GLOBAL RESEARCH ALLIANCE
ON AGRICULTURAL GREENHOUSE GASES

IPCC Greenhouse Gas Inventory Methodology

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InveN$_2$Ory & ResearCH$_4$ Synthesis

Agricultural UK GHG PLATFORM

defra
Department for Environment Food and Rural Affairs

Overview

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- Greenhouse gas inventories
  - Why
  - What
  - How
- Sources and categories of gases
- Methods of estimation
  - Suitable or unsuitable for inventory purposes
  - Strengths and weaknesses

Focus on livestock in this talk

Inventory Good Practice

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National inventories of anthropogenic greenhouse gas emissions and removals consistent with good practice are those, which contain neither over- nor under-estimates so far as can be judged, and in which uncertainties are reduced as far as practicable.

Estimates of this type are presumably the best attainable, *given current scientific knowledge and available resources*.

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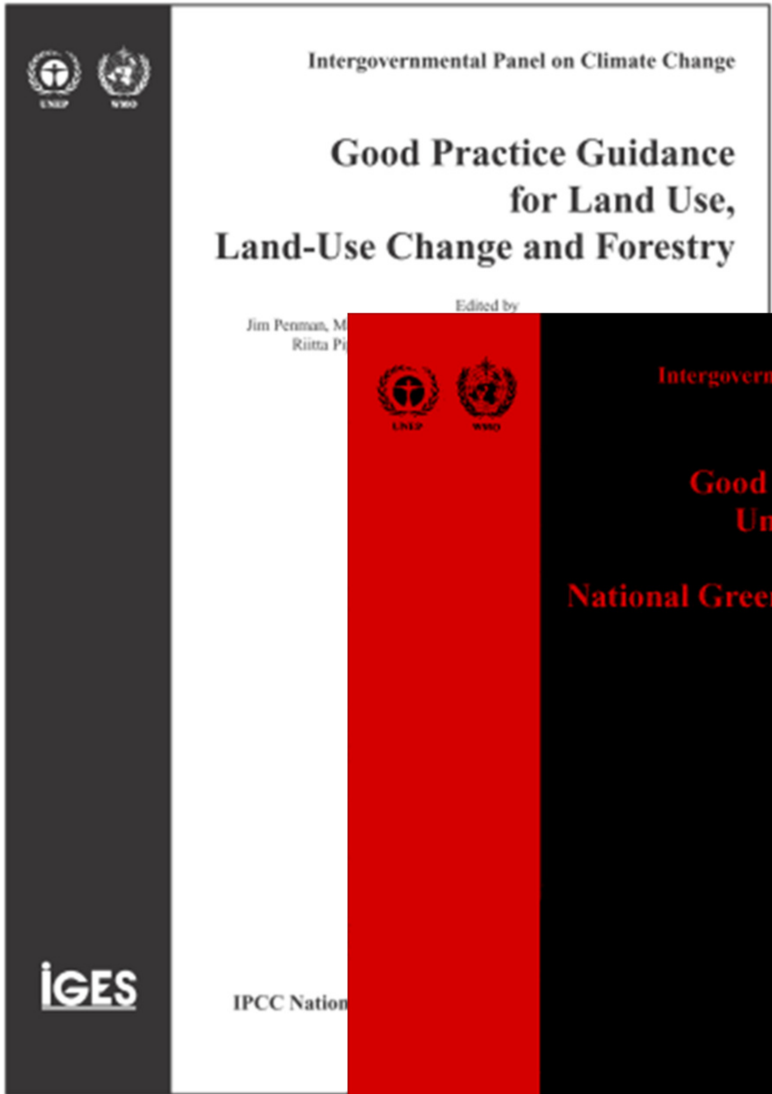

