Request for response to Petition of Steve Abel on behalf of Greenpeace: Cut Synthetic Fertilizer, for our Climate and Rivers

This submission from the Fertiliser Association of New Zealand is in response to your request to Ravensdown Ltd and Ballance Agri-Nutrients, to provide written evidence to the Environment Select Committee on the petition.

Attention: Ged Lynch, Clerk of Committee, environment@parliament.govt.nz.

Due: 30 August 2021

Summary

- It would be economically catastrophic to ban nitrogen fertiliser, and it would not achieve environmental aspirations.
- Input controls achieve neither environmental nor economic outcomes.
- There needs to be consistent direction, and coherent polices across both our response to water quality and climate change to achieve economic and environmental aspirations.
- A mix of co-ordinated regulatory and non-regulatory levers is needed to enable enhanced land use practices that leave a lighter footprint.
- Enabled practices need to be evidence-based and have ongoing evaluation incorporated from the onset.
- Good stewardship has to be core to brand for New Zealand's primary products.

Mineral Fertilizers: Feeding the World

Today, it would be impossible to feed the planet without mineral fertilizers.

The nitrogen produced by the Haber-Bosch synthesis process for mineral fertilizers is vital for producing large crop yields. Scientific research published in 2008 estimated that the lives of nearly half of the world's population (48%) are only made possible by Haber–Bosch produced nitrogen. (Erisman et al., 2008)

Role of nitrogen fertiliser in world food production

Half of the world's food production is dependent on nitrogen fertiliser. Nitrogen is the key building block of protein and is essential for growing food. While nitrogen supply from the recycling of manure, waste, composts and sludges are an important part of nutrient supply to the food system, alone they are not sufficient to feed the current world population.

There is increasing concern that use of nitrogen fertiliser to support the world's population is unsustainable – both because of the use of fossil fuels to manufacture nitrogen and because of the impact of loses to the environment when the nitrogen is applied to land.

Globally, creating food security for a rapidly growing population while minimising environmental impact is being addressed in a number of ways:

- Improved management of productive land areas, reducing impact on biodiversity by reducing land clearance.
- Reducing wastage in food production, storage and transportation systems.
- Improving land management practices so that nutrients are managed well and losses are reduced.
- Improving recycling of wastes (promoting the circular economy).
- Developing innovations and technologies which result in reduced emissions from nutrients applied to land.

- Innovations in the manufacture of nitrogen fertiliser1.

A number of these approaches are particularly relevant in a New Zealand context.

Early agriculture

The earliest forms of agriculture—known as 'shifting agriculture'—were based on slash and burn rotations, requiring a rotation over long periods of time. With slash and burn rotations yields reduced after a few years due to nutrient depletion, so the cycle needed to restart on a new area.

With the onset of permanent agriculture, manure became the basic input of nutrients for plant production. With increased urbanisation the circulation of nutrients from animals and humans into the soil became more difficult. The development of modern agriculture and increased food demand resulted in a search for methods to improve nutrient efficiency and replace the nutrients removed in food.

Composts and organic materials release nutrients as they breakdown through the actions of soil living micro-organisms, releasing plant available nutrients and building soil organic matter. Legume cover crops can also introduce additional nitrogen through the symbiotic relationship with rhizobium bacteria which 'fix' nitrogen from the atmosphere. In pastoral soils, clover remains an important legume for just this purpose.

Pastoral soils typically build soil carbon over time. This occurs through the production (and degradation) of the fine, dense root systems and through grazing with the return of organic matter in dung and uneaten herbage. In cropping, cultivation exposes soil organic matter to air and enables more rapid degradation of organic matter. Therefore, pastoral soils tend to have very high organic contents compared to cropping soils[2].New Zealand soils also tend to have higher organic matter contents than other soils studied internationally[3].

Long-term field trials (160 years) from Rothamsted in England, have shown that with regular inputs of compost, the amount of organic matter in soil slowly accumulates over many decades until an equilibrium is reached (Figure 1). Soils have the capacity to store only a defined amount of organic matter, with continued plant residues or animal manure inputs required to maintain the equilibrium organic matter content.

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[1] Technology development is heading towards the ability to manufacture nitrogen fertiliser without the use of fossil fuels – and may be possible within a decade. In the Haber-Bosch process, hydrogen and nitrogen are reacted together at high temperatures and pressures to produce ammonia, from methane, water and air, using steam methane reforming. This requires high energy use and is the key source of carbon dioxide emissions in nitrogen fertiliser manufacture. The best way to reduce carbon emissions when making ammonia is to use low-carbon hydrogen. One of the most likely options for creating carbon-free hydrogen at scale is 'green hydrogen.' Green hydrogen is produced using water electrolysis to generate hydrogen and oxygen, using sustainable electricity in the process. Work is already underway to pilot this type of approach in New Zealand at Kapuni focussed at generating green urea and hydrogen for heavy goods transport see https://ballance.co.nz/Kapuni-hydrogen-project.

[2] International Fertiliser Association, integrated plant nutrient management: increasing yields and improving soil health

[3] http://earth.waikato.ac.nz/staff/schipper/download/soilcarbon.pdf

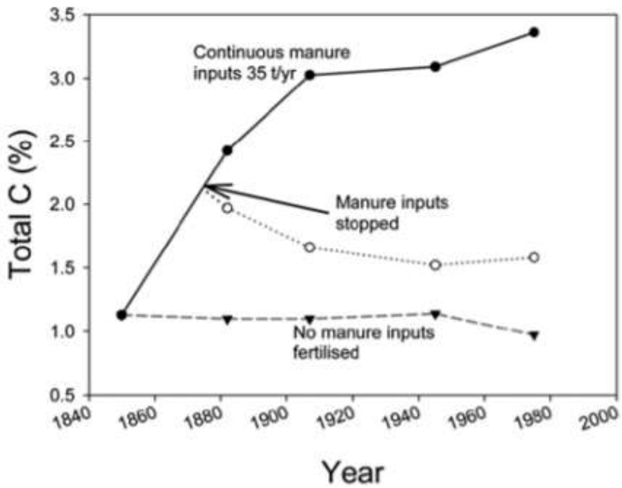


Figure 1: Organic matter changes at the Rothamsted long-term trials. The dashed line is from a soil used to grow cereal without manure or fertiliser inputs. The solid line represents the same soil with continuous organic natter inputs of organic matter (35 t/year). The open circle represents the soil when organic matter inputs were stopped in 1870[4]

Organic Fertilizers: Feeding the Soil

Organic fertilizers increase soil health, supporting carbon capture and plant growth.

Soil organic matter (SOM) has a strong influence on the overall health of soil and its beneficial functions. By introducing soil organic carbon that helps build up SOM, organic fertilizers stimulate microbial activity, improve soil structure and increase both its water-holding and cation exchange capacity. This can reduce soil erosion and degradation, improve nutrient retention, act as a buffer against soil acidification and limit nutrient losses into waterways. Increased SOM also increases soils' capacity to capture carbon.

