# Solutions to the Environmental and Climatic Challenge

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The following is a brief outline of the N cycle, Greenhouse Gases (GHG) and an evaluation of the current and future solutions to meet the environmental and climatic change required by farmers.

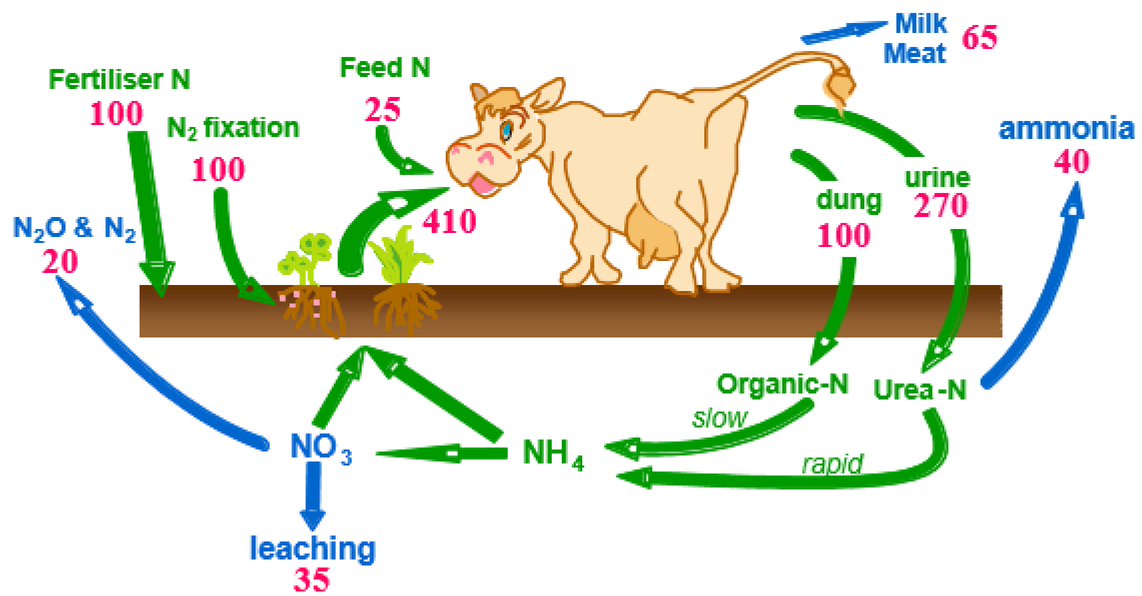
## N Cycle

The N cycle (Figure 1) shows how N inputs from fertiliser, feed and the atmosphere (through clover fixation) move from the soil to the plant, through the animal (using some for growth and milk production), out through urine and dung, and back into the soil where it is incorporated into organic matter or taken up by plants. Nitrogen is exported from the cycle via products (milk, meat and feed), and lost from the cycle via gas (volatilisation, denitrification) and drainage (N leaching).

Key points:

- The cow does not create N: N eaten 410 + 25 – N Product 65 – Dung + Urine 370 = 0
- N needs to be in nitrate form to be leached
- To get N leaching need both a N surplus and drainage.
- Farm gate N surplus (kg N/ha/year) = the difference between N inputs and N outputs (225 - 65 = 160).

