MPI Policy and Trade

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2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 4, Chapters 10 and 11

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Purpose of this paper

1. To inform the Panel of proposed updates to New Zealand's agricultural greenhouse gas inventory, aimed at aligning it with the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Proposed updates include:

    a) Inclusion of enteric fermentation emissions for ostriches and emus

    b) Updating the methane conversion factor used to calculate methane emissions from dairy anaerobic lagoons

    c) Updating the methane emission factors for manure management for goats, horses, and donkeys

    d) Updating the $Frac_{GasMS}$ parameter for poultry

    e) Revising EF_1 where the IPCC 2006 default is used (organic amendments, crop residues, and N mineralised from mineral soil as a result of loss of soil carbon)

    f) Updating EF_3 (pasture range and paddock), for minor species where the default value is used.

2. The suggested changes would decrease reported emissions by approximately 168 kilotonnes (kt) of carbon dioxide equivalent (CO_2-e) emissions reported in 2023. This represents a 0.5% decrease in total agricultural emissions. This change would be applied retrospectively across the full time series.

Background

3. The 2019 Refinement to the 2006 IPCC Guidelines was developed to enhance the scientific robustness and methodological clarity of national greenhouse gas inventories. It provides updated default values, improved disaggregation by climate and species, and refined estimation methods for key agricultural sources.

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4. The new emission factors and parameters in the 2019 Refinement consider new research conducted since development of the 2006 guidelines. While adoption of the 2019 Refinement is voluntary under Decision 5/CMA.3, it is considered best practice for improving inventory accuracy and comparability.

5. The Inventory team reviewed relevant updates in:

    a) Volume 4, Chapter 10: Emissions from Livestock and Manure Management

    b) Volume 4, Chapter 11: N_2O Emissions from Managed Soils and CO_2 Emissions from Lime and Urea Application

6. Updates from Chapter 5 (Cropland) and Chapter 6 (Grassland) are out of scope for this exercise. These mostly relate to LULUCF.

Proposed changes – aligning the Inventory with the 2019 Refinement

Summary

7. Ostriches and Emus are proposed to be included as a separate species in the Inventory with the following parameters:

    a) Enteric Fermentation emissions of 5 kg CH_4 per head per year

    b) Manure management CH_4 emissions of 5.67 kg CH_4 per head per year

    c) Nex of 15.6 kg N per head per year

    d) 80% of manure deposited on pasture, 20% in solid storage

8. All other emission factors and methods follow those used for *Other Poultry*.

9. Changes to emission factors are summarised in Table 1.

Table 1 : Summary of EF updates from 2019 refinement

Emission Factor or parameter	2006 IPCC default value	2019 Refinement value
MCF for dairy anaerobic lagoons	0.74	0.6-0.76 (region specific)
MM CH_4 EF (kg CH_4 per hd per year)		
Goats	0.2	0.1
Horses	2.34	0.5
Donkeys	1.1	0.2
$Frac_{GasMS(Poultry)}$	0.25	0.4
EF_1 for organic N	0.01	0.006
EF_3 prp		
Poultry and pigs	0.01	0.004 (wet climate value of 0.006)
Alpacas, donkeys, horses	0.01	0.003

10. A detailed list of differences between the 2019 Refinement and the 2006 Guidelines is in the appendix.

11. The areas where updates to the New Zealand inventory were suitable are listed below.

Ostriches and Emus (update 1a)

An enteric fermentation default EF for ostriches has been developed

12. The 2006 Guidelines do not include default enteric fermentation emission factors for poultry of any kind. The 2019 Refinements developed a default enteric fermentation methane emission factor for ostriches. The default is 5 kg CH_4 per head per year. The value was derived from Frei et al. (2015) and the Danish National Inventory Report (Nielsen et al., 2018), assuming an average live weight of 120 kg per bird.

13. To implement this change, ostriches and emus must be disaggregated from the "Other Poultry" category, where they are currently grouped. The APS reports on the ostrich and emu population (LC8075) from 2007 onwards, showing a gradual decrease in their share of the "Other Poultry" category over time.

14. We assumed a constant emu and ostrich population prior to 2007. There is evidence of a "boom and bust" in the ostrich and emu population that occurred in the 1990's from news articles and other anecdotal sources, but we do not know the exact timing of the decline. In the absence of information, a constant population (2007 population) was chosen.

