A SCIENTIFIC PERSPECTIVE ON BIOLOGICAL EMISSIONS FROM AGRICULTURE

An Executive Summary

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INTRODUCTION

The science is clear.
When debating emissions,
consider your goals.

This paper was commissioned by the Parliamentary Commissioner for the Environment in the context of the Commissioner's investigation into the merits of an "all-gases, all-sectors'" Emissions Trading Scheme. Motu brought together a group of New Zealand climate change and agriculture specialists to respond to five specific questions, and their corollaries, posed by the Commissioner.

WHAT IS THE CURRENT STATE OF UNDERSTANDING OF THE CLIMATE IMPACTS OF EACH GREENHOUSE GAS (CH_4, N_2O, CO_2)? WHERE IS THERE CONSENSUS AND DIVERGENCE?

There has been a robust scientific understanding of the climate impacts of each of the greenhouse gases (GHGs) in question for many decades.

- Nitrous oxide (N_2O) and carbon dioxide (CO_2) are both long-lived gases. N_2O has an atmospheric lifetime of about 120 years, whereas CO_2 can remain in the atmosphere for centuries to millennia. Tonne for tonne, however, N_2O is a much more powerful greenhouse gas than CO_2.
- Methane (CH_4) is a short-lived gas with an atmospheric lifetime of about 12 years. Despite its short lifetime, CH_4 is also a more powerful greenhouse gas tonne for tonne than CO_2.
- Carbon dioxide is the largest single contributor to human-induced climate change, however, because of the high volume of CO_2 emissions and its long lifetime.

Estimates of the relative potency of the different gases are updated from time to time. This is not evidence of diverging scientific opinion, but simply reflects the fact that increasing amounts of GHGs in the atmosphere change the radiative efficiency of these gases. In addition, evidence about additional indirect warming effects and about the natural processes by which GHGs are removed from the atmosphere is increasing with on-going research, which can result in revisions to the exact numbers.

PUTTING ASIDE FEASIBILITY, WHICH GREENHOUSE GASES SHOULD BE THE CENTRAL FOCUS OF SHORT-, MEDIUM- AND LONG-TERM MITIGATION EFFORTS? WHY?

The overriding need to reduce carbon dioxide emissions is scientifically uncontentious. There is a strong, direct relationship between cumulative emissions of CO_2 and global warming; ultimately, net CO_2 emissions have to decline to zero for the climate to stabilise. In this sense, therefore, CO_2 must always be the "central" focus of mitigation efforts in the short, medium and long term.

This research was funded by The Parliamentary Commissioner for the Environment. The authors gratefully acknowledge this assistance.

Since N_2O is also a long-lived gas, it should also, feasibility aside, decline to zero. In practice, there are (in principle) ways to take more CO_2 out of the atmosphere than is being put in by human activities. This could enable some N_2O emissions to continue if that was deemed desirable, compensated for by a net global removal of CO_2 from the atmosphere.

By contrast, emissions of CH_4 and other short-lived climate forcers do not have to decline to zero for the climate to stabilise; they only have to stop increasing.

The debate over the desirability and urgency of CH_4 mitigation turns on whether, and in what circumstances, effort should be put into mitigating CH_4 emissions in addition to mitigating emissions of long-lived greenhouse gases.

On one side, advocates of a comprehensive multi-gas approach point to the cost-effectiveness of this approach, as it would allow CO_2 emissions to be reduced to zero just a little more slowly, so the same maximum (peak) warming could be achieved as under a CO_2-only strategy but the net cost of mitigation would be lower. In addition, recent studies suggest that without mitigation of agricultural non-CO_2 gases, CO_2 emissions would have had to peak already or in the very near future to leave a reasonable chance of not exceeding the current internationally agreed target of a maximum 2°C warming above pre-industrial levels.

On the other side, advocates of a focus on long-lived gases, or exclusively on CO_2, argue that putting effort into short-lived gases misses the point that every emission of CO_2 today matters for the ultimate peak temperature. They argue for a "peak CO_2 first" approach, where concerted action on short-lived gases starts only once it is clear that CO_2 emissions are trending downwards. They express concern that CO_2 mitigation promises to be difficult and costly enough without adding extra costs to the economy by trying to address other gases as well.

These differences are about how to apply generally agreed scientific and economic understanding to policy. They are not about the science itself. The drivers for the two 'sides' reflect different assessments of political and economic conditions.

CONSIDERING ISSUES OF FEASIBILITY, HOW MUCH EMPHASIS SHOULD BE PLACED ON MITIGATION OF AGRICULTURAL NON-CO_2 GASES? WHY?