**Figure 1** **N Cycle (an example; numbers in kg N/ha/year)**

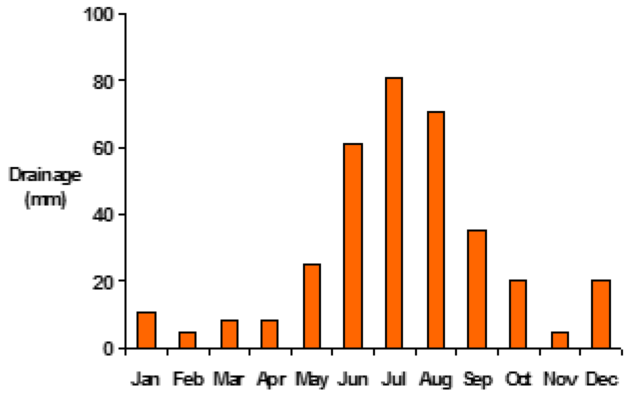


## Drainage

Drainage of excess water through the soil profile is needed to get leaching. Therefore, as annual drainage increases, generally total annual N leached increases, until there is no more surplus nitrate to leach. Drainage is driven by the amount of water the soil can hold, water applied (rainfall and irrigation), evapotranspiration and run-off. The ability of soils to hold water are affected by soil properties. Drainage will be higher in sandier free-draining soils than poorer-draining soils. In poorer-draining soils, there are relatively greater N losses via denitrification and lower losses via leaching compared to that for free-draining soils.

The timing of when this drainage occurs is a key factor when considering mitigations. Annual drainage for a Waikato farm is shown in Figure 2. The more nitrate in the soil before drainage events, the more N is leached. Most of the nitrate at risk of being leached is in urine patches, making autumn/winter a high risk time for N leaching as there is a build-up of urine patches and low plant demand for N. Cultivation over these months also releases nitrate into the soil that is at risk of being leached.

**Figure 2 Average drainage pattern (mm/month) for a Waikato Farm**




## Greenhouse Gases (GHG)

Dairy farms primarily emit two GHGs: Methane ($CH_4$) from enteric fermentation in the rumen, and nitrous oxide ($N_2O$) arising mainly from denitrification of urinary N in the soil and nitrogen fertiliser application. Agriculture is responsible for about 50% of total GHG emissions in New Zealand. Agriculture's contributions to national emissions of methane ($CH_4$) are 86% and nitrous oxide ($N_2O$) 95% (Ministry for the Environment, 2017). From 1990 to 2015, total enteric fermentation emissions from dairy cattle have increased 130%. Total $N_2O$ emissions increased 51% over the same period (Ministry for the Environment, 2017). <u>A 6-fold increase in the application of synthetic nitrogen fertiliser since 1990, increased supplementary feed inputs and an 88% increase in the size of the national dairy herd over the same period have been the main drivers for this change in emissions</u> (Ministry for the Environment, 2017).

***NZ has committed to the Paris Agreement for 30% lower GHG emissions by 2030***

Table 1 details the breakdown of dairy farm GHG in $CO_2$-equivalents.

**Table 1 Average NZ Dairy Farm GHGs in $CO_2$-equivalents**

| GHG | % IN $CO_2$ EQUIVALENTS | BREAKDOWN OF % $CO_2$ EQUIVALENTS |
|---|---|---|
| **METHANE ($CH_4$)** | 66% | Rumen 97%; Dung and FDE [1/] 3% |
| **NITROUS OXIDE ($N_2O$)** | 19% | Excreta 75%, N fertiliser 22%, FDE 3% |
| **CARBON DIOXIDE ($CO_2$)** | 15% | Feeds 46%, N fertiliser 30%, P K S fertiliser 4%, lime 5%, Fuel 5% Electricity 10% |

Note 1 FDE = farm dairy effluent

## Mitigation Options

**<u>Reduce N eaten (N inputs): apply less N fertiliser, less N eaten</u>**

1. **Less N fertilis**er:

   *Profit* maintained or improved where farmers can apply less N fertiliser for the same amount of pasture eaten i.e. an improvement in N use efficiency (NUE %; N outputs/N inputs). If apply less N fertiliser, eat less pasture and produce less milk, profit will dependent on whether the cost savings both in N fertiliser and other costs are greater than the lost milk income..

   *Environment:* Gains greatest if remove May-July applied N followed by Jan-April N with smaller gains for the rest of the season. If eat same amount of feed very small gains in reducing GHG (reduced nitrous oxide), if eat less pasture then gain in GHG reductions.

