_2O from soils? How has the total N load of the water been derived? From statistics or from assumptions? How have the different contributors been quantified? (Human sewage effluent N, industrial wastewater effluent N and agricultural N from leaching and runoff)	Much of the activity data such as fertilizer consumption and livestock nitrogen excretion will have been previously developed. To ensure consistency the same data as used in previous categories should be used. If this is not the case please specify the reasons.
Completeness		Is the estimate complete? Have all components of emissions from the IPCC GPG been estimated? If relevant and if data are available the inventory should	Emission factors for NO_X and NH_3 associated with biomass burning can be found in the IPCC GPG page 4.74. In some countries sewage sludge is applied to soils. If data are available this emission

		also include indirect N_2O emissions from savanna burning and agricultural residue burning. Is sewage sludge applied to soils?	source can be included.
Recalculations/ Consistent time series		Are all factors the same in all years? If not what are the reasons?	Reducing the leaching and runoff to groundwater and surface water can reduce emissions. This could be reflected in the time trend.
Uncertainty		Has the country performed an uncertainty assessment?	Information about emission factors, leaching and volatilization fractions are sparse and highly variable. Please provide a reference if country has performed an uncertainty assessment.
Reporting and documentation		Are the estimates properly reported and documented? Could other countries learn from these experiences?	It is good practice to document and archive all information required to produce the national emissions inventory estimates. It is not enough to simply refer to a background document that may or may not be available during the review. Please provide a reference to the documentation.
QA/QC		Have QA/QC checks been applied by the inventory agency? Has external review been applied to the research results leading to country specific emission factors? Has the country put a research program in place to update and document emission factors? Are countries coordinating their efforts? Do measurements take place over periods of one year or longer?	If using country specific emission factors the inventory agency should compare them to the IPCC default values. Caution should be used in developing country specific values without thorough measurement programs and peer review on results.

Table 4.C: Methane Emissions from Rice Production

Source Category	4.C Methane Emissions from Rice Production – Overview		
Definition	Methane emissions from flooded rice fields occur by way of anaerobic decomposition of organic material. Emissions are a function of rice cultivar, number and duration of crops grown, soil type and temperature, water management practices, and the use of fertilizers and other organic and inorganic additions.		
Potential Key Issues:	Poor statistics on rice cultivation. Lack of data and documentation. Natural Variability. Reporting under the wrong sub-category.		
General References	IPCC good practice guidance (GPG) chapter 4.9		
Source Category		**4.C Methane Emissions from Rice Production - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CH_4	Does the method used account for the various conditions of rice cultivation within a country?	Seasonal methane emissions are affected by variations in water management practices, organic fertilizer use, and soil type. Disagregating total national total harvested area into sub-units and multiplying the harvested area for each sub-unit by an emission factor accounts for the variability in growing conditions.
Emission Factor		Are the emission factors specific or default IPCC? Are country specific emission factors based on recent research results within the country? Have scaling factors been used?	The following rice production characteristics should be considered in developing emission factors: Regional differences in rice cropping practices, Multiple crops, Ecosystem type, Water management regime, Addition of organic ammendments, and soil type.
Activity Data		Describe source of activity data. Is data for all sectors disaggregated to the same level?	Activity data consists of rice production and harvested area statistics. The activity data should be broken down by rice ecosystem or water management system type. If in country data are unavailable, data may be obtained from the FAO (www.fao.org/ag/agp/agpc/doc) or from IRRI's World Rice Statistics. It is good practice to match data on organic ammendments and soil types to the same level of disaggregation as the activity data.
Completeness		Is the estimate complete? Have all rice systems from the IPCC GPG been estimated?	Complete coverage requires estimation of emissions from the following activities: Emissions outside the rice growing season, Other rice ecosystem categories (e.g: swamp, inland-saline or tidal rice fields), and Different kinds of rice crops.
Recalculations/ Consistent time series		Have research results recently become available that warrant recalculations?	It is good practice to recalculate historic emissions when methods or data are changed or refined (see GPG 7.3)
Uncertainty		Has the country performed an uncertainty assessment on the parameters in the methodology?	Uncertainty may be influenced by natural variablility and lack of activity data and documentation.
Reporting and documentation		Is the appropriate additional information reported?	To ensure transparency, the following additional information should be reported: Water management practices, Types and amounts of organic ammendements used, Soil

		Has the country a research program in place to update and document emission factors? Are countries coordinating their efforts? Do measurements take place over periods of one year or longer? Are the methods to translate research results into emission factors properly documented?	types used for rice agriculture, Number of rice crops grown annually, and the most important rice cultivars grown. Countries should provide information on the origin and basis of emission factors.
QA/QC		Have QA/QC checks been applied by the inventory agency?	At present, it is not possible to cross-check emissinos estimates from this source category through external measurements. Emission estimates may undergo quality control by: cross-referencing aggregated crop yield and reported field area statistics with national totals or other sources of crop yield/area data, back-calculating national emission factors from aggregated emissions and other data, adn cross-referencing reported national totals with default values and data from other countries.

