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ESTIMATING NATIONAL GREENHOUSE GAS EMISSIONS FROM FERTILISER AND LIME

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Abstract

The application of nitrogen fertilisers, lime and dolomite lead to the production of greenhouse gases (GHG). In 2016 these sources were responsible for 2.7 million tonnes of carbon-dioxide equivalent emissions, or about 3.4% of New Zealand's gross GHG total. Nitrogen fertilisers and lime have also been one of New Zealand's fastest growing emission sources mainly due to the increased use of urea over this period.

This paper will discuss how fertiliser emissions are currently estimated in the national greenhouse gas inventory, and will also describe the different types of fertiliser which are included in New Zealand's emissions reporting. An analysis of the emissions generated per tonne of nitrogen fertiliser and lime is also included.

Context

As a country that has ratified the United Nations Framework Convention on Climate Change (UNFCCC) New Zealand is required to estimate anthropogenic greenhouse gas emissions. These estimates are published annually in the National Inventory Report (the inventory).

The inventory helps to evaluate whether New Zealand is on track to meet the targets the Government has set for reducing greenhouse gas emissions (Ministry for the Environment, 2017). The two long-term (2030 and beyond) targets are:

- 30 per cent below 2005 emission levels by 2030 (equivalent to 11 per cent below 1990 levels by 2030)
- 50 per cent below 1990 emission levels by 2050

Under the reporting rules, New Zealand must report all anthropogenic emissions, including those from agriculture which made up almost half (49.2 per cent) of New Zealand's gross emissions in 2016 (Ministry for the Environment, 2018). Figure 1 show the portion of New Zealand's agriculture emissions from different sources.