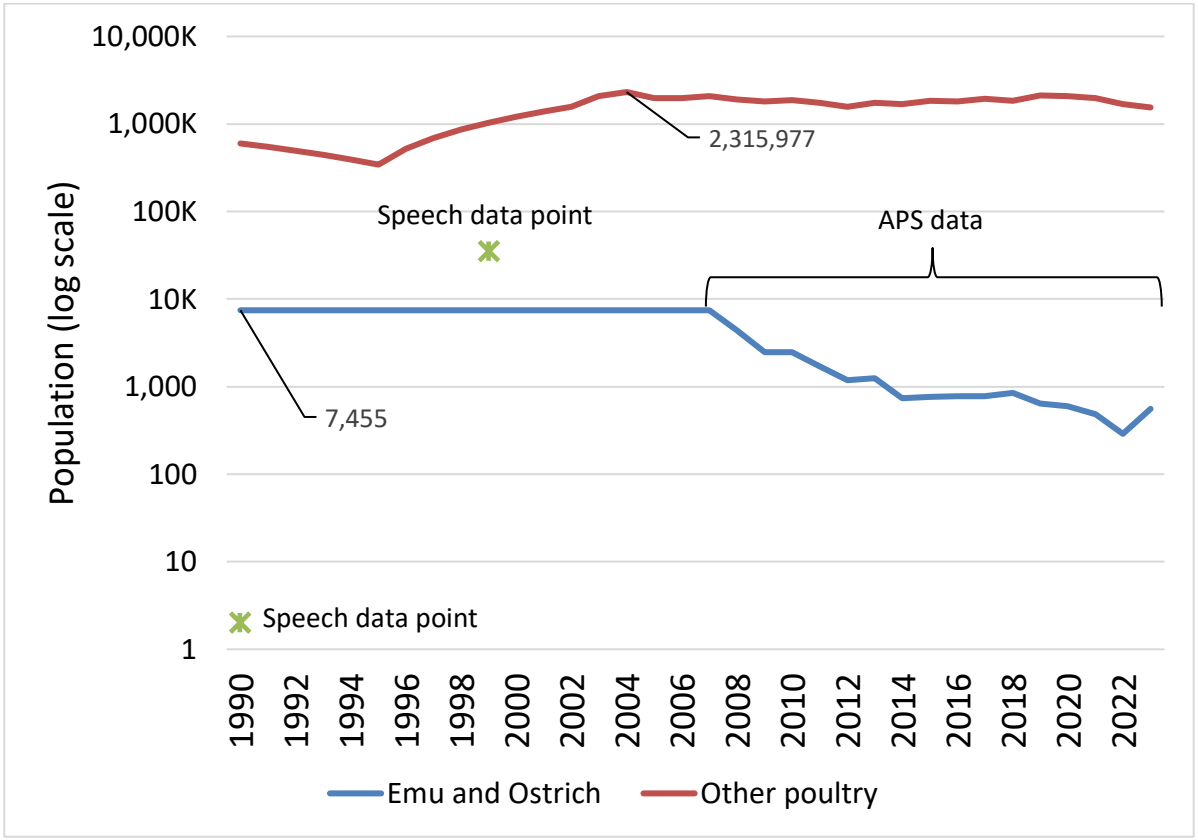
15. Below is some anecdotal data we are aware of but have chosen not to reflect in the population estimates.

    a) For the 1990–2006 period, population data are sparse. One of the few available sources is a 1999 public statement that provides anecdotal but useful estimates. This source states:

        - "Ten years ago (1989), Murray Gos, a Manawatu farmer, started out with one pair of emus."
        - "Today (1999) the national flock totals 15,000 emus spread over 150 farms."
        - "In 1994, the only ostriches in New Zealand, were the five zoo animals at Orana Wildlife Park just outside Christchurch."
        - "The first importation of incubating ostrich eggs came from Australia in August 1994, and the first importation of birds for farming, came from the UK in May 1995."
        - "These birds and the further importations of eggs, have led to a national flock of 20,000 birds in less than five years. "

    b) Based on these quotes the 1990 population of ostriches and emus was likely 2, and the 1999 population was likely 35,000. This is 3.5% of the "Other Poultry" population in 1999. These estimates are included in figure 1.