[4] http://earth.waikato.ac.nz/staff/schipper/download/soilcarbon.pdf

Nitrogen fertiliser use in New Zealand

In 2017, 443,000 tonnes of fertiliser nitrogen were applied to agricultural land. Approximately 66% of this was applied to dairy land (Figure 2), and 25% applied to sheep and beef farms.[5]

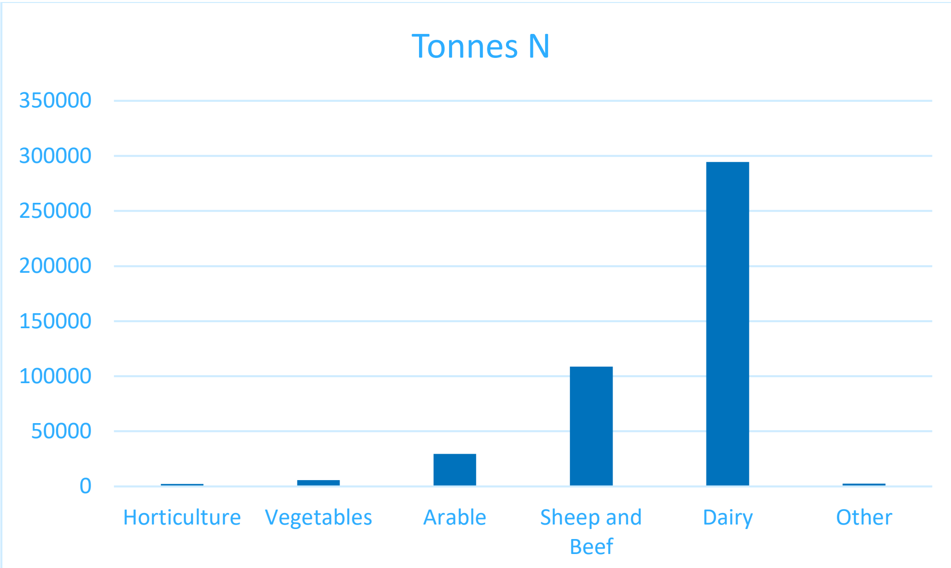


Figure 2: Total nitrogen use for a range of crops.

Typical rates of N fertiliser used for dairy, sheep and beef pastures, and a range of vegetable and arable crops, are shown in Figure 3.

Recently, total nitrogen fertiliser use has declined. In 2020,there was an 8% decline in use compared to the previous year.

Other nitrogen sources

The volume of organic material available for use in food production in New Zealand is relatively small. An MPI report estimated total organic amendments to soil at 4,271 tonnes N, derived from six sources:

- dairy processing wastewater
- compost
- meat processing wastewater/sludge
- grape marc
- vegetable processing wastewater
- sewage sludge[6].

[5] AgFirst (2019) The Value of Nitrogen Fertiliser to the New Zealand Economy Phil Journeaux, AgFirst Waikato, John Wilton & Leander Archer, AgFirst Hastings; Stuart Ford, AgriBusiness Group Gary McDonald, Market Economics. Prepared for the Fertiliser Association. Available at https://www.fertiliser.org.nz/Site/research/projects/the-value-of-nitrogen-fertiliser-to-the-new-zealand-economy.aspx

[6]MPI (2014) Reporting to 2006 IPCC Guidelines for N_2O emissions from additional sources of organic N, **p**repared for the Agriculture Greenhouse Gas Inventory. Tony van der Weerden, Cecile de Klein, Frank Kelliher and Mike Rollo

This volume supports about 1% of current agricultural nitrogen needs. In addition, because of the low nutrient content, there is often risk that the negative externalities of transport exceed its benefit except for very localised use.

Nitrogen fixing clover and other legumes have been the mainstay of New Zealand pastoral systems. However, research from the 1970s and 1980s demonstrated the benefits of strategic use of nitrogen fertiliser for more productive pastoral systems, and for maintaining the international competitiveness of New Zealand pastoral farming. This research was adopted over the next few decades, resulting in an increase in productivity, and significant increases in export income, which supported New Zealand's standard of living.

This development occurred in response to government signals for more efficient, competitive, and unsubsidised farm production[7].

Average application rates of nitrogen fertiliser, within each of the primary sector groups is not high by most standards, (Figure 3). For pastoral land, numerous research trials evaluating leaching losses have demonstrated that there is no significant difference in the whole farm system nitrate leaching between clover-based pastures and pasture receiving up to 200 kg N/ha/yrs[8]. The recent introduction of a nitrogen fertiliser limit on pastoral soils is very precautionary, as it is below this value.

[7] 1978_30._Tactical_use_of_fertiliser_N.pdf (agronomysociety.nz)

[8] 1997, Sprosen, et.al., Nitrate leaching is similar in N_2 fixing grass clover pasture and N fertilised grass only pasture at similar N inputs, Proceedings of the New Zealand Grassland Association 59: 125–128

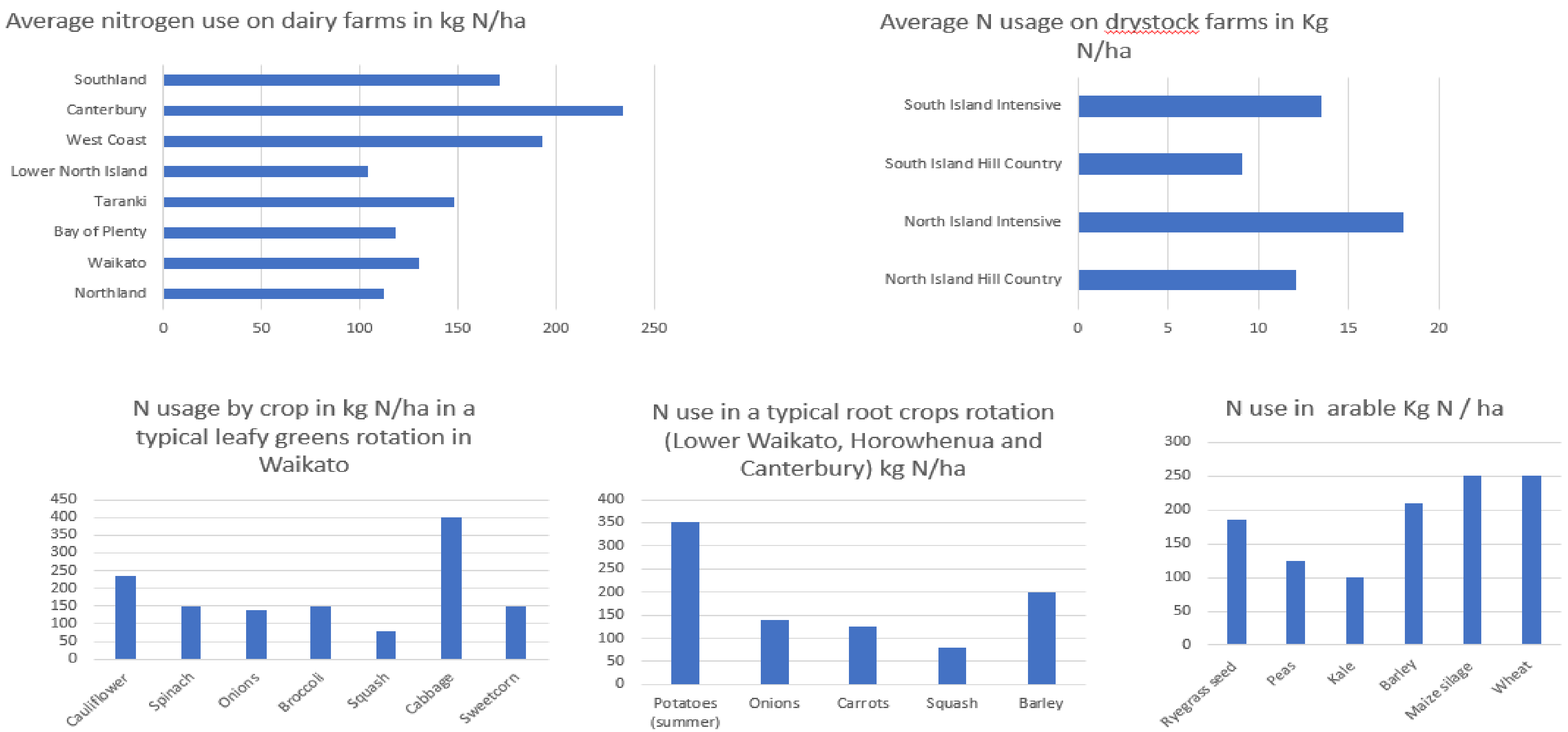


Figure 3: Nitrogen usage on typical crops. Average nitrogen fertiliser use on dairy farms over five seasons (2013/14, 2014/15, 2015/16, 2016/17, 2017/18) for major regions, based on DairyBase data; average nitrogen fertiliser use on sheep and beef farms over five seasons (2013/14, 2014/15, 2015/16, 2016/17, 2017/18) based on data from Beef and Lamb NZ Economic Service. These figures represent application rates where nitrogen is applied rather than averaged across the farm system; data for root crop and leafy green rotations and arable based on consultants estimates as described in AgFirst 2019.