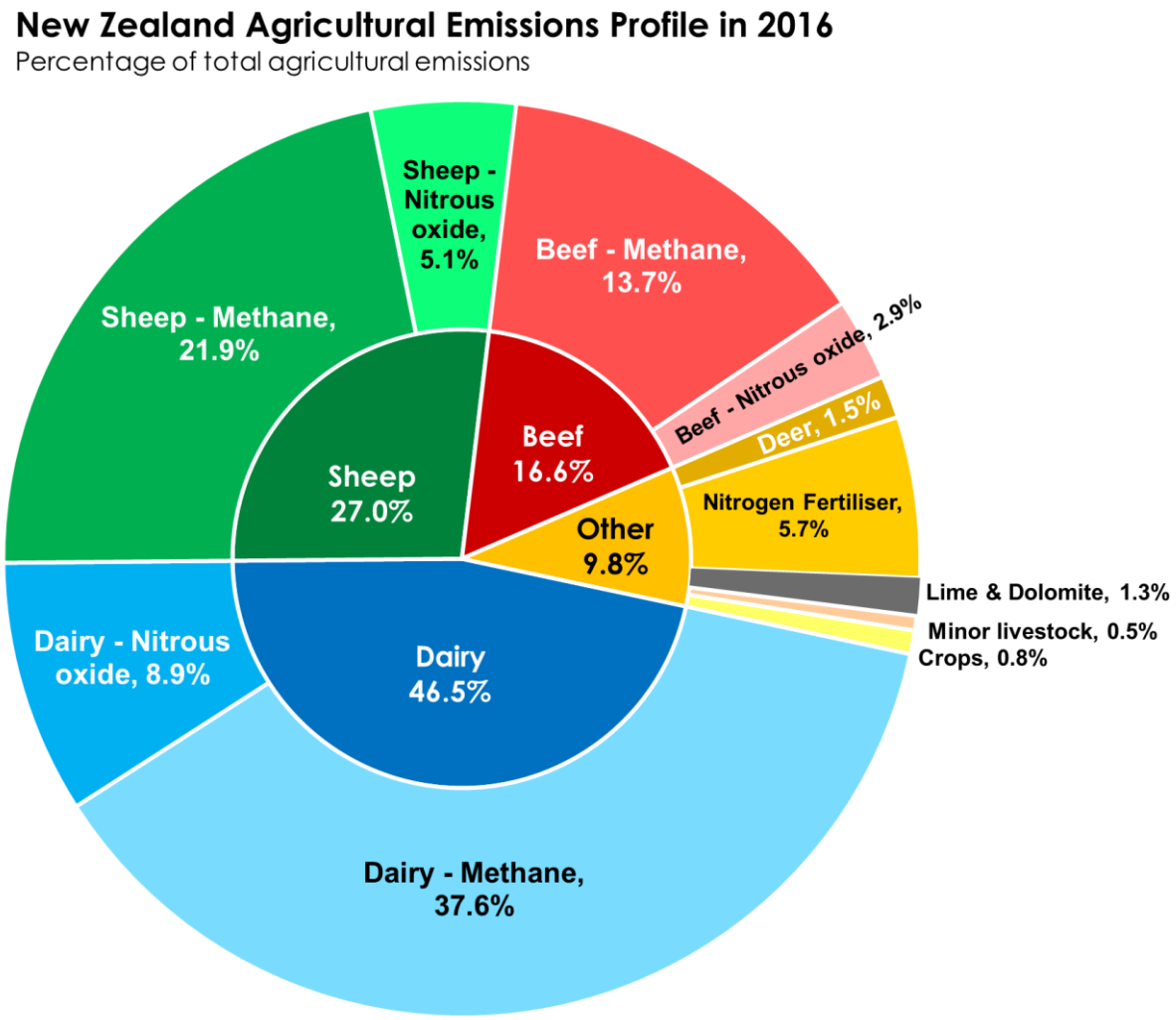

Figure 1. *Profile of agricultural emissions by activity (Biological Emissions Reference Group, 2018).*

About half of New Zealand's agriculture emissions are from dairy cattle, one quarter are from sheep and around one-sixth from beef cattle.

Emissions from the application of nitrogen fertiliser and lime make up about 7% of agriculture emissions, which equated to about 2.7 million tonnes of carbon dioxide equivalent (CO_2-e) emissions in 2016.

Processes behind the production of fertiliser and lime emissions

The application of nitrogen fertilisers lead to the production of the greenhouse gas nitrous oxide (N_2O), while application of urea, lime and dolomite result in emissions of carbon dioxide (CO_2). Urea application results in emissions of both N_2O and CO_2.

N_2O emissions from nitrogen fertiliser is produced from direct and indirect pathways. Direct N_2O comes from the soils to which nitrogen has been added. Indirect emissions come from the volatilisation (evaporation or sublimation) of nitrogen from the land. A fraction of this volatilised nitrogen returns to the ground during rainfall and is then re-emitted as N_2O. Indirect emissions also arise from leaching and runoff of nitrogen (IPCC, 2006).

Nitrogen fertiliser and lime emissions in New Zealand

New Zealand reports emissions from five different types of fertiliser and lime:

- Urea fertiliser coated with urease inhibitor (which generates CO_2 and N_2O)
- Urea fertiliser NOT coated with urease inhibitor (which generates CO_2 and N_2O)
- Other (non-urea) nitrogen fertilisers (which generate N_2O)
- Lime (which generates CO_2)
- Dolomite (which generates CO_2)

N_2O emissions from nitrogen fertiliser are estimated using country-specific emission factors. CO_2 emissions from urea, lime and dolomite are estimated using basic methodology and emission factors set by the Intergovernmental Panel on Climate Change (IPCC) (Ministry for the Environment, 2018).

The addition of lime (e.g., calcic limestone ($CaCO_3$), or dolomite ($CaMg(CO_3)_2$) results in CO_2 emissions as the carbonate limes dissolve and release bicarbonate (2HCO3-), which breaks down further into CO_2 and water (IPCC).

Table 1 shows New Zealand's estimated emissions from the application of fertiliser and lime onto soil. Emissions or removals caused by manufacture or transport of fertiliser and lime are not included in these estimates, and are relatively small compared to the figures in table 1.

The contribution of different gases such as N_2O and CO_2 to climate change is often expressed by using the concept of carbon-dioxide equivalent (CO_2-e). This metric allows the emissions of different gases to be added together and compared in terms of their impact on climate change. About 1.8 million tonnes of CO_2-e emissions are due to the use of urea, and 0.5 million tonnes of CO_2-e emissions are due to the use of lime (Ministry for the Environment, 2018).

