



MPI Policy and Trade

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Refining estimates of nitrogen leaching

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Purpose of this paper

1. To seek a recommendation from the Panel regarding whether the Fra_{CLEACH} values used to calculate indirect N_2O emissions from agriculture should be changed based on recently completed research by Welten et. al (2021). Two options are proposed:
 - a. Adopt an updated Fra_{CLEACH} value for nitrogen deposited on grazing land of 0.08 (covering both dairy and sheep and beef, and others such as deer and goats). This includes using a weighted Fra_{CLEACH} for fertiliser inputs based on its usage across grazing and cropping systems; or
 - b. Continue to use a uniform Fra_{CLEACH} value of 0.07 of key N inputs for grazing systems (status quo).
2. Attached to this paper are the reports;
 - a) Welten B, Mercer G, Smith C, Sprosen M, Ledgard S. 2021. *Refining estimates of nitrogen leaching for the New Zealand agricultural greenhouse gas inventory*. Report for Ministry for Primary Industries (unpublished);
 - b) Independent peer review of *Refining estimates of nitrogen leaching for the New Zealand agricultural greenhouse gas inventory* by Professor Russ Tillman;
 - c) Inventory change approval form completed by Professor Russ Tillman; and
 - d) Email correspondence from Joel Gibbs to members of the Panel on 20 December 2022.

Background – nitrogen leaching in the agriculture inventory

3. In New Zealand, agricultural soils are a major source of nitrous oxide (N₂O) which contribute significantly to total agricultural greenhouse gas emissions.
4. Indirect N₂O emissions from leached nitrogen (N) is estimated using the F_{CLEACH} parameter in the NZ agricultural greenhouse gas inventory. This is based on the Intergovernmental Panel for Climate Change (IPCC) best practice guidelines (2006) and the recent report by Welten et al (2021). This F_{CLEACH} parameter accounts for the proportion of N applied to agricultural land that is lost through leaching and run-off into water bodies (i.e., groundwater, rivers, wetlands). A proportion of the leached N is subsequently transformed and emitted as N₂O.
5. Calculations of emissions from leached N use the following equation, however the input parameters vary depending on whether you are calculating this based on a cropping or grazing system.

$$F_{\text{CLEACH}} = (\text{Leached N}) / (F_{\text{SN}} + F_{\text{ON}} + F_{\text{PRP}} + F_{\text{CR}} + F_{\text{SOM}})$$

Where:

F_{SN} = synthetic nitrogen fertiliser use

F_{ON} = organic fertiliser use

F_{PRP} = manure deposited by grazing livestock in pasture, range and paddock

F_{CR} = decomposition of crop residues left on fields

F_{SOM} = nitrogen mineralisation associated with loss of soil organic matter

6. Based on the recommendations of the Panel in 2021, the New Zealand GHG inventory uses a F_{CLEACH} of 0.10 and 0.07 for cropping and grazing systems respectively.

Proposed change – F_{CLEACH} parameter

7. At the Panel meeting in 2021, MPI introduced the recently completed research by Welten et al., (2021) and the report recommendations for consideration. As a result, the F_{CLEACH} of 0.10 for cropping systems was adopted.
8. However, there was concern from Panel members in regard to the proposed F_{CLEACH} value of 0.08 for grazing systems given a lot of this was based on modelled results using OVERSEER. This related to the review of OVERSEER by the Scientific Advisory Panel, and whether the pasture quality values used in OVERSEER were consistent with those used in the agricultural GHG inventory model.
9. As a result of this, the F_{CLEACH} value of 0.07 was retained for grazing systems and an action was created for MPI to follow up with the authors of the research to determine the validity of the concerns by Panel members and any affect this might have on the overall recommendation.

10. Researchers confirmed that while OVERSEER does use pasture quality values that are not completely consistent with the agriculture GHG inventory model, the impact of this is very minor and does not impact the final recommendation.
11. This discussion with researchers was emailed to Panel members by Joel Gibbs on 20 December 2022 (see attached material) and no concerns were raised as a result of this.
12. As such, we are proposing that the F_{CLEACH} value of 0.08 for grazing systems be adopted within the methodology for the agriculture inventory.
13. MPI would also like to reaffirm our intention to apply the leaching value for F_{SN} based on a weighted basis dependent on the ratio of N fertiliser applied to grazing and cropping systems (approximately 90:10 based on recent data from Statistics New Zealand, which is also reasonably consistent across the entire reporting period).
14. Given the F_{CLEACH} for grazing systems was unchanged following the 2021 Panel meeting, MPI thought it reasonable to leave the leaching value for F_{SN} at 0.07 for the 2022 publication of the national GHG inventory.

Independent Review

15. Following the submission of the final report and recommendations, MPI commissioned an independent review of the methodology and analysis carried out by AgResearch to determine whether there was sufficient evidence to support the suggested change to the agricultural inventory. Professor Emeritus Russ Tillman, a soils expert from Massey university was contracted to undertake this review, which he completed in September 2021.
16. He found that the research had successfully met the primary aim of the research [refer paragraph 8], with a clear set of recommendations that are well supported by data. In doing so, they have compiled a comprehensive database of the experimental trials used in New Zealand that have measured on-farm leaching losses of nitrogen.
17. Professor Tillman reviewed the alternative approaches that were provided in the report and agrees with their final recommendation on the suggested approach. He is confident that the use of the recommended values of F_{CLEACH} in the NZ agricultural GHG inventory will result in more accurate estimates of indirect N_2O emissions from leaching and runoff than under the current methodology.
18. Professor Tillman made a couple of additional points that are worth noting, although do not compromise the validity of the recommended values of F_{CLEACH} . These include:
 - a) The values of F_{CLEACH} in the report being derived by dividing the measured or modelled amount of N leached by the sum of various N inputs. These N inputs vary between grazing and cropping, and in both cases some possible inputs are not included. Notably, this omits F_{SOM} from the F_{CLEACH} for

cropping systems, and is important that future inventory compilers are aware of this in the calculations.