Fertiliser Association
Shaping profitable and sustainable farming

Impact of a ban on nitrogen in New Zealand

Evidence demonstrates that low inputs, low overheads, and low production levels, can still provide a suitable return per hectare for an individual pastoral farm, that is not significantly leveraged with debt. However, none of these evaluations consider or assess what the low production levels mean to New Zealand export potential and resultant impact on the New Zealand economy if the majority of farms operate at low production levels.

AgFirst modelled the impact on yield and profitability for a range of crop and farming systems, assuming that full use was made of available compost[9]. The study explored the costs to the primary sector, both at the farm gate and to the wider New Zealand economy, associated with removing nitrogen fertiliser or using a substitute. For pastoral farms this includes use of supplementary feed, often from imported sources.

The assessment was done on a 'with nitrogen' versus 'without nitrogen' basis across five sectors:

- Pastoral agriculture – dairy
- Pastoral agriculture – sheep and beef
- Permanent horticulture – tree and vine crops
- Vegetables
- Arable

The cost implications for the primary sector without nitrogen fertiliser were estimated at the farm gate as follows (see Figure 4):

- $1.7 billion if nitrogen fertiliser is removed and no substitution is used; or
- $2.1 billion if substitution with other supplementary feeds and legume cover crops are utilised.

At the national level, these impacts would flow through as:

- a drop in gross output by $19.8 billion
- a drop in Value Add (GDP) of $6.7 billion or over 2% of national GDP
- a reduction in employment by 73,760.

[9] AgFirst (2019) The Value of Nitrogen Fertiliser to the New Zealand Economy Phil Journeaux, AgFirst Waikato, John Wilton & Leander Archer, AgFirst Hastings; Stuart Ford, AgriBusiness Group Gary McDonald, Market Economics. Prepared for the Fertiliser Association. Available at https://www.fertiliser.org.nz/Site/research/projects/the-value-of-nitrogen-fertiliser-to-the-new-zealand-economy.aspx

Figure 4: Value of nitrogen fertiliser to the New Zealand economy shows a summary of impacts of a ban on nitrogen fertiliser in terms of economic impact.[10]

Whether they are aware of it or not, all New Zealanders benefit from having a strong export market. Without primary produce bringing in money from exports, the cost of many imports would be prohibitively expensive for many New Zealanders.

It should be acknowledged that the report looked at the economic consequence of not using nitrogen fertiliser in farming production systems, it did not cover the potential environmental costs of any clean-up of waterways or the mitigations current and future to reduce nitrogen losses A key finding was that leaching of nitrogen is not eliminated by removal of nitrogen fertilisers.

[10] https://www.fertiliser.org.nz/Site/research/projects/the-value-of-nitrogen-fertiliser-to-the-new-zealand-economy.aspx

Impacts for vegetable systems

The use of nitrogen fertiliser in the vegetable sector provides the ability to grow a greater range of crops continuously and at a much higher yield, as a result providing a greater range of fresh vegetables to the New Zealand consumer at an affordable price. The effects of not using nitrogen would be particularly impacting on affordable fresh vegetables supply within a single growing season.

Without access to mineral nitrogen fertiliser most vegetable production would fail, either through complete crop failure, not meeting market quality requirements, or not producing an economically viable yield.

This has been clearly recognised by government when considering placing a cap on nitrogen fertiliser for vegetables:

> “Notwithstanding the importance of managing nitrogen for ecosystem health, we recognise that food security and stability of supply for human health, depend on domestic production of adequate and affordable supplies of fresh vegetables. We consider that it will not be practicable to reduce nitrogen to meet national bottom lines in the vegetable growing areas of those catchments for a range of attributes without significantly compromising vegetable production.”[11]

Pastoral agriculture

The role of nitrogen in pastoral agriculture is in essence the same as in market gardening. It supports and enables food production—but for livestock and ultimately humans.

The natural seasonal growth of pasture means that without intervention and management, there are periods of feed surplus and period of feed deficiency. Animal requirements for feed don’t adequately match pasture growth for parts of the year. The graph (Figure 5) below depicts how deficits typically occur in winter/early spring and summer.[12] These deficits are greater when soil fertility is sub-optimal because wet, cold and dry soil conditions restrict the ability of soil biological and chemical processes to keep nutrients cycling in soils and plants growing. Nitrogen fertiliser is best used strategically to manage these feed deficits.

Advice on fertiliser use has historically been that total N fertiliser applications of 200 kg N/ha/year or more should only be implemented after referring to the Code of Practice for Nutrient Management[13] and obtaining the advice of a certified consultant[14].

[11] Cabinet Paper, Action for healthy waterways – decisions on national direction and regulations for freshwater management, https://environment.govt.nz/assets/Publications/Cabinet-papers-briefings-and-minutes/cab-paper-action-for-healthy-waterways-decisions-on-national-direction-and-regulations-for-freshwater-management.pdf
[12] Ground Effect 2016 Spring Edition
[13] https://www.fertiliser.org.nz/Site/code-of-practice/
[14] See https://www.fertiliser.org.nz/Site/resources/booklets.aspx

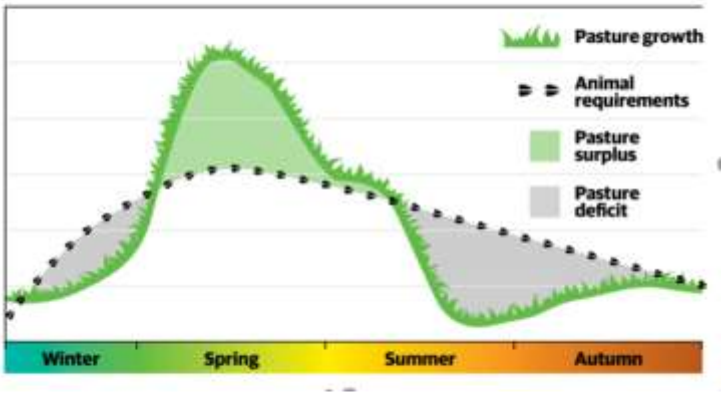


Figure 5: Dryland pasture growth and animal requirement curves.

In the absence of nitrogen fertiliser for pastoral systems, or some other source of feed for production and animal welfare, production will be significantly reduced. In contrast to vegetable production, where the economic and food supply impacts are felt immediately, any constraints on production from pastoral agriculture will only be felt by the average New Zealander over the longer term, as the balance of trade slowly affects the cost and availability of imported manufactured goods.

Production of milk or meat is directly proportional to animal feed intake, and quality pasture-based milk and meat products are supported by good nutritive value and metabolizable energy. Increased productivity from nitrogen fertiliser use has enabled a 250% increase in export income from the primary sector since 2004 (Figure 6). To return to pre-1990 production methods will impose a significant detrimental economic impact.