New Zealand farmers have already made substantial efficiency gains that have constrained the rise in total agricultural GHG emissions. There may be scope for more consistent implementation of current best practice on farms, and there are some new options on the horizon, but total agricultural emissions are projected to continue to rise in the short to medium term because of planned production increases.

To achieve overall reductions in agricultural GHG emissions would take some or all of the following:

- Constraining total production at current levels while increasing efficiency gains
- Future scientific and technological breakthroughs
- Shifts in production (i.e., away from ruminant animals).

HOW ARE METHANE AND NITROUS OXIDE EMISSIONS FROM THE AGRICULTURE SECTOR CALCULATED, AND HOW ACCURATE ARE SUCH CALCULATIONS?

Current methods for measuring emissions of CH_4 and N_2O at the level of individual animals or paddock scale are resource intensive and subject to considerable uncertainty. It would not be feasible to use these methods as tools to directly estimate and monitor farm-level emissions across the country.

The only on-farm calculator widely in use in New Zealand is the nutrient budget model OVERSEER® (Overseer), which has a mixed reputation within the farming community. Overseer was not designed for GHG accounting, but it does capture many key pieces of information. It does not currently consider the different soil conditions or microclimates within a farm, which can be crucial for N_2O emissions. In general, Overseer is better used to track changes over time (trends), rather than specific numerical estimates.

On a broader scale, New Zealand's National Inventory of GHGs includes estimates of agricultural GHG emissions. These are based on agricultural statistics of total production and average productivity per animal. Basic biological equations and agricultural statistics are then used to relate production per animal to feed intake. Estimated feed intake, in turn, is used to estimate methane emissions per animal and total nitrogen excreted. The estimated total nitrogen excreted is used to estimate nitrous oxide emissions as a percentage of total nitrogen excreted or applied in the form of nitrogen fertilisers. While these equations are simple, and miss differences between farms, they are based on an increasing number and diversity of empirical measurements, and are considered broadly robust at the regional and national level.

WHAT METHODS ARE USED TO DETERMINE CO_2 EQUIVALENCIES FOR OTHER GREENHOUSE GASES? WHERE IS THERE CONSENSUS AND DIVERGENCE ON HOW BEST TO DO THIS?

There are numerous metrics available to calculate an 'exchange rate' between GHGs. Metrics typically use CO_2 as the benchmark and compare other gases to it. The two most common metrics are:

Global Warming Potential (GWP) – used, with a time horizon of 100 years, as the standard metric in IPCC Assessments and under the UNFCCC. GWP measures the cumulative warming effect of the emission of 1 kg of a GHG over a given time period relative to the cumulative warming effect of 1 kg of CO_2 over the same period. The current best estimate of GWP100 for methane is 28.

Global Temperature change Potential (GTP) – increasingly discussed as an alternative. GTP measures the global temperature change at a given point in the future due to the emission of 1 kg of a GHG relative to the temperature change at the same future point due to 1 kg of CO_2. The current best estimate of GTP100 for methane is 4. This is lower than for GWP100 because most of the warming effect of methane occurs in the first three decades after emission, not in 100 years' time, whereas GWP100 calculates the gases' cumulative effect over the first 100 years.

To be most efficient, the metric chosen needs to be the best proxy for the aims of global climate change policy, such as limiting total temperature change (focus on the peak temperature) and/or limiting the rate of temperature change (focus on the temperature path) and/or limiting overall damages from climate change. Both the merits of the metrics themselves and the policy goals are vigorously debated by some New Zealand climate scientists, but the distinction between metrics and goals is often fuzzy.

Nonetheless, there is consensus that:

- the right value depends on the policy goal and could change substantially over time; and
- if the main policy goal is to cost-effectively limit global average warming to 2 degrees above pre-industrial levels, then the value of CH_4 should be less than the GWP100 value of 28 until global CO_2 emissions have begun to decline steadily towards zero.

How much less? As noted above, the arguments reflect judgments about politics, economics and the intersection of policy and science.

One argument goes that if the goal is to limit warming to about 2 degrees at lowest global economic costs, CH_4 must be regarded as having a value of at least 10 relative to CO_2 today. This argument is based on the fact the GTP100 of CH_4 is more than 10 when climate-carbon cycle feedbacks are included, and the assessment that 100 years is an extremely generous time horizon for limiting warming to near 2 degrees and would also cater for moderately higher levels of warming such as 2.5 and possibly even 3 degrees.

Another strand of debate is the current GTP100 value of 4 for CH_4 (excluding climate-carbon cycle feedbacks) may be more appropriate for today, given that the current priority must be to reduce CO_2 emissions. Potential revisions to metrics – which may be appropriate in the event that progress is made on CO_2 – could be conducted periodically alongside other potential revisions to targets, reviews of progress, etc.

With regard to New Zealand's economic self-interest, it is by no means clear which metric is best.

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