Table 4.E: Prescribed Burning of Savannas

Source Category	**4.E Prescribed Burning of Savannas - Overview**		
Definition	Burning of savannas occurs every one to several years. The burning results in an instantaneous release of carbon dioxide emissions, however, because regrowth of vegetation occurs between burn cycles, net carbon dioxide emissions are assumed to be zero. Savanna burning also contributes methane and nitrous oxide emissions.		
Potential Key Issues:	Poor statistics on savanna burning. Reporting under the wrong sub-category.		
General References	IPCC good practice guidance (GPG) chapter 4.5, Appendix 4A.1.		
Source Category		**4.E Prescribed Burning of Savannas - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CH_4, N_2O	Is country specific or IPCC default data used? Are all parameters accounted for? Has Combustion Efficiency been used to depict the combustion and vegetation conditions?	If country specific data are unavailable, default values in Table 4.A.1 of the IPCC GPG may be used. It is good practice to provide values for all aboveground biomass and both the oxidised and carbon fraction in living and dead biomass. Combustion Efficiency is defined as the molar ratio of emitted carbon dioxide concentrations to the sum of emitted carbon monoxide and carbon dioxide concentrations from savanna fires. It is good practice to monitor the fraction of

		Are all parameters accounted for?	burned savanna area, the aboveground biomass density, the percentage of the aboveground biomass burned, and the combustion efficiency.
Emission Factor		Are the emission factors direct estimates or default IPCC?	The methane emission factor is negatively linearlly correlated with the combustion efficiency. GPG Table 4.A2 lists different combustion efficiencies and combustion factors. Nitrous oxide emission factors are linearly correlated with the emission of carbon dioxide and are dependent on the nitrogen content of vegetation.
Activity Data		Does the activity data account for all parameters?	The activity statistics for each savanna ecosystem includes the values for the fraction of aboveground biomass burned and the carbon and nitrogen content of the biomass. It is good practice for the inventory agency to collect seasonal data on the fraction of savanna burned, the aboveground biomass density, and the fraction of aboveground biomass burned in each savanna ecosystem from the early to late dry season.
Completeness		Is this inventory complete for all parameters of savanna burning?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series		Have any recalculations been made?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty		Did the country perform an uncertainty assessment of the input and results?	The uncertainty emission factor for CH_4 and N_2O is +/- 20%. The uncertainty of aboveground biomass in a savanna ecosystem ranges from +/- 2% to +/- 60% and the uncertainty of the fraction actually burned is +/-10%.
Reporting and documentation		Has all information been fully and adequately documented and archived? Are all sources of country specific data given? Is reporting and documentation according to good practice?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC		Have QA/QC checks been applied by the inventory agency? Has external review been applied to the research results?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.

Table 4.F: Field Burning of Agricultural Residues

Source Category	4.F Field Burning of Agricultural Residues - Overview		
Definition	In addition to a net release of carbon dioxide, the burning of residue from agriculture is also a net source of methane and nitrous oxide emissions. Emissions from agricultural residue burned away from the field for energy is confronted in the Energy section.		
Potential Key Issues:	Misallocation of residue burning into the Agriculture and Energy sectors which leads to double counting. Uncertainty regarding the fraction of agricultural residue burned in the field.		
General References	IPCC good practice guidance Chapter 4.6, Appendix 4A.2		
Source Category		**4.F Field Burning of Agricultural Residues - Details**	
Detailed Review Element	**GHG**	**Questions**	**Elaboration/Clarification**
Methodology	CH_4, N_2O	Do local and regional practices account for all appropriate factors? Is country specific or IPCC default data used?	To achieve a complete mass balance of residue, local and regional practices must reflect the following factors: 1) the fraction of residue burned in the field; 2) the fraction transported off the field and burned elsewhere; 3) the fraction consumed by animals in the field; 4) the fraction decayed in the field; and 5) the fraction used by other sectors. The good practice guidance suggests a value of 10% of total agricultural residue burned in the field in both developed and developing countries?
Emission Factor		During which season did the inventory agency carry out its measurement experiments?	It is good practice to carry out measurement experiments during both the dry and rainy season, as emission factors are dependent upon weather conditions.
Activity Data		Describe the source of activity data.	Crop production data may be obtained either from country specific data or from the *FAO Production Yearbook.* For country specific data, it is good practice to compile data on the amount of each crop residue burned after harvest and monthly weather data.
Completeness		Does the mass balance account for all crop residue burned in the field?	National inventories should cover all sources and sinks, and all GHGs, within the national boundaries of the reporting Party.
Recalculations/ Consistent time series		Have any recalculations been made?	It is good practice to recalculate historic emissions when methods are changed or refined (see GPG 7.3)
Uncertainty		Did the country perform an uncertainty assessment of the input and results?	The uncertainty of CH_4 and N_2O emission factors for agricultural residue burning in the dry season is +/- 20%. The uncertainty of emission factors during the rainy season is unknown.
Reporting and documentation		Has all information been fully and adequately documented and archived? Are all sources of country specific data given? Is reporting and documentation according to good practice?	Inventory documentation should ensure transparency and facilitate understanding, replication of results, and assessment of the inventory.
QA/QC		Have QA/QC checks been applied by the inventory agency? Has external review been applied to the research results?	It is good practice to implement QA/QC procedures, taking into account the needs of particular source categories and national circumstances.