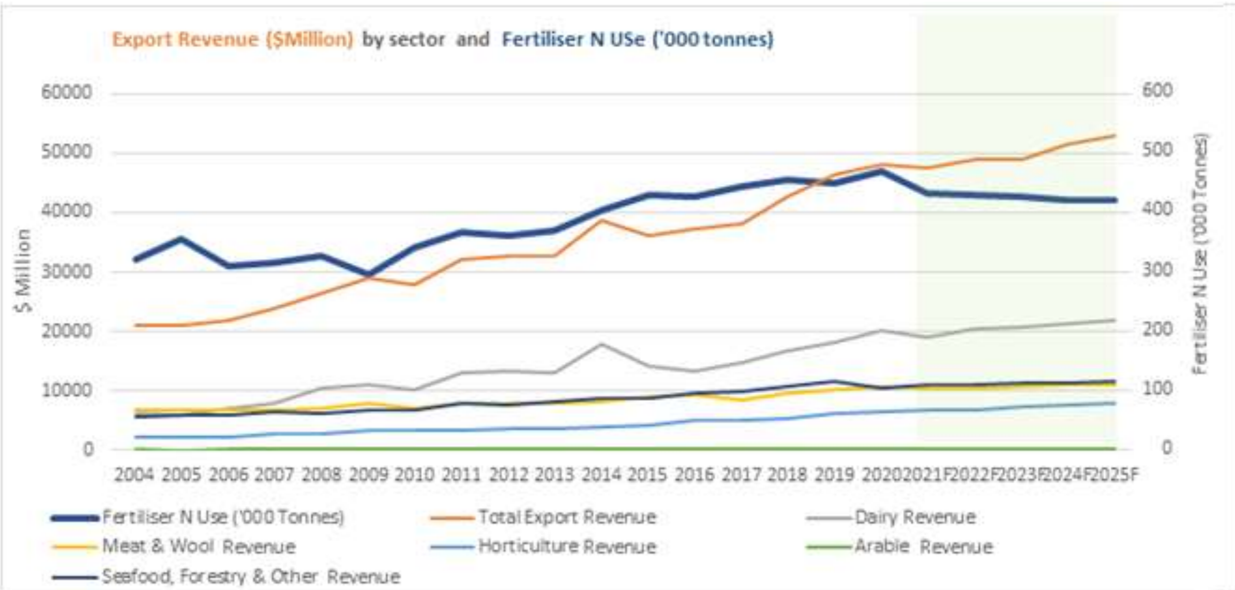


Figure 6: Export revenue and nitrogen fertiliser use.[15]

[15] Data Sources: The Ministry for Primary Industry's 'Situation and Outlook for Primary Industries' (June 2021), which predicts continued increase in export revenue. Ministry for the Environment's Fourth Biennial Report under the United Nations Convention for Climate Change predicts a steady decline in nitrogen fertiliser use out to 2035s. Fertiliser Association of New Zealand estimates of total fertiliser nitrogen consumption.

Environmental impact of nitrogen fertiliser

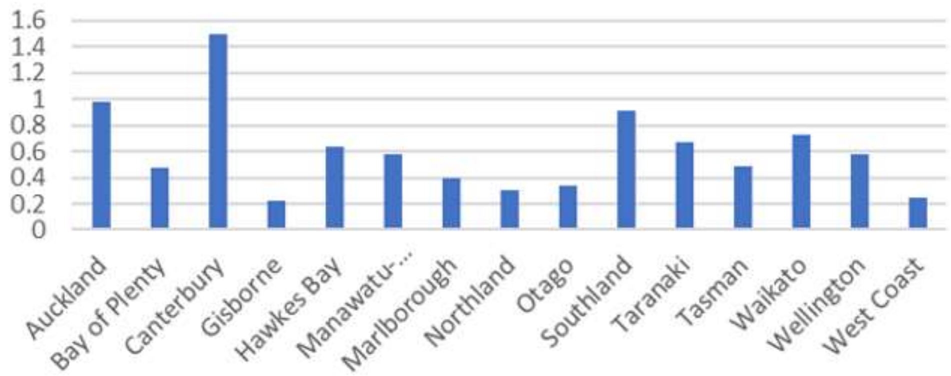
The environmental impact of New Zealand farming systems is under increasing scrutiny, both in terms of impacts on water quality and on greenhouse gas emissions. The increase in productivity from the agricultural sector has been associated with some environmental impacts.

Nitrogenous fertilisers have both direct and indirect influence on nitrate leaching and nitrous oxide emissions. Nitrogen fertiliser contributes 4.8% of agricultural greenhouse gas emissions, mainly in the form of nitrous oxide emissions[16]. In pastoral agriculture, direct loss in leaching from applied nitrogen fertiliser is dependent on rates and timing of N fertiliser use[17], but typically represents less than 10% of nitrogen applied, if good management practices are employed. For both nitrous oxide losses and nitrate leached, direct losses from fertiliser are a small proportion of overall losses with the vast majority of the source coming from animal urine.

Regions with water quality impaired by nitrogen

The first regulatory controls addressing nitrogen outputs were applied to the Lake Taupo catchment. Nitrogen losses were grand parented to the highest annual leaching loss (estimated using Overseer) within the 2001–2005 production years. A trading scheme was introduced to allow flexibility for farms to operate within the overall load for the lake, and a further 20% reduction in load was purchased by the Lake Taupo Protection Trust to reduce the nitrate load to acceptable limits[18]. The next council plan to implement output-based controls was Horizons Regional Council, through the One Plan process. The One Plan's intention to address the issue in water quality in the region is showing success except at the sites that were most degraded.[19]

Over the last decade, other councils have imposed limits on nitrogen losses. These include four of the five regions in New Zealand which have elevated nitrogen levels often associated with intensive agriculture—Canterbury, Hawke's Bay, Southland, and Waikato (see Figure 7). The regions which already have strict limits in place or are under development, are shown in Table 1.



16 https://environment.govt.nz/assets/Publications/New-Zealands-Greenhouse-Gas-Inventory-1990-2019-Volume-1-Chapters-1-15.pdf, Table 5.5.1

17 Ledgard, S.F. 1986. *Nitrogen Fertiliser Use on Pastures and Crops*. Ministry of Agriculture and Fisheries, Ruakura, New Zealand; Ledgard, S.F. 1989. Effects of time of application and soil temperature on the fate of nitrogen fertiliser applied to dairy pasture. *Proceedings of the Workshop: Nitrogen in NZ Agriculture and Horticulture*.

18 https://www.waikatoregion.govt.nz/community/your-community/for-farmers/taupo/nitrogen-trading-in-the-lake-taupo-catchment/

19 State and Trends of River Water. Quality in the Manawatū-Whanganui Region. November 2018. Horizons Report 2018/EXT/1619.

Figure 7: Median total oxidised nitrogen in rivers reported in LAWA from 2008–2017 (mg N/l). This is a simplification but identifies on a national scale which regions are likely to have higher river quality. impact due to nitrogen.

Table 1: Regional council limit setting processes in areas with elevated nitrogen.

Region	Measures
Canterbury	The Canterbury Land and Water Regional Plan places responsibility on farmers to operate within water quality limits. This means a land use consent required if the property exceeds certain farming activity limits such as a nitrogen loss threshold. These limits vary across Canterbury depending on the water quality status within local nutrient allocation zones. Consents tend to allow for a phased reduction in nitrogen loss.
Hawke's Bay	Landowners in the Tukituki Catchment have catchment specific rules. Rules require farming consents if nitrogen levels exceed a threshold value.
Southland	Environment Southland's proposed Southland Water and Land Plan was made partially operative in January 2021. Consents are required for land use intensification. All land holdings >20ha need a farm environment plan, which effectively grandparents existing losses.
Waikato	The decisions version of the Proposed Waikato Regional Plan Change 1 was notified in April 2020. The Plan Change sets controls on N leaching.

The 190 kg N/ha/yr input limit on nitrogen fertiliser

Council regulation of agriculture is directed by the National Policy Statement on Freshwater Management, the National Environment Standards and regulations under the RMA.

Government has set a cap on nitrogen use on pastoral land use, at 190kg N/ha/yr. This requirement has been in place since 1 July this year. It is anticipated that a material number of dairy farms will be impacted by this cap. Approximately 32% of dairy farms which apply nitrogen fertiliser could be impacted by the cap, many of these are irrigated dairy farms in Canterbury[20].