Figure 1: Estimated Ostrich and Emu population (log scale)



Associated Updates for Manure Management and Agricultural Soils

16. Disaggregating ostriches and emus also necessitates separate treatment for manure management and agricultural soil emissions. The following IPCC 2019 default values were applied:

    a) Methane emissions from manure management: 5.67 kg CH_4 per head per year (IPCC 2019, Table 10.15)

    b) Nitrogen excretion rate: 15.6 kg N per head per year (IPCC 2019, Table 10.19)

    c) Manure management system distribution (Table 10.19, footnote 11):

        i. 80% assumed to be deposited on pasture and range

        ii. 20% assumed to be managed in solid-based systems

17. For all other emission sources (e.g., indirect N_2O emissions), the same emission factors used for "Other Poultry" were applied to ostriches and emus.

Default values for MCFs for dairy manure management systems have been updated (update 1b)

18. New Zealand's agricultural inventory currently applies the Tier 2 methodology from the 2006 IPCC Guidelines to estimate methane emissions from dairy anaerobic lagoons.

19. This approach uses a Tier 2 equation derived from Equations 10.23 and 10.24 of the 2006 Guidelines, which link volatile solids (VS) to faecal dry matter (FDM). This equation only applies to mature milking cows.

$$CH_{4AL-dairy} = FDM \times (1 - ASH) \times B_0 \times 0.67 \times MCF \times MS$$

Where:

FDM is the faecal dry matter excreted by dairy cows (on pasture and stored in anaerobic lagoons) (kg head-1 month-1)

ASH is the ash content of manure, 0.08 (IPCC, 2006, default value)

B0 is the maximum CH_4-producing capacity of manure variable by species and diet, 0.24 (IPCC, 2006; Oceania default value, verified by Pratt et al., 2012)

0.67 is the conversion factor for converting CH_4 from cubic metres to kilograms (IPCC, 2006)

MCF is the CH_4 conversion factor, 0.74 (IPCC, 2006, table 10.17, default for uncovered anaerobic lagoons, average annual temperature 15 degrees Celsius, verified by Pratt et al., 2012)

MS is the fraction of total dairy manure excreted that ends up in anaerobic lagoons.

20. While Pratt et al., (2012) has verified the current MCF value, this research focused on B0 and methane emissions from anaerobic lagoons more broadly. It did not investigate MCFs directly, aside from including a range of values in sensitivity analyses.

21. The 2019 Refinement revises MCFs for manure management systems. The revised values are desegregated by climate zone rather than average annual temperature. The guidance states that in cases in which countries lie in multiple climate zones, it is good practice for compilers, if possible, to disaggregate livestock populations by climate zone.

22. Figure 10A.1 of the 2019 Refinement was used to identify New Zealand's climate zones. These zones were then matched to the corresponding anaerobic lagoon MCFs. Table 2 presents the results of this interpretation, showing the dominant climate zone for each region and the associated MCF value.

