



Greenhouse gases: **Farm Planning Guidance**

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Our partners



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Introduction

This document is a guide for farmers and growers to help them measure, manage and reduce greenhouse gas emissions. It has been developed collaboratively by the primary sector, Federation of Māori Authorities, government and scientists from New Zealand universities and Crown Research institutes through the He Waka Eke Noa partnership.

This guidance is intended to help farmers, growers and their advisors incorporate the management of greenhouse gases into farm planning, by understanding their emissions profile and what contributes to it, exploring opportunities to reduce it, and keeping good farm records.

Many farmers and growers already have a farm plan, often as part of an industry assurance programme. Primary sector organisations and processors involved in He Waka Eke Noa are committed to supporting all farmers and growers to have a written plan to measure and manage emissions by 2025.

This guidance sets out four principles to guide farmers and growers, backed by practical information on opportunities to reduce greenhouse gas emissions and capture carbon. It is intended to help farmers and growers, as steward of our environment, understand what they can do to measure manage and reduce their greenhouse gas emissions.

This guidance is the first product in the He Waka Eke Noa toolkit for mitigating and adapting to climate change.

He Waka Eke Noa is also working on:

- a system for measuring and reporting on emissions;
- a mechanism for pricing emissions as an incentive to take action.

Farmers and growers will be involved in this ongoing work.

He Waka Eke Noa – the Primary Sector Climate Action Partnership is committed to finding the best outcomes for Aotearoa New Zealand and farmers and growers, while playing our part in global efforts to tackle climate change.

The partnership will equip farmers and growers with practical information and tools to measure, manage and reduce on-farm emissions; recognise, maintain or increase integrated sequestration on farms; and adapt to a changing climate.

Find out more at
www.hewakaekenoa.nz

This document will be updated regularly. The first update in March 2021 will include a list of recognised methods for calculating your farm emissions.

Why reduce farm greenhouse gas emissions

New Zealand's international brand, and the value of our products in international markets, is built on our environmental credentials.

New Zealand farmers and growers are known as innovators and producers of premium products. We already have a reputation for having some of the most sustainable agricultural practices in the world.

We can continue to increase the value of our products by demonstrating that we are continually improving our practices, including managing greenhouse gas emissions.

Around the world, governments are increasingly focused on reducing emissions to limit further temperature rises. New Zealand must play its part to retain and grow market access in a low-emissions global economy.

From a te ao Māori world view, we are all part of te taiao and have a responsibility to care for it.

The Māori view, that the land provides for the people and therefore the people must provide for the land, strongly aligns with the view of most farmers and growers who see themselves as stewards of the land.

Farmers and growers are already active in protecting and restoring waterways, protecting and increasing biodiversity, and reducing emissions.

These interconnected actions will increase the value of our products and strengthen our brand and reputation, while helping to protect, restore and sustain our environment, and enhance our wellbeing and that of future generations.

To limit global temperature increases, to avoid greater impacts, New Zealand has joined other nations around the world in committing to reduce emissions (through the United Nations Framework Convention on Climate Change Paris Agreement).

New Zealand has agreed to reduce emissions by 30% below 2005 levels by 2030. The Climate Change Response (Zero Carbon) Act sets out New Zealand's path to a low emission, climate resilient future, with specific emission reduction targets for carbon dioxide, nitrous oxide, and methane.

More detail on our emissions targets are at www.hewakaekenoa.nz. Meeting these targets will require action from all New Zealanders.

Māori input to the partnership is through Te Aukaha, which is led by Maori land owner representatives and Maori agribusiness specialists. Te Aukaha is developing a Treaty based framework to reflect the unique circumstances of Māori land owners, and to ensure Māori engagement with climate action is driven by hapū, Iwi or other Maori collectives. It is envisaged that there will be a mana whenua stream established to harness the strength of the collective, and ensure a comprehensive and balanced approach to achieve intergenerational environmental outcomes. A collective approach to farm planning by Māori as kaitiaki is being developed by the Aukaha workstream.

Managing greenhouse gases through a Farm Plan

Farm planning is a useful tool to support farmers and growers manage the different parts of their farm business, and for providing assurance of good practice to consumers and other interested parties.

Many farmers and growers already have some form of farm plan, often as part of Industry Assurance Programmes (such as Fonterra's Tiaki programme, the red meat sector's NZ Farm Assurance Programme or Horticulture's GAP assurance programmes).

This guidance is intended to help farmers and growers incorporate a greenhouse gas module into their farm planning. It is designed to integrate with existing programmes and become part of an integrated farm plan.

It is likely that existing programmes will provide additional information drawing on this guidance.

Developing a greenhouse gas module in their farm plan, will help farmers and growers build:

- A clear understanding of their farm greenhouse gas emissions
- The knowledge to make informed decisions on actions to reduce emissions appropriate to their farm business, while considering effects on other aspects of the farm business.