Modelling for Canterbury irrigated dairy farms suggests a 13.9% reduction in earnings (EBITD). This reduction in earnings will be associated with a 6.6% reduction in nitrogen leaching.

The likely environmental impact of the cap remains uncertain because of the unintended impacts of implementing input limits:

- Fertiliser nitrogen is but one of three main sources of nitrogen within the farm system. If there is a compensatory increase in the use of supplementary feed, then the total amount of nitrogen within the system may well not alter, and hence no change in nitrate leaching would be achieved
- If nitrogen fertiliser input is reduced, there will be some compensatory increase in the amount of nitrogen fixed by legumes (i.e. clover) meaning that there may be limited change in overall nitrate lost.

[20] https://www.fertiliser.org.nz/Site/research/projects/impact-of-the-190kg-fertiliser-nha-limit.aspx

- Organic nitrogen fertilisers are exempt from the application limit. While nitrate leaching from this fertiliser is minimal as a result of direct application, once mineralised they contribute to the total nitrogen pool within the farm system, and hence to nitrate leaching.

The single national level cap on nitrogen does not create the specificity to design management controls that reflect specific catchment needs. Instead, it risks the unintended impact of giving a licence for many farms to use up to the capped amount. As an industry this is at odds with our advice to use nitrogen carefully and strategically to manage feed deficits.

Control of greenhouse gas emissions associated with nitrogen fertiliser

Government has indicated that emissions associated with fertiliser use will be subject to a price either under the New Zealand Emission Trading Scheme or under the He Waka Eka Noa arrangements. It is intended that a price on emissions will be in place by 2025, with reporting requirements beginning earlier.

Environmental credentials

Environmental credentials are an increasing part of the value of New Zealand's primary products. Many industry assurance systems are focusing on nutrients. Schemes like Tiaiki, NZGAP and NZFAP all have a role to play in creating value from good environmental management. This provides additional incentives for judicious use of nitrogen fertiliser.

Are the range of existing New Zealand regulations and measures having an impact?

The National Science Challenge: Our Land and Water have been closely examining the potential impact of agricultural mitigations on water quality. In a recent paper, researchers modelled uptake of the impact of a range of mitigation interventions and compared them with water quality variables for 2015.[21] They found that if available mitigation actions were fully implemented across dairy and sheep/beef farms, losses of N could have been decreased by up to 16%, compared to the estimated losses for 2015.

Mitigation options for dairy farms included:

- fencing out stock access to waterways
- improved management of fertiliser
- improved irrigation practices
- careful management of farm dairy effluent
- off-paddock grazing management.

Mitigations for beef and sheep farms included fencing out stock from waterways and land retirement.

The researchers also evaluated the potential impact if established and new mitigation actions were fully implemented by 2035. They estimated that nitrogen loss could decrease by up to 34%, compared to 2015 losses. The set of developing mitigations considered included: technologies to capture losses from the edge of the field; the application of urease and nitrification inhibitors to reduce the mobility of

[21] Richard W McDowell, Ross M. Monaghan, Chris Smith, Andrew Manderson, Les Basher, David F. Burger, Seth Laurenson, Peter Pletnyakov, Raphael Spiekermann & Craig Depree (2020): Quantifying contaminant losses to water from pastoral land uses in New Zealand III. What could be achieved by 2035? New Zealand Journal of Agricultural Research, DOI: 10.1080/00288233.2020.1844763

nitrogen; limiting nitrogen imports in feed and fertiliser and the use of retention dams and managed drainage systems.

Owing to the greater number and effectiveness of mitigation actions available and greater yields, more nitrogen was mitigated from dairy than sheep/beef land uses. The dairy farms which showed the greatest reduction in nitrogen loss following the implementation of mitigation actions were often the more intensive irrigated farms, where actions such as better scheduling of irrigation or dairy effluent applications had most impact.

It is important to remember there will always be a delay in impact of mitigations for improved water quality. The median lag time for nitrate–N across 34 catchments was recently estimated at 4.5 years, meaning that catchments wouldn't exhibit decreases in nitrate–N because of practice change in under five years.[22]

These results suggest that we now have the technologies available to mitigate nitrogen loss and achieve environmental improvement. Encouraging uptake of practices and technologies, tailored to farm specific conditions, will likely achieve the greatest environmental benefit, while at the same time continuing the important role of agriculture for the New Zealand economy.

It is important to recognise that while the management of nitrogen losses from our farm systems is important, direct losses from nitrogen fertiliser is only a relatively small part of the farm system losses needing to be addressed.

How does New Zealand compare with rest of world?

There is a sharp contrast in fertiliser use between OECD and non-OECD counties.

OECD countries have generally stable levels of nitrogen use having peaked in the early 1990s. The increasing focus on measures to manage the environmental impacts of agriculture through subsides to compensate for potential reduction in yields has led to reduced use of nitrogen fertiliser in Europe. In the United States, shared cost burden arrangements have been implemented in some states to encourage use of best practice approaches, while nitrogen trading systems have also been implemented (often resulting in payments to farms from water authorities to reduce nitrogen use to offset the cost of treatment of drinking water).

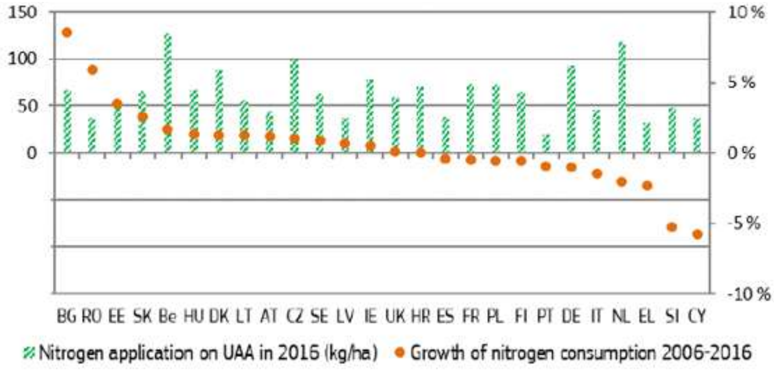
In contrast, many non-OECD countries' governments are subsidising the cost of fertiliser to encourage its use to manage food security.

New Zealand is a bit of an outlier from other OECD countries as it only started to use more nitrogen fertiliser when other OECD countries had already peaked. Comments that New Zealand has had exccessive use of nitrogen fertiliser since the 1990s are very spurious, if it is understood that New Zealand used trivial amounts of nitrogen fertiliser prior to the 1990s, instead relying only on clover based pasture systems with lower agricultural product output.

Nitrogen fertilier application rates in the EU suggest they are generally at higher levels than in New Zealand. See Figure 8. Comparable figures for New Zealand in terms of national application on utilised

[22] The implications of lag times between nitrate leaching losses and riverine loads for water quality policy R. W. McDowell, Z. P. Simpson2, A.G.Ausseil, Z. Etheridge & R. Law Scientific Reports (2021) 11:16450 https://doi.org/10.1038/s41598-021-95302-1

agricultural area suggest an average application rate of 40 kg N/ha. (Note that any national statistics tend to obscure higher and lower use on individual sectors – compare with Figure 2.)



Source: DG AGRI, based on Eurostat
Note: Be stands for Benelux

Figure 8: Nitrogen fertiler applciation in EU countries (kg N/ha) [23]

Policy approaches to managing the impacts of nitrogen

Countries that have banned Nitrogen fertiliser

A limited number of jurisdictions have introduced a ban on fertiliser: Sikkim, Bhutan, and Sri Lanka. See Table 2. These bans on fertiliser appear to have resulted in putting their agricultural economies at risk.

Table 2: Countries or States that have imposed a ban on use of nitrogen fertiliser.