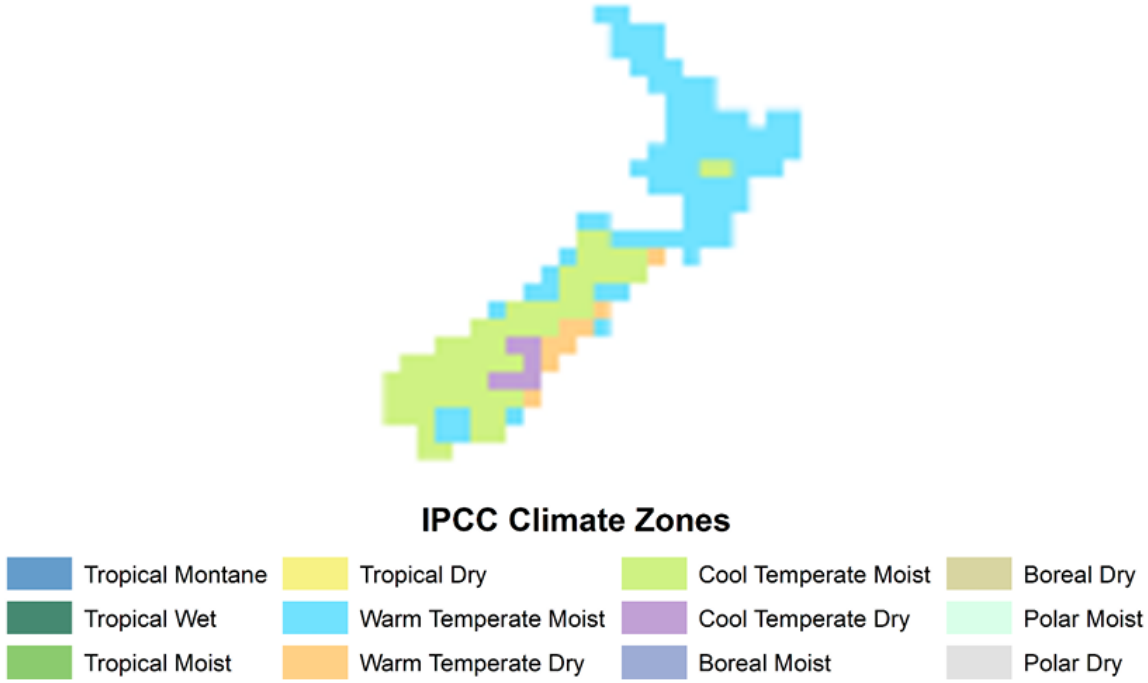


Table 2: Climate specific MCF for anaerobic lagoons

Region	Dominant climate zone	AL_MCF
Northland Region	Warm temperate, Moist	0.73
Auckland Region	Warm temperate, Moist	0.73
Waikato Region	Warm temperate, Moist	0.73
Bay of Plenty Region	Warm temperate, Moist	0.73
Gisborne Region	Warm temperate, Moist	0.73
Hawke's Bay Region	Warm temperate, Moist	0.73
Taranaki Region	Warm temperate, Moist	0.73
Manawatū-Whanganui Region	Warm temperate, Moist	0.73
Wellington Region	Warm temperate, Moist	0.73
West Coast Region	Warm temperate, Moist	0.73
Canterbury Region	Warm temperate, Dry	0.76
Otago Region	Cool temperate, Moist **(Revised to Warm temperate, Dry)**	0.6 **(0.76)**
Southland Region	Cool temperate, Moist	0.6
Tasman Region	Cool temperate, Moist **(Revised to Warm temperate, Moist)**	0.6 **(0.73)**
Nelson Region	Warm temperate, Moist	0.73
Marlborough Region	Cool temperate, Moist **(Revised to Warm temperate, Dry)**	0.6 **(0.76)**

Default values for methane emission factors by animal category, manure management system and climate zone have been updated (update 1c)

23. New Zealand uses IPCC (2006) default CH_4 emission factors for manure management for goats, horses, and donkeys (table 10.15 of the 2006 IPCC Guidelines). The Inventory currently uses the IPCC values for temperate developed countries and assumes all manure is deposited on pasture for these species.

24. The default manure management methane values have been revised in the 2019 Refinement. The 2019 Refinement gives the g CH_4 per kg volatile solids (VS) rather than a per head per year value. Table 3 shows the provided values and calculated annual manure management methane emissions factors.

Table 3: Manure management CH_4 EFs for goats, horses and donkeys

Species	kg VS per 1000 kg animal mass per day *Table 10.13A*	g CH_4 per kg VS (Pasture Range and Paddock) *Table 10.14*	Animal mass (kg)	Annual VS (kg)	Annual CH_4 (kg per head per year) - 2019 Refinement	Annual CH_4 (kg per head per year) - 2006 Guidelines
Goats	9	0.6	38	124.8	0.1	0.2
Horses	5.65	0.6	377	777.5	0.5	2.34
Donkeys	7.2	0.6	130	341.6	0.2	1.1

25. The calculated values are much lower than the 2006 default values. This is because the manure management system is now specified as pasture range and paddock, which has a lower methane emission factor than most other systems.