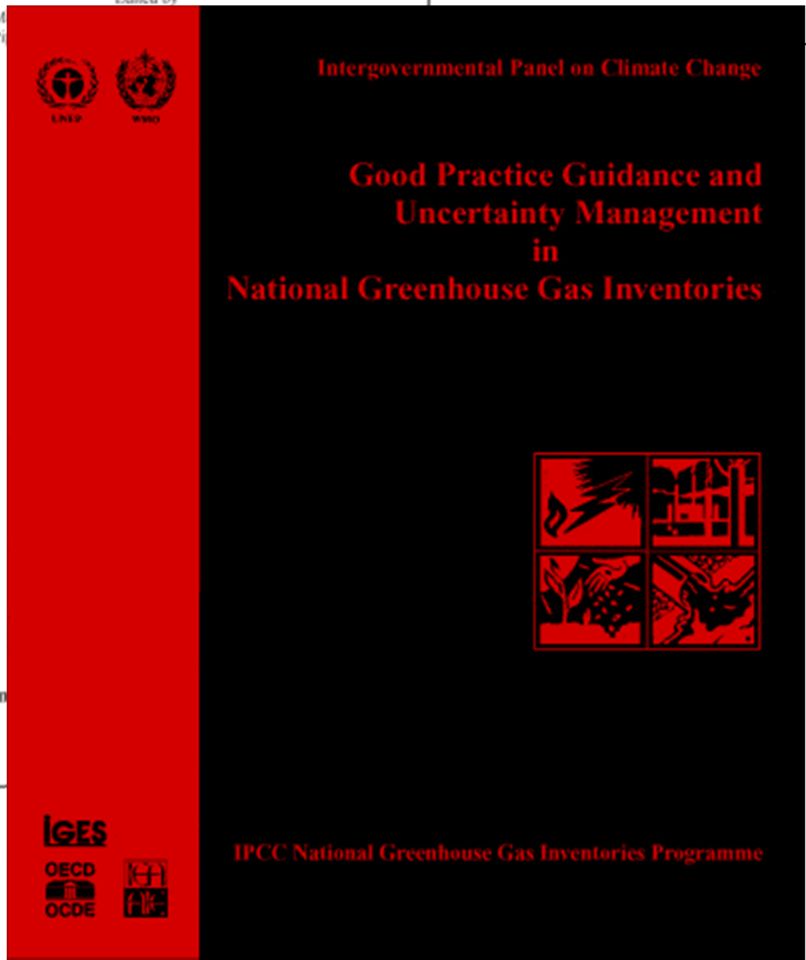

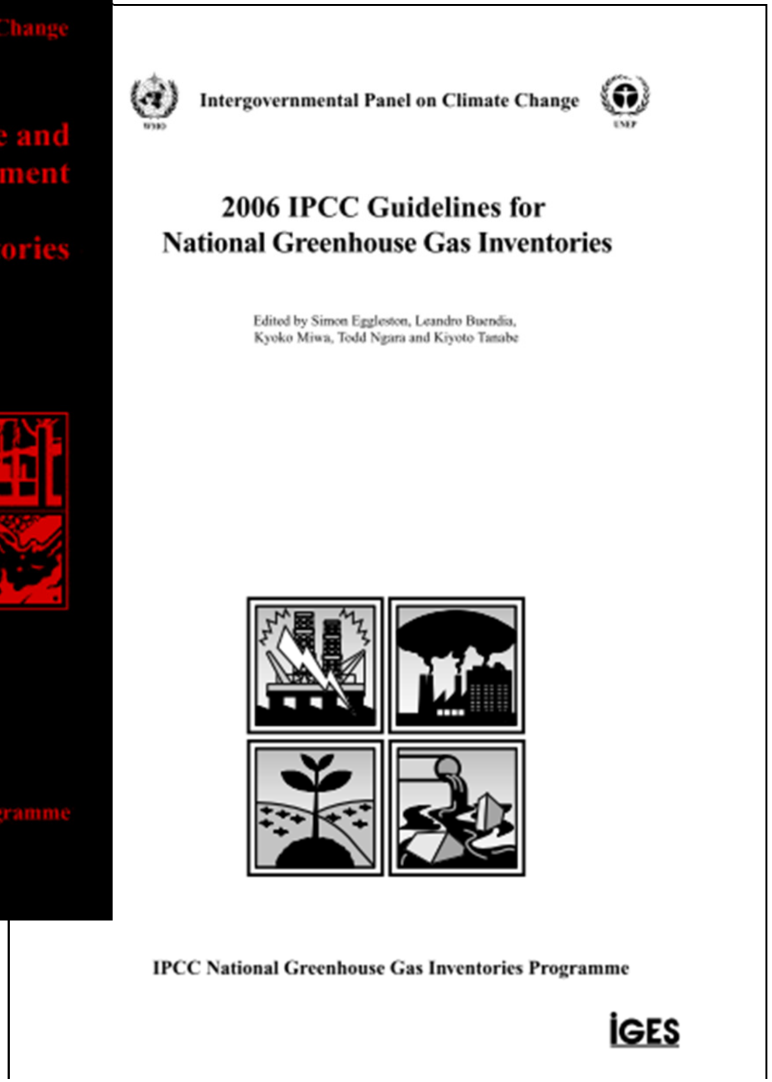

http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

GPG 2000

Agriculture Sector

- Livestock CH_4
- Manure CH_4 and N_2O

- Direct N_2O from soils
- Indirect N_2O from agricultural N

- Rice paddies CH_4
- Savannah and crop residue burning CH_4 and N_2O

Revised 2006 Guidelines

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Combines Agriculture Sector and LULUCF