State/Country	Impact
Sri Lanka	• Government banned import of fertilisers including urea from May 2021. The ban is partly due to the central bank imposing import bans to reduce the outflow of foreign currency. The policy, has been promoted, as helping Sri Lankan agriculture become organic. • Likely to impact tea production in Sri Lanka. • Prior to the ban, fertiliser was subsidised. Government is planning to import organic fertiliser sufficient for 500,000 ha of paddy fields.
Sikkim	• Government announced that it is supporting a shift to organic farming and ending fertiliser use. • Sikkim had low use of fertiliser (5 kg N/Ha). Sikkim has become an importer of vegetables, and the cost of vegetables has risen. The main export crop is cardamon which is grown on cleared forest—so unaffected by ban. Up until the pandemic, Sikkim saw a growth in tourism party attributed to its promotion of its organically based farming systems.
Bhutan	• In 2012, Bhutan declared it would become a 100 percent organic state by the year 2020.

[23] EU Agricultural Markets Brief, No 15 June 2019, Fertiliser in the EU, Prices, Trade and Use

	• They are unlikely to meet that target as concerns have arisen because of Bhutanese dependence on cereal import (34 percent is imported), and widespread food insecurity in the country. • Despite the ban, the use of chemical fertilisers increased drastically from 1,983.4 MT in 2013 to 5,033.5 MT in 2015 and then declined in 2017 at 1,213MT in 2017, according to Bhutan RNR statistics, 2017.

Countries that have imposed input limits on nitrogen fertiliser

The European nitrate directive requires member states to enforce conditions (good management practices) for farm activities, and provide for monitoring and reporting. These measures are targeted at nitrate vulnerable zones and set a maximum use of organic nitrogen (manure and slurries) of 170 kg N/ha. A number of pastoral European counties received a derogation to limit organic nitrogen to 250 kg/ha.

The European Community also provides supports to farmers to farm less intensively. Limits on inputs have reduced the nutrient cycling in European farm systems. However, despite some improvement, environmental goals have not always been achieved and the economic costs have been significant.

The European model of subsidised reduction in productivity is a luxury New Zealand does not have. For a New Zealand context, where agricultural export is critical to the economy, an alternative export income for New Zealand will take decades to develop.

Table 3: International examples of nitrogen controls

Limits in place
Europe The European Nitrates Directive set limits of 170 kg N/ha on the amount of organic nitrogen applied to farmland. Countries with extensive areas of pastoral farming got a derogation to the list of 250 kg N/ha. The Directive does not set controls on nitrogen fertiliser. The Directive requires member countries to establish Nitrate Vulnerable Zones and set location specific practices to ensure that levels of nitrate in water meet drinking water standards. Recent practice in Europe has sought to coordinate incentives for agricultural production and environmental management. Extensive environmental programmes subsidize farmers for farming less intensively in accordance with set management practices. For pastoral land uses, these include practices such as better collection of effluents from winter housing, prohibition on manure spreading in winter months; or maintaining winter crops to reduce nitrate leaching. In many countries this is supported by government agency provision of farm planning information, tools or advisory services. **Denmark** In Denmark, a wide range of national regulatory measures have been implemented since the mid-1980s, all with the aim to reduce land-based N and P loadings of the Danish aquatic environment[24].

[24] Kronvang, B., Blicher-Mathiesen, G. and Windolf, J., 2017. 30 years of nutrient management learnings from Denmark: A successful turnaround and novel ideas for the next generation. In: Science and policy: nutrient management challenges for the next generation. (Eds L. D. Currie and M. J. Hedley).

Limits in place

In 2013 Denmark moved from national level regulatory measures to targeted measures. This was intended to allow for increased agricultural growth along with an improved environment. This aimed for more efficient regulation by applying advanced technological mitigation methods using local attenuation capacity for nutrients. In 2016 a new regulation allowed farmers to apply economic optimum levels of nitrogen to crops after nearly 18 years of regulations restricting application to below economic optimum.

Some of this change was a result of the Danish response to the European nitrogen directive. Reduced nitrogen use required in response to the Directive led to reduced wheat protein levels, leading to lost market, and transition for Denmark from being a net wheat exporter to wheat importer[25].

Ireland

The most recent Regulations in force are the European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2017. Farmers are obliged to ensure that the total amount of nitrogen from organic manure applied to their own lands (including that deposited by the animals themselves) does not exceed 170 kgs/ha.

Farmers can apply for a Nitrates Derogation, which allows them to apply up to 250 kgs organic nitrogen per hectare per year, subject to some additional conditions being met. This does not limit application rates of fertiliser nitrogen: Failure to comply with the regulation impacts on subsidy payments[26].

United Kingdom

The United Kingdom has maintained the approach originally established under the European Nitrates Directives and is focused on Nitrate Vulnerable Zones[27]. This may shortly be replaced by the Sustainable Farming Incentive. Vulnerable zones cover 55% of land areas in England. Application of organic and inorganic nitrogen is limited for different crops. Limits range from 150–270 kg N/ha. In pasture application is limited to 300kg N/ha with an additional allowance of 40 kg N/ha if grass is cut for conservation. A limit of 250kg N/ha for organic manures does not include manure directly applied by livestock. This limit can be increased if more than 80% of the farm is in pasture. There are limits on timing of nitrogen fertiliser application during winter months.

United States

Measures in the United States tend to be manure focused because of the prevalence of intensive animal feedlots and the environmental impact associated with them. Most States have some sort of nutrient management programme for fertilisers and manure. Some states, like Missouri, New Hampshire, New York, and Rhode Island, have voluntary programs of various forms. Other states, like Florida, Illinois, North Carolina, Oregon, South Dakota, and Wisconsin, have mandatory programs codified through legislation. Some states, like Alabama, Iowa, Texas, and Utah, offer

http://flrc.massey.ac.nz/publications.html. Occasional Report No. 30. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. 9 pages

[25] https://www.thelocal.dk/20150601/low-quality-danish-grain-gets-dropped-worldwide/
[26] https://assets.gov.ie/99046/5312115e-a279-4347-8afc02d1c466c127.pdf
[27] https://www.gov.uk/guidance/using-nitrogen-fertilisers-in-nitrate-vulnerable-zones

Limits in place

technical assistance, information, and training through land grant and university extension programs[28.]

Florida

Many Florida counties have implemented prohibition on the application of any fertilisers containing nitrogen or phosphorus between June 1 and September 30, or when the National Weather Service predicts heavy rain to occur within 24 hours.

Illinois

The Illinois Nutrient Loss Reduction Strategy guides state efforts to improve water quality by reducing nitrogen and phosphorus levels in lakes, streams, and rivers. The strategy lays out a comprehensive suite of best management practices for reducing nutrient loads from wastewater treatment plants and urban and agricultural runoff. Implementation of the plan is largely reliant on education and extension[29.]

North Carolina

Nutrient trading arrangements have been established in specific catchments in North Carolina. Nutrient sensitive waters strategies have been established for specific high-risk catchments. Farmers are able to achieve the reduction goals collectively, focusing on critical areas and conservation practices. In most cases, farmers sign on either with an advisory committee that develops a local strategy, or they implement the standard best management practice option of the rules30. An example includes the Neuse rule[31.] A cost share approach to impending BMPs is applied.

In 2019 soil and water conservation districts spent over $1,084,000 through the Agriculture Cost Share Program in the Neuse River Basin, and the Natural Resources Conservation Service spent over $2,817,000 through the Environmental Quality Assistance Program in the counties of the Neuse River Basin. These programs have all helped fund erosion and nutrient reducing BMPs in the Neuse Basin.

Wisconsin

The Department of Natural resources rule NR 151 sets performance standards and prohibitions for farms. The rule is being modified for highly permeable soils which are susceptible to groundwater contamination to achieve nitrate groundwater standards. The rule revisions will define sensitive areas in the state and the performance standards needed to protect groundwater quality in these areas.