Default values for nitrogen loss fractions due to volatilization of NH_3 and NOx and leaching of nitrogen from manure management have been updated (update 1d)

26. $Frac_{GasMS}$ is the percent of managed manure nitrogen which volatilises as NH_3 and NO_x. New Zealand uses default values for $Frac_{GasMS}$ in Table 4. These values are consistent with the 2019 Refinement, except for the "other" manure management system. Poultry are the only species that send manure to "other" manure management system. "Other" accounts for 94-97% of poultry emissions depending on subtype.

27. In the current Inventory $Frac_{GasMS(other)}$ is set at 0.25. This value is the value from IPCC 2006 Table 10.22 for an *animal type* of Other (Other includes sheep, horses, and fur-bearing animals) and an MMS of Deep bedding.

28. Fick, 2011 states there are only 2 systems used in the poultry industry in New Zealand PR&P/free range and solid storage/dry lot litter management – other.

29. The 2019 Refinement provides a $Frac_{GasMS}$ for poultry manure in solid storage of 0.4 and poultry manure with litter of 0.4. Therefore, the poultry $Frac_{GasMS}$ should be altered from 0.25 to 0.4.

Table 4: $Frac_{GasMS}$ values

Manure management system	Livestock category	Current Inventory $Frac_{GasMS}$ Value (fraction)	2019 Refinement $Frac_{GasMS}$ Value (fraction)
Anaerobic lagoons	Dairy	0.35	0.35
	Swine	0.40	0.40
Daily spread	Swine	0.07	0.07
Anaerobic digester	Swine	0.25	0.25
Deep bedding	Swine	0.4	0.4
Composting passive windrow	Swine	0.6	0.6
Pit storage	Swine	0.25	0.25
Other	Swine	0.25	NO
	Poultry – broilers	0.25	0.4
	Poultry – layers	0.25	0.4
	Poultry – other	0.25	0.4

EF_1 has been disaggregated by nitrogen type and climate (update 1e)

30. EF_1 is a set of emission factors used for calculating direct N_2O emissions from synthetic fertilisers, organic fertiliser, crop residues, and N mineralised from mineral soil as a result of soil carbon loss.

31. New Zealand uses country-specific EF_1 values for urea fertiliser (0.0059) and dairy cattle effluent manure (0.0025) applied to soils (van der Weerden et al., 2016a and 2016b). The IPCC default value of 0.01 is used for other nitrogen. This emissions factor of 0.01 was verified as suitable for New Zealand conditions by Kelliher and de Klein (2006). However, the Kelliher and de Klein (2006) research focused on urea, rather than organic nitrogen sources, when verifying EF1 in New Zealand conditions.

32. The 2019 refinement provides emission factor values disaggregated by nitrogen type and climate (Table 11.1). New Zealand falls into the 'wet climate' category according to the IPCC definition. In wet climates the default value has been set at 0.6 percent of organic N inputs and 1.6 percent of synthetic N inputs.

33. We only propose updating the EF_1 for organic N inputs to reflect the 2019 refinement (from 0.01 to 0.006). This would apply to organic fertiliser (other than dairy), crop residues, and N mineralisation

34. We do not propose changing the EF_1 for non-urea synthetic fertiliser based on the 2019 Refinement. An alternative proposal based on New Zealand research has been submitted to the Panel, recommending EF_1 values for ammonium sulphate (AS), diammonium phosphate (DAP) and monoammonium phosphate (MAP) to take the same value as urea.

Table 5: Suggested EF_1 values with 2019 revision for organic fertiliser

Parameter	Value	Reference	Sources EF is applied to
EF_1	*0.01*	*IPCC (2019, table 11.1) Kelliher & de Klein, 2006*	*non-urea synthetic fertiliser. Noting the proposal to combine EF1 values.*
$EF1_{urea}$	*0.0059*	*Kelliher et al., 2014*	*Urea*
$EF1_{organic}$	*0.006*	*IPCC (2019, table 11.1)*	*Non manure organic fertiliser, Organic fertiliser (manure, other than dairy), crop residues, N mineralisation*
$EF1_{Dairy}$	*0.0025*	*van der Weerden et al. (2016a, 2016b)*	*Dairy manure*

EF_3 (pasture, range and paddock) has been updated (update 1f)

35. For minor livestock categories, New Zealand uses IPCC (2006) default value of 0.01 to calculate direct N_2O emissions from manure deposited on soil. Research conducted in New Zealand confirmed that the IPCC default emission factors and methodology are appropriate for New Zealand conditions (Carran et al., 1995; de Klein et al., 2003; Muller et al., 1995).