- Not yet approved by COP for UNFCCC inventories
- Being investigated by SBSTA for implementation from 2015
- So currently working to 1996 guidelines (GPG 2000)

United Nations Framework Convention on Climate Change

SBSTA = Subsidiary Body for Scientific and Technological Advice

Tiers 1 & 2

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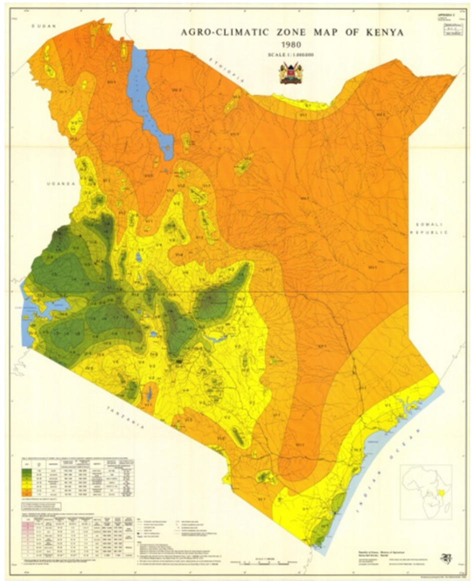
- **Tier 1**
  - Simplest to use
  - Default emission factors (EF)
  - Requires simple country-specific activity data (i.e. census data)

- **Tier 2**
  - Same methodological approach as Tier 1 but applies emission and stock change factors that are based on country- or region-specific data, *for the most important land-use or livestock categories*

Tier 3

- **Tier 3**
  - Models and inventory measurement systems, repeated over time, and driven by high-resolution activity data and disaggregated at sub-national level.
  - *These higher order methods provide estimates of greater certainty than lower tiers.*
  - Source estimates may include interannual variability.
  - Detailed disaggregation of livestock population according to animal type, age, body weight etc., can be used.
  - Models should undergo quality checks, audits, and validations and be thoroughly documented.



Default enteric EFs, Tier 1

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TABLE 4-3
ENTERIC FERMENTATION EMISSION FACTORS
(KG PER HEAD PER YR)

Livestock	Developed Countries	Developing Countries
Buffalo	55	55
Sheep	8	5
Goats	5	5
Camels	46	46
Horses	18	18
Mules and Asses	10	10
Swine	1.5	1.0
Poultry	Not Estimated	Not Estimated

All estimates are ± 20 %

Sources: Emission factors for buffalo and camels from Gibbs and Johnson (1993). Emission factors for other livestock from Crutzen et al. (1986).

Tier 1, Dairy Cows

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TABLE 4-4
ENTERIC FERMENTATION EMISSION FACTORS FOR CATTLE

Regional Characteristics	Cattle Type	Emission Factor (kg/head/yr)	Comments
***North America*:** Highly productive commercialised dairy sector feeding high quality forage and grain. Separate beef cow herd, primarily grazing with feed supplements seasonally. Fast-growing beef steers/heifers finished in feedlots on grain. Dairy cows are a small part of the population.	Dairy Non-dairy	118 47	Average milk production of 6,700 kg/head/yr Includes beef cows, bulls, calves, growing steers/heifers, and feedlot cattle.
***Western Europe*:** Hi dairy sector feeding h Dairy cows also used small dedicated beef feedlot feeding with g			
***Africa and Middle East*:** Commercialised dairy sector based on grazing with low production per cow. Most cattle are multi-purpose, providing draft power and some milk within farming regions. Some cattle graze over very large areas. Cattle of all types are smaller than those found in most other regions.	Dairy Non-dairy	36 32	Average milk production of 475 kg/head/yr. Includes multi-purpose cows, bulls, and young
***Indian Subcontinent*:** Commercialised dairy sector based on crop by-product feeding with low production per cow. Most bullocks provide draft power and cows provide some milk in farming regions. Small grazing population. Cattle in this region are the smallest compared to cattle found in all other regions.	Dairy Non-dairy	46 25	Average milk production of 900 kg/head/yr. Includes cows, bulls, and young. Young comprise a large portion of the population