Nebraska

Limits are set on timing of fertiliser application but not the amount. This is intended to protect groundwater which is at twice the US drinking water limit.

International evaluations of policy effectiveness

[28] https://www.acwa-us.org/wp-content/uploads/2018/03/Nutrient-Reduction-Progress-Tracker-Version-1.0-2017-Report.pdf
[29] https://www2.illinois.gov/epa/topics/water-quality/watershed-management/excess-nutrients/Pages/nutrient-loss-reduction-strategy.aspx
[30] http://www.ncagr.gov/SWC/watershed/NSW_strategies.html.
[31] http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2002%20-%20environmental%20management/subchapter%20b/15a%20ncac%2002b%20.0712.pdf

In 2012, the OECD published a review of policy approaches designed to deal with the impacts of agriculture on freshwater resources.[32] The review conclusion was that policies have generally fallen short of requirements to meet water quality policy goals in agriculture based on the report's assessment of recent OECD country experiences. The report provided recommendations on moving towards the sustainable management of water quality in agriculture.

The recommendations have been summarised in Table 4, along with our analysis of New Zealand's progress against each of the recommendations.

A more recent OECD review of performance of environmental policies in agriculture emphasises the importance of designing polices that enable results-oriented innovation for effectiveness:[33]

> Innovation, particularly the ability for a farm to 'embrace change' has been found to be one of the factors determining whether regulations positively or negativelyimpact economic performance.
>
> Stimulating innovation can also be key to the design of successful policy instruments. For example, results-oriented mechanisms are considered to have the potential to stimulate on-farm innovation and adaptation of environmental management practices to local conditions, and thereby achieve lasting improvements in agricultural environmental sustainability.

The review recognised that empirical evidence on the degree to which results-oriented mechanisms actually spur innovation is scant, not least because results-oriented mechanisms are still in their infancy.

Despite this proviso the author states:

> Nevertheless, there is much optimism, and burgeoning empirical evidence, that result-oriented measures will be both more effective and more efficient than practice-based mechanisms.

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[32] OECD (2012), *Water Quality and Agriculture: Meeting the Policy Challenge*, OECD Studies on Water, OECD Publishing. *http://dx.doi.org/10.1787/9789264168060-en*

[33] OECD (2019) trade and Agriculture Directorate, Environment Directorate, Joint Working Party on Agriculture and the Environment. Economic and Environmental Sustainability Performance of Environmental Policies in agriculture: A Literature Review Report T03450934

Table 4: Summary of recommendations in 2012 OECD report, and our assessment of New Zealand's progress.

Recommendation	New Zealand's progress
Use a mix of policy instruments to address water pollution.	The OECD's view was that a mix of policy instruments to address water quality issues in agriculture is likely to outperform a single policy instrument. In a New Zealand context, Regional Councils have now implemented a vast range of regulatory approaches, but there has been limited evaluation of how effective these polices have been in achieving outcomes. There has been limited investment in non-regulatory approaches. The role of farm advice has had limited investment for decades.
Enforce compliance with existing water quality regulations and standards.	There remains a gap between compliance actions and plan development processes in many regional councils.
Remove perverse support in agriculture to lower pressure on water systems.	New Zealand does not provide subsidies for agricultural production, so can be seen as free from perverse supports.
Take into account the Polluter-Pays-Principle to reduce agricultural water pollution.	While the concept of the polluter taking responsibility for impacts is enshrined in the RMA, its application is difficult, because diffuse source pollution cannot currently be measured at reasonable cost. The introduction of regulated farm plans will require documentation of activities, good management practices and mitigations undertaken to reduce nutrient losses.
Set realistic water quality targets and standards for agriculture.	The NPS-Freshwater Management sets a range of national targets for water quality.
Improve the spatial targeting of policies to areas where water pollution is most acute.	The RMA systems and processes currently allow for catchment-based targets.

Recommendation	New Zealand's progress
Assess the cost effectiveness of different policy options to address water quality in agriculture.	Consideration of producer abatement costs compared to the benefits generated by a given policy in terms of improving water quality are a core part of policy development in New Zealand. There tends to be less consideration of the resourcing implications of programme monitoring and enforcement. This limits actual evaluation of impacts of measures adopted.
Take a holistic approach to agricultural pollution policies.	In New Zealand we have started to take some steps towards a more holistic view of agricultural pollution policy design. For example, development of riparian buffers, which can limit pollutant runoff can also provide other benefits in terms of wildlife habitats and carbon sequestration. A current challenge is how water and climate policies can work to together effectively for enhanced effectiveness.

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A path forward

New Zealander's expectations for environmental management are high. The agricultural sector has to continue to push forward to meet them.

We welcome the government intention to put in place requirements for farm environment plans and support the approach through He Waka Eka Noa to establish a pricing system for greenhouse gases. We feel that farm environment plans will be important strategic documents that inform practice, ensuring that the environmental footprint of agricultural activities is minimised. At the same time, these plans will enable productivity to support our economy, and will be critical to ensuring that our food export markets give credit for the way in which we farm. This is critical to increasing the value of New Zealand's exports.

Enabling flexible approaches to managing for the best environmental outcomes has to be core to good design of controls going forward.

- **It would be economically catastrophic to ban nitrogen fertiliser, and it would not achieve environmental aspirations.**
- **Input controls achieve neither environmental or economic outcomes. They risk creating unintended distortions risking failure to achieve environmental outcomes.**
- **There needs to be consistent direction, and coherent polices across both our response to water degradation and climate change to achieve economic and environmental aspirations.**
  - Uncoordinated polices risk failure in achieving outcomes. Currently, it appears that the policies targeting greenhouse gas and water emissions are largely developed in isolation of one another. This dichotomy will be exacerbated as the policies will have different implementation responsibilities and mechanisms. While these policies are designed to act on the same decision maker, uncoordinated and fragmented approaches risk creating additional cost, along with conflicting and unintended outcomes.
- **Creating regulatory certainty enables change. To achieve progress, farming in New Zealand will need to continue to adopt and embrace change with confidence to be able to invest accordingly.**
  - The inevitable time lag in uptake of new practices and technologies delays outcomes. This is exacerbated in the case of water management by the times lags associated with nutrient transfers. Confident regulation needs to understand these impacts in terms of achieving practice change and environmental outcomes.
- **A mix of co-ordinated regulatory and non-regulatory levers is needed to enable enhanced land use practices that leave a lighter footprint.**
  - New Zealand relies almost solely on regulation to achieve change. Non regulatory approaches are location specific and usually limited to measures like assistance with riparian planting, or management plans. There is little national consideration of non-regulatory options—and how these can support effectiveness of the regulatory options.
  - Land practices need to be carefully tailored to what needs to be managed in individual catchments.

- Farm plans should be the strategic tool for farms that sets direction and supports compliance.

- **Enabled practices need to be evidence-based and have ongoing evaluation incorporated from the onset.**
  - Evidence-based approaches are critical to sustained improvement, avoiding practices driven by untested ideology.
  - Innovation, testing and exploration of new systems and technologies in their particular farm situation will be core to farming's response.
  - Farmers and growers will need access to good advice and tools for a clean transition.
- **Good stewardship must be core to brand for New Zealand's primary products.**

Appendix 1

Measures the fertiliser industry has introduced and promoted to ensure best management of nitrogen

Fertiliser co-operatives focus on shareholder value not sales volume

New Zealand's fertiliser industry is dominated by farmer-based co-operatives with a mandate to deliver robust science and advice along with consistent, effective and quality products. The owners of the businesses are also its customers and users of the products. This means that the focus is on shareholder value not sales volume.

As an industry our approach has been driven by enabling solutions that shareholders can implement to farm within environmental limits. It is recognised the environmental limits are catchment specific. For example, nitrogen loss limits in a catchment like Lake Taupo is always going to be more restrictive than in a river catchment on the Taranaki ring plain.