36. Carran et al., 1995 focuses on sheep and beef land, de Klein et al., 2003 focusses on cow urine, and Muller et al., 1995 focuses on sheep urine.

37. The 2019 Refinement suggests an updated value of 0.004 (wet climate value of 0.006) for poultry and pigs, and 0.003 for other animals (alpacas, donkeys, and horses). The inventory team believes it is now more defensible to use these emissions factors for alpacas, llamas, donkeys, and horses as they incorporate additional research conducted after the publication of the 2006 Guidelines.

Effect of proposed changes on emissions

47. The suggested changes would result in a decrease of approximately 168 kilotonnes of carbon dioxide equivalent (CO_2-e, GWP 100 AR5) reported in 2023. This equates to 0.5 percent of New Zealand's total agricultural greenhouse gas emissions.
48. At a more disaggregated level, the proposed change would change reported emissions from:
    a) Enteric fermentation by +0.08 kt CO_2-e, 0 percent;
    b) Manure management by -50.29 kt CO_2-e, -0.83 percent; and
    c) Agricultural soils by -118.3 kt CO_2-e, -1.86% percent.

Figure 2: Total agricultural emissions before and after moving to 2019 refinement

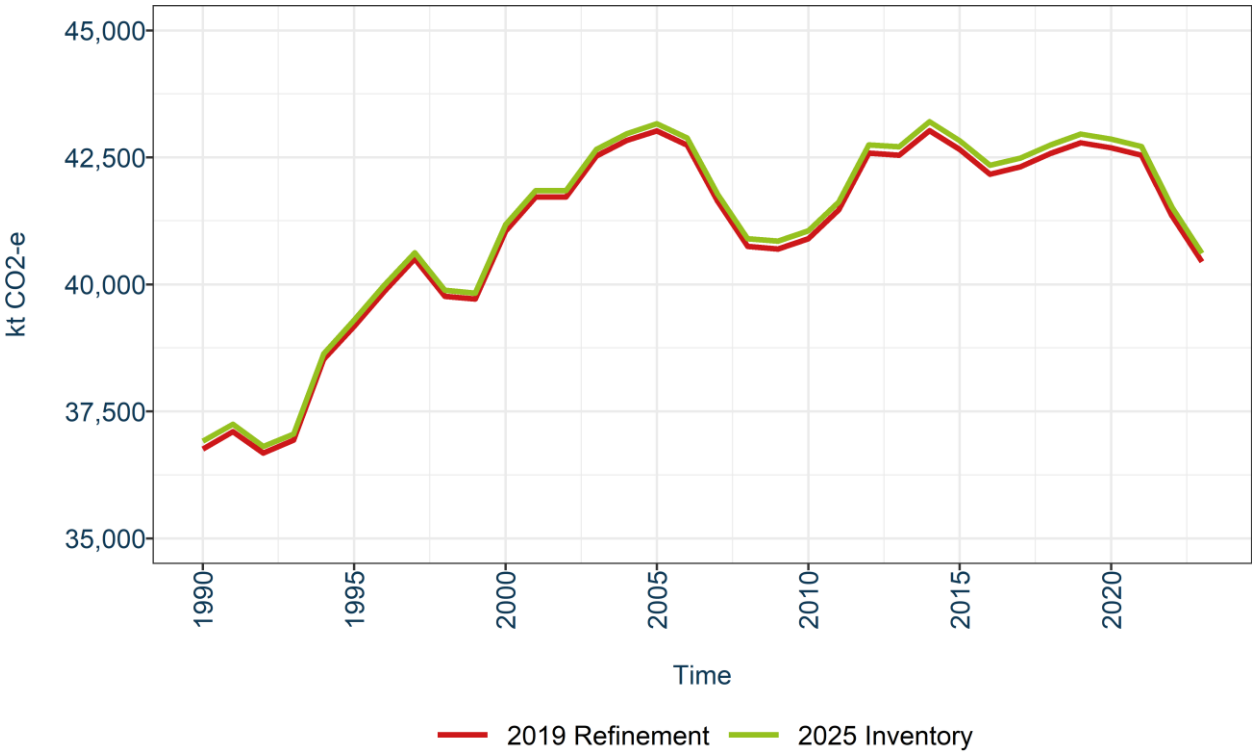


Table 6: Total agricultural emissions Carbon Dioxide Equivalent (kt CO_2-e)