Tier 1 emissions

EQUATION 4.12

EMISSIONS FROM A LIVESTOCK CATEGORY

$$\text{Emissions} = \text{EF} \bullet \text{population}/(10^6 \text{ kg/Gg})$$

Where:

Emissions = methane emissions from enteric fermentation, Gg CH_4/year
EF = emission factor for the specific population, kg/head/year
Population = the number of animals, head

EQUATION 4.13

TOTAL EMISSIONS FROM LIVESTOCK

$$\text{Total } CH_4 \text{ Emissions} = \sum_i E_i$$

Where:

Total Emissions = total methane emissions from enteric fermentation, Gg CH_4/year

index i = sums of all livestock categories and sub-categories
E_i = is the emissions for the i^{th} livestock categories and sub-categories

Tiers 2 and 3

Moving from Tier 1 to Tier 2 or 3

- Little specific guidance from IPCC

Actual distinction between Tier 2 and Tier 3 is fuzzy

- Whether Tier 2 or 3 is not important
- Important that detailed spatial and temporal data and country- or region-specific that increases accuracy *and reduces uncertainty*
- Tier 2 or 3 should be used for key source categories

Enteric fermentation and direct soil N_2O are key source categories for livestock

Tier 2 enteric methane

EQUATION 4.14

EMISSIONS FACTOR DEVELOPMENT

$$EF = (GE \bullet Y_m \bullet 365 \text{ days/yr}) / (55.65 \text{ MJ/kg } CH_4)$$

Where:

EF = emission factor, kg CH_4/head/yr

GE = gross energy intake, MJ/head/day

Y_m = methane conversion rate which is the fraction of gross energy in the feed converted to methane

Tier 2 sheep, UK

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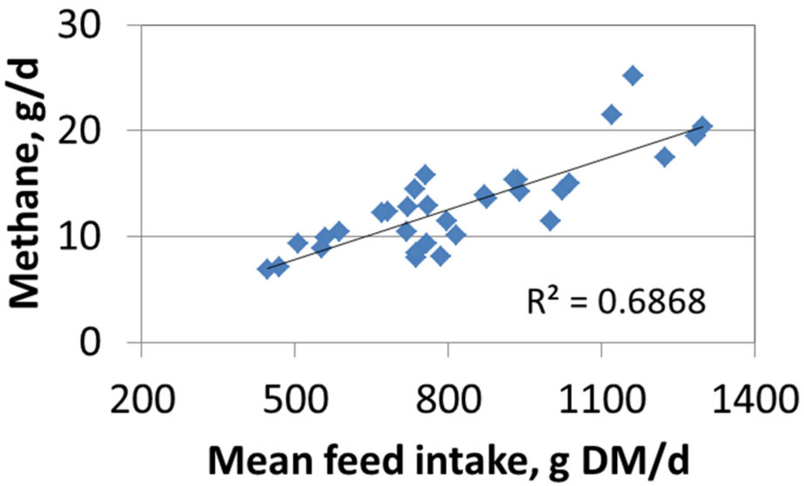

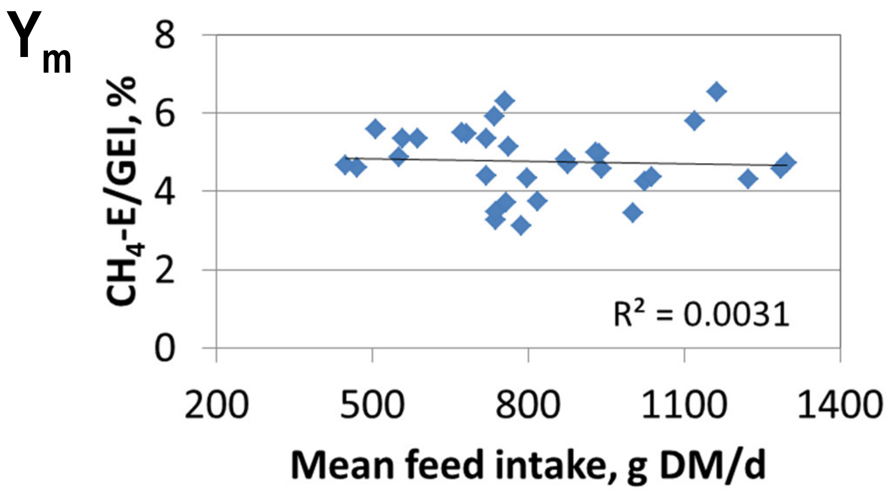

CH_4: Manures Default EFs (Tier 1)