The farm plan approach recognises the individual nature of each farm and that choices about how to reduce farm emissions are for each farmer and grower to make. Similarly, a collective approach to farm planning by Māori as kaitiaki is being developed by the Te Aukaha workstream.

By 2025 there is expected to be an emissions pricing mechanism, which will further inform individual farmer and grower decisions about the costs and benefits of actions to reduce emissions.

Choices about how to reduce farm emissions are for each farmer and grower to decide as part of their farm plan.

Farm greenhouse gas emissions

■ **Methane (CH₄)** – Generated by ruminants as a by-product of digestion. Most CH₄ is burped into the atmosphere by ruminant livestock. A small amount of CH₄ (less than 5%) also comes from dung and effluent systems.

The total feed eaten by livestock on your farm (per kilogram of dry matter intake) is the driver of CH₄ emissions.

■ **Nitrous Oxide (N₂O)** – Released into the atmosphere from dung and urine patches, and N fertilisers.

The nitrogen content of feed and the amount of nitrogen applied are the main drivers of N₂O emissions, temperature and soil moisture can also play a role.

■ **Carbon Dioxide (CO₂)** – The main driver of net farm CO₂ emissions is the area of woody vegetation. Woody vegetation captures CO₂ but also releases it when cleared.

To a much lesser extent the application of lime and urea nitrogen (N) fertilisers can also contribute to farm CO₂ emissions.

Soil management can both release and sequester CO₂ and this is under investigation so it can be better quantified.

Energy use is the other driver of farm CO₂ emissions. As it is already accounted for under the New Zealand Emissions Trading Scheme it is not included in your farm greenhouse gas emissions. However, it should be considered when assessing the costs and benefits of reduction opportunities, and to calculate your carbon footprint.

Talk to your sector organisation or an experienced rural professional for more detailed farm greenhouse gas emissions information.

The AgMatters website is a valuable source of information on farm greenhouse gas emissions
www.agmatters.nz

Opportunities to reduce farm greenhouse gas emissions

Methane (CH₄) – Reduce the total feed eaten on your farm through refining your stocking policy, improving animal health and reducing stock losses, improving your pasture and grazing management, converting your least productive land to indigenous or exotic trees, or converting more productive land to high value crops

Nitrous Oxide (N₂O) – Reduce the N-surplus on your farm through reducing the total amount of N fertiliser applied and refining your production system to reduce the nitrogen content of feed eaten

Carbon Dioxide (CO₂) – sequestration (capture and storage) – Increase the area of indigenous or exotic trees.

See the tables from page 9 for details on the opportunities to reduce greenhouse gases.

Good Farming Practice Principles for reducing greenhouse gas emissions

The Good Farming Practice Principles guide each farmer and grower to understand their emissions profile and what contributes to it, explore opportunities to reduce it, and keep good farm records.

1. Know your farm's greenhouse gas emissions
2. Identify opportunities to reduce your farm's greenhouse gas emissions and capture carbon
3. Choose your actions
4. Keep records, monitor and review.

1 Know your farm's greenhouse gas emissions

Knowing what your greenhouse gas emissions are and where they come from is the first step towards reducing them.

He Waka Eke Noa has a target of all farmers and growers knowing their farm emissions levels by December 2022.

A list of recognised methods for calculating your farm emissions will be included in an updated version of this document, and on the He Waka Eke Noa website, from March 2021.

2 Identify opportunities to reduce your farm's greenhouse emissions and capture carbon

There are many opportunities to reduce greenhouse gas emissions, and capture carbon; the potential will depend on the type of farming operation and current practices.

The broad opportunities include:

- Improving the efficiency of pasture and crop production
- Reducing the total amount of feed eaten
- Matching feed demand with pasture growth and utilisation
- Improving the management of livestock effluent
- Capturing and storing carbon in indigenous and exotic trees

You can find out more about each of these in the following pages.

3 Choose your actions

Each farmer or grower will know which of the opportunities to reduce emissions are appropriate to their operation, and whether they will involve simple changes to current farm management practices, or more significant action.

Based on this knowledge, each farmer and grower will choose which actions to take, as part of optimising their farming operation.

By 2025 it is expected there will be a pricing mechanism for emissions. This will inform decisions about the costs and benefits of actions.

Farmers and growers will be involved in developing the emissions pricing mechanism, through the He Waka Eke Noa partnership.

There is no fixed amount by which each farmer has to reduce emissions, and choices will depend on farm-specific opportunities and costs.

4 Keep records, monitor and review

Record keeping is essential to inform future decision-making and allow easy verification of farm emissions, which will likely be a future requirement.

Minimum information to record for the calculation of farm emissions includes:

- Livestock numbers by stock type, either using monthly values or, for simple tools, a weighted annual average
- Amount of synthetic N fertiliser applied annually.