- b) The values of F_{CLEACH} reflect the regional distribution of farming systems and management practices as they exist in New Zealand in 2020, based on the weighting that has been used to generate the F_{CLEACH} values. These values will need to be re-evaluated in the future as we expect the regional distributions and farming practices to continue to change in New Zealand, as they have been doing historically.

Proposed change – summary

19. We propose using the following F_{CLEACH} values for N inputs across the entire time series:
 - a) $F_{\text{SN}} = 0.082$
 - b) $F_{\text{ON}} = 0.08$
 - c) $F_{\text{PRP}} = 0.08$
 - d) $F_{\text{SOM}} = 0.10$
 - e) $F_{\text{CR (CROP N-FIXING)}} = 0.10$
 - f) $F_{\text{CR (CROP RESIDUES)}} = 0.10$
 - g) $F_{\text{CR (PASTURE RENEWAL)}} = 0.08$
20. F_{CLEACH} values of 0.10 have already been applied as a result of the 2021 Panel recommendations but have been shown above to aid in transparency.
21. As mentioned earlier, the value for F_{SN} of 0.082 is a result of calculating this on a weighted basis using the ratio of N fertiliser applied to grazing versus cropping systems.
22. Data from Statistics New Zealand on N fertiliser use by land use type shows only minimal fluctuations in the suggested ratio of the reporting period. MPI's suggestion is to use a static F_{CLEACH} value of 0.082 until such a time that available data suggests that this needs to be recalculated.

Effect of proposed changes

23. The proposed change would result in a relatively small increase in emissions from agriculture. Our analysis indicates that this would increase total agricultural emissions by 76.3 kilotonnes $\text{CO}_2\text{-e}$, or 0.19 per cent based on 2020 data from the 2022 submission of the National Greenhouse Gas Inventory.
24. All of these emissions would occur within the Agricultural Soils reporting category, increasing reported emissions from that category by just under 1 per cent based on 2020 data.

Table 1: Comparison of total agricultural emissions before and after incorporation of proposed Frac_{LEACH} values for 1990 and 2022.

Emissions (kt CO ₂ -e)		1990	2020	Change in emission outputs between 1990 and 2020 (kt CO ₂ -e)	Per cent change in emission outputs between 1990 and 2020
Total emissions from Agriculture category (kt CO ₂ -e)	2022 (1990–2020) emissions estimate using previous Frac _{LEACH} values	33,792.9	39,425.5	5,632.7	16.7
	2022 (1990–2020) emissions estimate using new Frac _{LEACH} values	33,849.3	39,501.8	5,652.5	16.7
	Difference in emission estimates compared with current inventory	56.4	76.3	19.8	
	Per cent difference in emission estimates	0.17	0.19		

Table 2: Comparisons of Agricultural Soils emissions before and after incorporation of proposed Frac_{LEACH} values for 1990 and 2020.

Emissions (kt CO ₂ -e)		1990	2020	Change in emission outputs between 1990 and 2020 (kt CO ₂ -e)	Per cent change in emission outputs between 1990 and 2020
Total emissions from Agricultural Soils (kt CO ₂ -e)	2022 (1990–2020) emissions estimate using previous Frac _{LEACH} values	5,300.9	7,882.8	2,581.9	48.7
	2022 (1990–2020) emissions estimate using new Frac _{LEACH} values	5,357.4	7,959.1	2,601.7	48.6
	Difference in emission estimates compared with current inventory	56.4	76.3	19.8	
	Per cent difference in emission estimates	1.06	0.97		

Opportunities and risks

- All research carried out via the Greenhouse Gas Inventory Research (GHGIR) Fund is done for the direct purpose of increasing the accuracy of reported emissions. Undertaking this research provides us with the opportunity to increase the accuracy of reported agricultural emissions by adopting the findings within the inventory model.

26. However, all updates to the agricultural inventory must be suitably robust and defensible to international reviewers. If changes are made which do not adhere to these criteria, then this poses a significant risk to the credibility of the inventory, other policy, and international targets which utilise this as a source of information.

Next steps

27. Two options are proposed:

Option a

Adopt a $Frac_{LEACH}$ value of 0.08 for grazing systems. This includes using a weighted $Frac_{LEACH}$ for fertiliser inputs based on its usage across grazing and cropping systems.

Option b (status quo)

Continue using a $Frac_{LEACH}$ value of 0.07 across all grazing systems.

28. If the Panel recommends the adoption of option a, this recommendation will go to the Deputy Director General (Policy and Trade) for approval to include in the 2023 Inventory.



Recommendations

It is advised that the Agricultural Inventory Advisory Panel:

29. **Recommend** the proposed Frac_{CLEACH} values as outlined in option a

Agree

Approved

Gerald Rys
Principal Science Advisor, Science and Skills Policy
Chair Agricultural Inventory Panel

Date 14/02/2023