Nutrients are 'tools' in good farm management practice

Nutrients like nitrogen are best seen as tools. Like any tool, they can be used wisely or unwisely in the wider context of good management practice. Use the tool too little and you forego precious export dollars that can be used for schools, hospitals, vaccines and other social programmes. Use too much and environmental impacts can increase.

There is clearly an optimum to be struck and the focus must be on using nitrogen well. The co-operatives have trained nutrient management specialists who are advising their shareholder customers on this topic every day.

To manage and control farm system losses, it is necessary to understand the nutrient cycle in the farm system. Production outputs, soil mineral nitrogen, plant residues, greenhouse gas emissions, surface runoff and nitrate leaching are all part of the nutrient cycle which needs to be balanced by the appropriate rate and timing of nitrogen inputs, if a sustainable farm system is to be met.

Providing farmers and growers with the best nutrient management products and advice

A lighter footprint for New Zealand farming is enabled by ensuring farmers and growers have access to world-leading nutrient know-how, coupled with the latest technical advice and environmental guidance. It is about maintaining the best soil conditions to support all our productive food creation systems including grass-fed livestock. Farmers and growers have always seen themselves as stewards for the next generation.

The industry strives for a lighter footprint in developing codes of practice by:

- creating tailored plans for individual farmers
- significant investment in R&D
- creating smart products
- developing precision application technology
- investing in the capability that is needed to deliver world class nutrient management.

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Nutrient management plans have evolved from simple rule of thumb based on crop removal to accounting for all nutrient sources and understanding likely nutrient losses. The nutrient budget, supported by models such as Overseer, allow for documentation and evaluation of nutrient cycles in proposed farm systems. The nutrient budget can then be incorporated into a Nutrient Management Plan and the Farm Environment Plan. Documentation, evaluation and review of scenarios under a well-structured farm plan (as with any business plan) enables the best decision support for achieving farm production and environmental goals.

Through understanding the nutrient losses from the farm system, new innovations have been developed to reduce environmental impacts. For example, high sugar (low protein) grasses can result in lower nitrogen loss from the urine patch. Similarly benefits of reduced nitrogen loss have been identified with feed supplements such as maize silage and more recently some significant reduction in nitrogen losses identified with some varieties of plantain. By addressing whole system nitrogen losses, farmers are encouraged to innovate and seek ways to reduce nitrogen loss while remaining productive and economically viable, for the benefit of the New Zealand economy.

Reducing nitrogen fertiliser for pasture production and increasing reliance on supplement imported to the farm will have minimal impact on nitrogen lost because in a pasture system it is primarily the urine patch which drives nitrate leaching. Input limits for the most part only very indirectly affect farm system losses.

New innovations, tools and resources are now available to support farmers and growers: application technologies; spatial mapping systems; new models (LUCI, Mitigator), which identify critical source area and nutrient movement on farm and in catchments; variable rate application to match nutrient requirements to specific conditions.

Developments in variable rate irrigation technology along with soil mapping provides for precision technologies, which support and improve efficient, highly localised application of nutrient where and when required. GPS mapping and soil mapping technology supports the precision agriculture principles in aerial and ground spread applications. The New Zealand Groudspreaders Association estimates that 70% of fertiliser applied used proof of placement technology[34].

Smart products, such as fertiliser coated with urease inhibitor have a proven potential to significantly reduce greenhouse gas emissions and nitrogen leaching.

The biggest gains in reducing nitrogen losses arise arise from enabling a reduction in fertiliser use if the system losses are understood and reduced in this way. Through recognition of the efficiency gains, there has been a steady increase in the percentage of urea fertiliser, which is coated with a urease inhibitor, with associated reduction in greenhouse gas. Current usage is outlined in Figure 9. New Zealand is to the forefront globally of use of these technologies.

Urease inhibitors help reduce the loss of greenhouse gases when urea is applied to soil. Increasing use of urease inhibitors is desirable for the farm system and for the environment.

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[34] Mel Dingle, pers comm

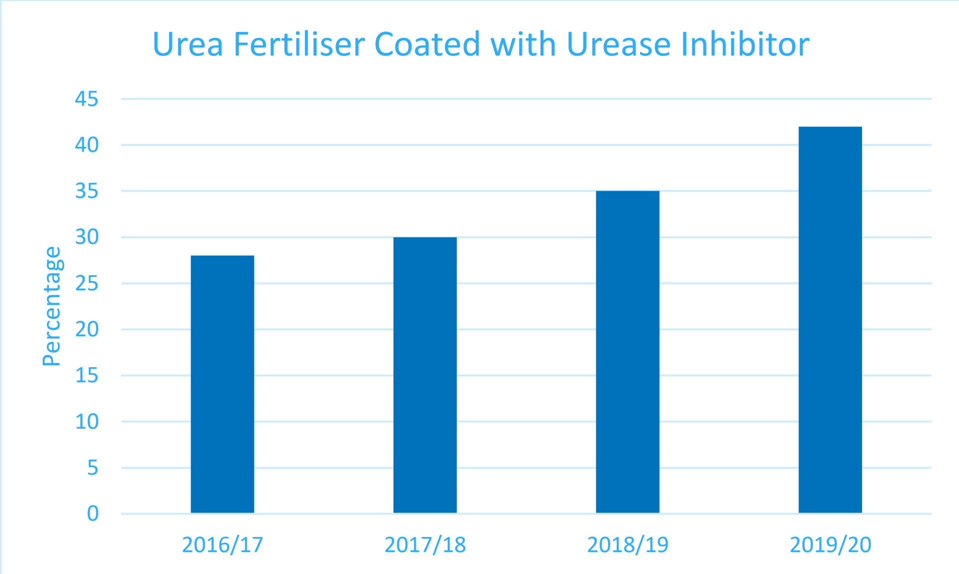

Figure 9: Use of Urease Inhibitors.

New nitrification inhibitor products show promise for even great benefits in the reduction of nitrate leaching and greenhouse gas emissions from nitrogen fertiliser products and livestock urine patches. These products could deliver up to 70% reduction in greenhouse gas emissions depending on conditions, and similar winter reduction in leaching or annual reduction of leaching of 20–30%. [35]

Training and advice

The primary sector, including the fertiliser industry, has consistently invested strongly in supporting capability with highly qualified rural professionals to support responsible farm systems. In 2002, the industry funded development of the post graduate training at Massey University (Intermediate Nutrient Management Course). Followed in 2005 by the Advanced Nutrient Management Course. The course on Agricultural Greenhouse Gas Emissions and Management was initiated at Massey University in 2009. An additional course focusing on capability for development of farm environment plans was established in 2020. These courses have become industry standards and are world class training and certification programmes for rural professional with few, if any comparable programs found internationally.

A Code of Practice[36] for nutrient management has been in place since 1998 and has been regularly updated. A booklet series on science-based nutrient management[37] for a range of crop and livestock systems, has been developed to support qualified informed and responsible use of nutrients.

The Nutrient Management Adviser Certification Programme (NMACP) was developed by the fertiliser industry in conjunction with primary sector partners, to provide an assurance program for the expertise and currency of rural professionals providing nutrient management advice. Currently, there are 226 certified advisers.

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[35] SF Ledgard, J Luo, MS Sprosen, JB Wyatt, SF Balvert & SB Lindsey (2014) Effects of the nitrification inhibitor dicyandiamide (DCD) on pasture production, nitrous oxide emissions and nitrate leaching in Waikato, New Zealand, New Zealand Journal of Agricultural Research, 57:4, 294-315, https://doi.org/10.1080/00288233.2014.928642

[36] https://www.fertiliser.org.nz/Site/code-of-practice/

[37] https://www.fertiliser.org.nz/Site/resources/booklets.aspx