Description	1990	2023	Change in emission outputs between 1990 and 2023	Percentage change in emission outputs between 1990 and 2023
Inventory 2025	36,915.10	40,613.00	3,698	10%
2019 Refinement	36,760.55	40,444.53	3,687	10%
Difference between current and updated model	-154.56	-168.47		
Percentage difference between current and updated model	-0.42%	-0.41%		

Next steps

49. The Inventory team intend to implement these changes in preparation for the 2026 Inventory submission.

Recommendations

The Greenhouse Gas Inventory Team recommends that the Agricultural Inventory Advisory Panel:

50. **Note** that the Inventory team plans to implement several updates in the 2026 inventory model aimed at aligning it with the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, including:
    a) Inclusion of enteric fermentation emissions for ostriches and emus
    b) Updating the methane conversion factor used to calculate methane emissions from dairy anaerobic lagoons
    c) Updating the methane emission factors for manure management for goats, horses, and donkeys
    d) Updating the poultry $Frac_{GasMS}$
    e) Revising EF_1 where the IPCC 2006 default is used (organic amendments, crop residues, and N mineralised from mineral soil as a result of loss of soil carbon)
    f) Updating the EF_3, pasture range and paddock, for minor species where the default value is used.

Noted



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9 / 4 / 2026

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Appendix – 2019 refinements considered

Overarching

Refinement	2006 IPCC Guidelines Section Number	2019 Refinement Section Number	Update needed?
A split of the default EFs by high/low productivity systems was introduced in place of the allocation between developing and developed countries used in the 2006 IPCC Guidelines	10.2.2/10.	10.2.2	Not at this time as New Zealand does not have low productivity local subsistence systems counted by the APS.

Enteric Fermentation

Refinement	2006 IPCC Guidelines Section Number	2019 Refinement Section Number	Update needed?
Enteric fermentation default EFs for cattle (both dairy and non-dairy) and buffalo have been revised	TABLE 10.11	TABLE 10.11	No, New Zealand uses T2 methods for cattle and does not currently account for buffalo separate to the dairy herd.
Tier 2 Ym values have been updated for cattle and buffalo	TABLE 10.12	TABLE 10.12	No, New Zealand uses country specific Ym for cattle.
A simplified tier 2 approach to estimate feed intake has been updated	10.2.2	10.2.2	No, New Zealand uses country specific methods to calculate feed intake.
Enteric fermentation default EFs for sheep and goats have been updated	TABLE 10.10	TABLE 10.10	No, NZ uses T2 method for sheep and country specific EF for goats.
An enteric fermentation default EFs for ostriches has been developed	None	TABLE 10.10	Yes, NZ currently groups Ostriches and Emus as :other Poultry" long with duck, geese, and turkeys. No enteric fermentation

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			emissions are calculated for poultry
A tier 2 approach has been developed to estimate enteric emissions from goats		10.3.2	No, NZ uses a T1 approach for goats.

Manure management

Refinement	2006 IPCC Guidelines Section Number	2019 Refinement Section Number	Update needed?
Default values for CH4 EFs by animal category, manure management system and climate zone have been updated and provided as g CH4 per VS;		TABLE 10.14	Yes. NZ uses CS emission factors for MM methane apart from goats, horses, mules and asses. These need updating.
Default values for VS excretion rates have been introduced in terms of kg VS/1000 kg animal mass/day;	None	TABLE 10.13A	Yes, these values are needed to update the per head MM CH4 for goats horses and donkeys.
Default values for B0 have been updated;		TABLE 10.16A	No. Currently NZ only uses B0 to calculate the methane from dairy anaerobic lagoons. The value for this (0.24) is the same between the two guidelines.
Default values for MCFs for manure management systems have been updated;		TABLE 10.17	Yes, The climate specific disaggregation allows us to chose the value that best matches each region
A tier 2 approach to calculate a country- or region-specific MCF has been introduced			Maybe, this approach could be investigated. However it is not a 1-1 upgrade.
A tier 2 approach to calculate MCF for biogas systems has been introduced;			No, NZ inventory does not use biogas
Definitions of manure management systems have been updated		TABLE 10.18	“Solid storage and drylot” is now split into “Solid storage” and “Dry lot”. All changes associated with this were implemented with