Table 1. *Estimated GHG emissions from the application of fertiliser and lime in New Zealand in 2016, showing relative contribution to total agricultural emissions and gross emissions (Ministry for the Environment, 2018).*

	Emissions (tonnes CO2-e)	Percentage of New Zealand agricultural emissions	Percentage of New Zealand gross emissions
Urea fertiliser coated with urease inhibitor	463,691	1.2%	0.6%
Urea fertiliser NOT coated with urease inhibitor	1,343,367	3.5%	1.7%
Other (non-urea) nitrogen fertiliser	388,044	1.0%	0.5%
Lime	503,645	1.3%	0.6%
Dolomite	10,766	0.0%	0.0%
Total nitrogen fertiliser, lime and dolomite	2,709,514	7.0%	3.4%

New Zealand's fertiliser and lime emissions have risen significantly since 1990 (as shown by figure 2). These emissions have been one of New Zealand's fastest growing emissions sources, alongside road transport and dairy cattle. In 1990, emissions from the use of nitrogen fertiliser

and lime were 0.67 million tonnes of CO_2-e. By 2016, emission had risen to 2.71 million tonnes of CO_2-e. The main reason behind this rise is an increase in the use of nitrogen fertiliser, particularly urea (Ministry for the Environment, 2018).

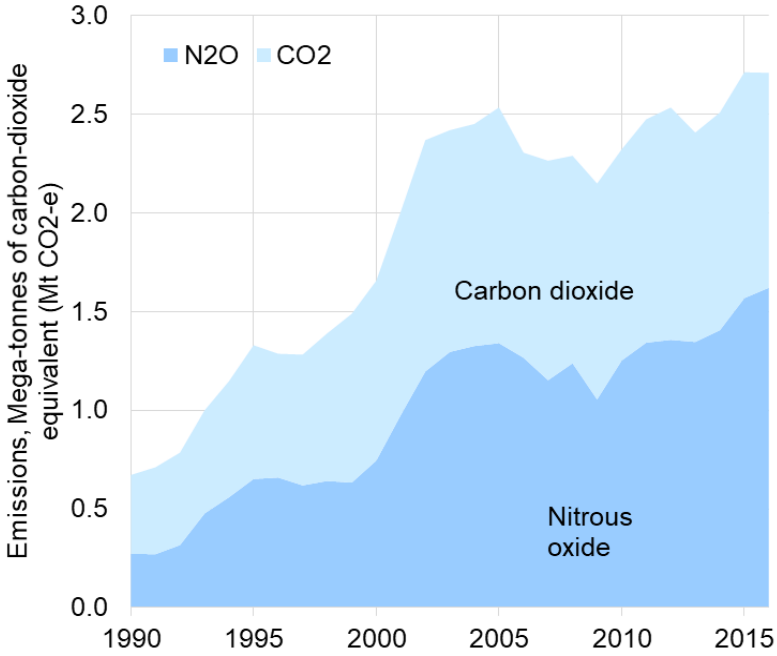

Figure 2. *New Zealand GHG emissions from the application of nitrogen fertiliser, lime, and dolomite, 1990-2016, split by gas.*

Emissions per unit of fertiliser use

Table 2 shows the emissions that would be generated from the application of one tonne of the different types of fertiliser and lime discussed in this paper (for urea and other nitrogen fertiliser, the one tonne only includes the nitrogen component of the fertiliser). These figures were calculated using the parameters and emission factors listed in the agriculture chapter of New Zealand's national inventory report (Ministry for the Environment, 2018). This table shows that the application of one tonne of nitrogen in the form of urea results in around five tonnes of CO_2-e emissions.

Table 2. *Emissions from the application of one tonne of different types of fertiliser, split by type of emission. For urea and other nitrogen fertiliser, this tonne only includes the nitrogen component of the fertiliser.*

	N_2O emissions (tonnes N_2O)				
	Direct emissions	Indirect emissions - volatilisation	Indirect emissions - leaching	CO_2 emissions (tonnes CO_2)	Total emissions (tonnes CO_2-e)
Urea fertiliser coated with urease inhibitor	0.009271	0.000864	0.000825	1.594203	4.86
Urea fertiliser NOT coated with urease inhibitor	0.009271	0.001571	0.000825	1.594203	5.07
Other (non-urea) nitrogen fertiliser	0.015714	0.001571	0.000825		5.40
Lime				0.440000	0.44
Dolomite				0.476667	0.48

The figures in table 2 can be compared with average annual emissions from a dairy cow, beef cow and sheep, which are 2.7, 1.8 and 0.4 tonnes of CO_2-e per year respectively (Parliamentary Commissioner for the Environment, 2016). In emissions terms, a tonne of nitrogen fertiliser is roughly equivalent to the annual emissions from two dairy cows or three beef cows. It is important to note however that these per animal emission figures are averages, and actual per-animal emissions for a farm will differ depending a range of factors including livestock productivity, soil characteristics and water content, and feed quality/feed type.

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