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TABLE 4-5
MANURE MANAGEMENT EMISSION FACTORS
(KG PER HEAD PER YR)

Livestock	Developed Countries			Developing Countries		
	Cool	Temp.[a]	Warm	Cool	Temp.[a]	Warm
Sheep	0.19	0.28	0.37	0.10	0.16	0.21
Goats	0.12	0.18	0.23	0.11	0.17	0.22
Camels	1.6	2.4	3.2	1.3	1.9	2.6
Horses	1.4	2.1	2.8	1.1	1.6	2.2
Mules and Asses	0.76	1.14	1.51	0.60	0.90	1.2
Poultry[b]	0.078	0.117	0.157	0.012	0.018	0.023

The range of estimates reflects cool to warm climates. Climate regions are defined in terms of annual average temperature as follows: Cool = less than 15°C; Temperate = 15°C to 25°C inclusive; and Warm = greater than 25°C. The Cool, Temperate and Warm regions are estimated using MCFs of 1 %, 1.5 % and 2 %, respectively.

a Temp. = Temperate climate region.

b Chickens, ducks, and turkeys.

All estimates are ±20 %.

Sources: Emission factors developed from: feed intake values and feed digestibilities used to develop the enteric fermentation emission factors (see Appendix A); MCF, and B_o values reported in Woodbury and Hashimoto (1993). All manure is assumed to be managed in dry systems, which is consistent with the manure management system usage reported in Woodbury and Hashimoto (1993).

CH_4: Tier 2 Manures

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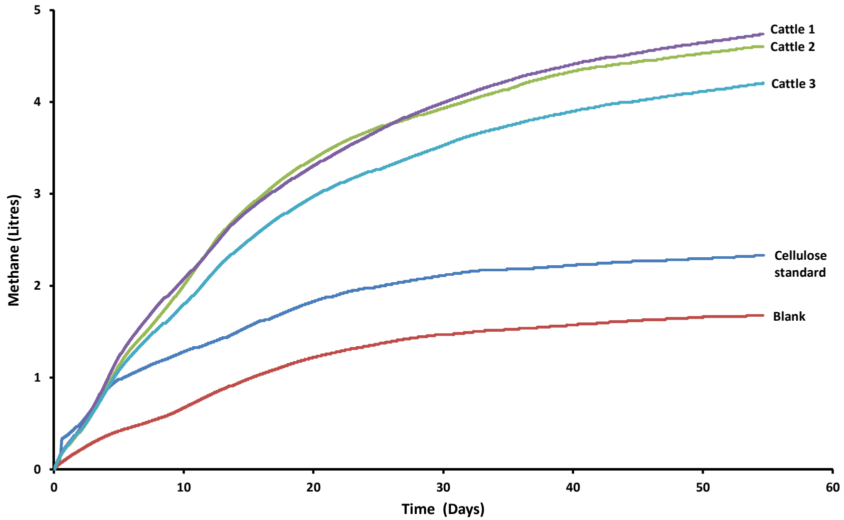
Lab scale characterisation of manures

$$EF_{MS} = VS \times 365 \times B_o \times 0.67 \times MCF$$



VS = volatile solids
Bo = total methane production potential
MCF = Methane Conversion Factor – varies with management practice

Nitrous oxide

- N_2O from grazing animals
- Direct N_2O from soils
  - Fertiliser applications
- Indirect N_2O
- Tier 1 uses table values
  - E.g. 1.25% N_2O-N/kg N-input for fertilisers
- Tier 2 - country-specific EFs

Comments on Tiers

- Greatest confidence with enteric fermentation
  - But as activity data improves on management and diet information we need better emission factors

- N_2O most uncertain and most use of Tier 1
- Carbon stock change for land use and land-use change becoming more developed
- Tier 3 uncommon generally for any category

Where next?

- For countries looking to improve to Tier 2 or higher, no one is going to do it for them
  - No “default” Tier 2 factors

- However, huge advantages for countries to work together to:
  - Share lessons learned, inventory knowledge, measurements, and methods
  - Collaborate to assist each other develop methodologies

Acknowledgements

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Agricultural UK GHG PLATFORM

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