2. **Reduce feed eaten per hectare** by:
   a. Less milk solids from fewer cows
   b. Reduce days in milk through early culling in autumn
   c. Produce same amount of milk from less cows so less feed eaten per kg MS. Only small reductions in N leached where cow liveweight increases with increasing MS per cow, over lactation. Lincoln University Dairy Farm (LUDF) cow liveweight has increased for 460 kg Lwt doing 440 MS/cow up to 490 kg Lwt at 500 MS/cow. Implementation is also a challenge as requires more monitoring and a higher pasture management skill as both Owl Farm and LUDF have found.
   d. Reduce replacement rate

   *Profit*: Can be maintained when match feed supply close to demand and reduce costs. Costs follow increases in feed eaten/milk production closely. However, some farmers find it difficult to reduce costs when reducing feed eaten as it is a system change and requires a different approach/way of thinking.

It is well documented that well implemented, low and high supplement systems return a similar return on asset (ROA). Low input systems returning higher ROA at low milk price, high input systems, higher ROA at high milk price). However, the challenge is low input systems require low cost structures, and some farmers are not keen to run this type of system.
*Environment*: Systems that can reduce N eaten and therefore N surplus reduce N leached. Low input systems have a smaller footprint/ha, both for N leached (unless urine is captured and spread) and GHG than for high input systems.

3. **Improve feed quality** so less kg DM eaten for same amount of MS
   *Profit*: More profit as less feed required
   *Environment*: N leached shows little change as increased quality is usually associated with increased N% of feed. GHG positive as it reduces feed eaten.

4. **Reduce N content of supplementary feed or crops eaten**
   The reduction in N leached dependant on the total reduction in N eaten. If a feed has a low N% but more of it is fed, it could increase N leaching. Fodder beet has lower N content per kg dry matter than kale.
   Feed Type and GHG (from lowest to highest emissions per kg DM):
   'Waste' feeds (e.g. kiwifruit, vegetable) < by-products (Brewer's grain, Molasses) < maize silage ≅ pasture silage < cereals, brassica < PKE
   *Profit*: Cost of supplement, crop and yield are key factors that drive the profit from feeding a low N supplement or crop.

5. **Capture a proportion of the surplus N** excreted by the cows
   N leaching can be reduced by capturing some of the surplus N over the high risk months and redistributing the N at times and in places that increases N utilisation. Off-paddock facilities for autumn or winter use; improved effluent management.
   *Profit*: These options require capital investment and result in more management decisions, stock movement and effluent spreading. Excellence in implementation can be a challenge. Standinf cows off affects staffing, animal health (particularly lameness), effluent systems and if feed out on the system, feed requirements and management.
   *Profit:* Difficult to increase/maintain.. Need significant improvement in pasture eaten from no pugging damage and reduction in regrassing costs.
   *Environment*: Positive for reducing N leached; neutral or negative to GHG as feed eaten unchanged or increased, more methane and nitrous oxide from effluent and compost barns.

**<u>Other</u>**

6. **Plantain**:

   Plantain has been shown to reduce N leaching through several mechanisms; slightly lower N% than ryegrass and if it makes up more than 30% of the diet the urine is diluted (less N per urine patch). Plantain also appears to be have an effect in the soil of slowing nitrification from ammonium to nitrate. However, to get these benefits at a system level may require a significant change to the farm system to get plantain to be ,say 40% of the diet over the high risk months Feb-May to get a significant reduction in N leached.

   The companion species, if plantain is sown as a diverse pasture also affects the N leached. If sown with clover there could be no reduction in N loading in the urine patch.

7. **Salt**:

   Trials have shown feeding salt increases water intake and reduces N concentration in the urine patch. This could be a practical solution when able to be added to other supplement in the autumn. More research is needed on any negative effects to soil and animal health if fed over 3-4 months and the practicality of getting cows to consistently eat up to 200g salt per cow a day.
   *Profit*: Cost to feed salt but not high.
   *Environment*: Reduction in N leached; no change or small decrease in GHG if same amount of feed eaten

## Future Mitigations

1. Low N cows: More N in dung than urine [Seven year research project underway]
2. Animal selection for low methane
3. Vaccines and additives to reduce animal methane emissions