		the update to pig calculations in the 2025 inventory.
Default values for Nex rates have been updated	TABLE 10.19	No, NZ uses CS Nex for all species other than Horses, Mules and asses, Other Poultry. These are unchanged from 2006 in the refinement.
Default values for liveweight for animal categories have been updated		No, NZ uses country specific liveweights.
Default values of crude protein contained in the diet of cattle and buffalo (by subcategory) have been introduced		No, NZ uses country specific diet parameters
Default values for the fraction of nitrogen in feed intake of livestock that is retained by cattle and buffalo (by subcategory) have been updated	TABLE 10.20	No, NZ uses T2 method to determine nitrogen retained
A tier 2 method for swine and poultry has been introduced		No, but could be considered for future improvement
Default EFs for direct N2O emissions from manure management have been updated	TABLE 10.21	No, most of these improvements were incorporated with the 2024 pig improvements. Anaerobic lagoons EF3 remains 0, EF3 Poultry manure remains 0.001
Default values for nitrogen loss fractions due to volatilization of NH3 and NOx and leaching of nitrogen from manure management have been updated	TABLE 10.22	Yes, FracGasMS for poultry “Other” MMS is currently 0.25, revised value for poultry manure with litter is 0.4. Other values are wither unchanged from 2006 guidelines or were incorporated in the 2024 pig changes
Ensuring consistency with reporting for N2O emissions		Revised advice on nitrogen flows through animal and crop production systems.

from managed soils has been updated			This is an area that could be improved but would require more information on the nitrogen content of bedding, better tracking of crop residues used for bedding, and likely other factors.

Agricultural soils

Refinement	2006 IPCC Guidelines Section Number	2019 Refinement Section Number	Update needed?
Default EFs to estimate direct N2O emissions from managed soils reported in table 11.1 have been updated			See below
EF1 has been disaggregated into values for synthetic fertilizer inputs in wet climates, other nitrogen inputs in wet climates and all nitrogen inputs in dry climates			Yes, revision required for EF1 used to estimate organic amendments, crop residues, and N mineralisation
EF1_FR for flooded rice fields has been updated and further disaggregated according to water regimes			No, no rice is grown in New Zealand
EF3PRP, CPP for cattle (dairy, non-dairy and buffalo), poultry and pigs has been updated and further disaggregated according to climate regimes			Yes, poultry and pigs currently use default values and should be updated
EF3PRP, SO for sheep and other animals has been updated			Yes, default EF3 used for alpacas, mules and asses, and horses
method to estimate annual amount of nitrogen in crop residues (above and below			No, New Zealand uses a country-specific method

ground) annually returned to soils has been updated	
Default values for NAG(T), NBG(T), RAG(T), RS(T) and DRY have been updated	No, NZ uses CS values
Default EF2 has been eliminated from table 11.1; however, a tier 1 guidance to estimate N2O emissions from cultivation of histosols has been revised. A more clear reference to the Wetlands Supplement has been introduced	Not at this stage. We will coordinate our approach with MfE, who are considering this guidance along with the IPCC 2013 Wetlands Supplement.
Default EF4 (nitrogen volatilization and redeposition) and EF5 (leaching/run-off) have been updated; In addition, EF4 has been further disaggregated according to climate regimes	Yes, the default values are used for EF4 and EF5. However as these have a larger impact on emissions they will be considered in a separate update.
Default FracGASF (volatilization from synthetic fertilizer), FracGASM (Volatilization from all organic nitrogen fertilizers applied, and dung and urine deposited by grazing animals) and FracLEACH-(H) (nitrogen losses by leaching/run-off in wet climates) have been updated; moreover, FracGASF has been further disaggregated by type of synthetic fertilizer.	No, NZ uses CS values for these EF.