Additional information that can support a more detailed understanding of farm emissions and reduction opportunities includes:

- Farm total and effective area
- Farm topography (slope)
- Livestock class, age, number, and movements
- N fertiliser or lime applications including product type, rate and timing
- Crop residues
- Production data such as milk solids, liveweight or crop yield
- Woody vegetation planting records.

Overview of farm greenhouse gas reduction opportunities

The table provides an overview of the currently available farm greenhouse gas reduction opportunities and the level of reduction that may be possible. Almost all these opportunities will reduce emission intensity, but many only reduce total farm emissions if changes are made to the farm system. For example, improving fertility rates or animal health reduces emissions intensity as the farm carries fewer non-productive livestock. However, total emissions are only reduced if the total number of mature livestock is then reduced.

More information about each opportunity is set out in the following pages. The potential reduction shown in the tables are indicative only, the actual impact will be highly dependent on your farming system.

Opportunity	Greenhouse Gas	Potential Reduction	Page
Improve the efficiency of pasture and crop production			10
Minimise N-Surplus through reduced N-fertiliser use	N ₂ O	Med	
Reduce N-Surplus through reduced use of supplementary feed	N ₂ O	Med	
Use inhibitor coated N-fertilisers	N ₂ O	Med – Low	
Improve crop husbandry	N ₂ O	Low	
Optimise soil pH levels	N ₂ O	Low	
Reduce total feed eaten			12
Convert less productive land to indigenous or exotic trees	CH ₄ N ₂ O	Med	
Cull less productive stock early	CH ₄ , N ₂ O	Med – Low	
Adjust stocking policy	CH ₄ , N ₂ O	Med – Low	
Reduce stock losses and optimise replacement rates	CH ₄ , N ₂ O	Low	
Increase animal performance through genetic selection	CH ₄ , N ₂ O	Low	
Convert more productive land to high value crops	CH ₄ , N ₂ O	Low	
Match feed demand with pasture growth and utilisation			14
Reduce bought-in supplementary feed	CH ₄ , N ₂ O	Med	
Use of lower protein forages	N ₂ O	Med – Low	
Optimise pasture quality and production	CH ₄	Low	
Improve the management of livestock effluent			16
Use captured effluent as a fertiliser	N ₂ O	Low	
Capture and store carbon in vegetation			17
Plant indigenous or exotic trees	CO ₂	Med	
Minimise periods of bare land	CO ₂	Med	

Greenhouse gas reduction opportunities

About the opportunity tables

The tables on the following pages provide information and examples to help you:

- Identify opportunities to reduce your farm's greenhouse emissions and capture carbon
- Choose your actions.

Each table gives a brief explanation of the action that could be taken to reduce greenhouse gases and then examples of what that action might look like in practice, supported by further information. For each action, the table sets out which gases would be affected and any other benefits, for example benefits for freshwater or biodiversity.

These tables are a summary of cross-sector information. More detailed information and advice may be available from your sector, and rural professionals.

Some of the opportunities in the table can be applied and assessed in combination, but their impact is often not cumulative; that is, you won't necessarily get additional reductions in emissions at the same scale from additional actions.

It is important the net greenhouse gas impact of any reduction opportunity is assessed – this should include methane, nitrous oxide, and carbon dioxide, including fossil fuel related emissions.

Remember, choices about how to reduce farm emissions are for each farmer and grower to decide as part of their farm plan. There is no fixed amount by which each farmer has to reduce emissions, and choices will depend on farm-specific opportunities and costs. These tables are intended to inform your choices; you are not expected to do everything listed in them.



Opportunity 1: Improve the efficiency of pasture and crop production

For pasture farmers, efficiency improvements will only reduce greenhouse gas emissions if the total feed eaten on farm is decreased.

For cropping farmers, improving the efficiency of production is the main opportunity to reduce emissions.

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Minimise nitrogen (N)-surplus through reduced use of N fertiliser and/or supplementary feed	<p>Use soil tests such as the Nitrate Quick Test and Deep Soil Mineral N tests for cropping.</p> <p>Use nutrient budgeting tools to plan nitrogen fertiliser inputs for crops, e.g. Crop Calculators and OVERSEER.</p> <p>Use feed and nutrient budgeting tools to plan nitrogen fertiliser inputs for pasture, e.g. FARMAX and OVERSEER.</p> <p>Maintain high levels of clover in pasture to reduce the need for N fertiliser applications.</p>	N ₂ O	Benefits freshwater by reducing nutrient loss to waterways	<p>Quick Nitrogen Test Mass Balance Tool & User Guide www.far.org.nz/articles/1231/quick-test-mass-balance-tool-user-guide</p> <p>LandWISE Nutrient Budgeting Templates for Vegetable Crops www.landwise.org.nz/projects/nutrient-budgeting-made-easy</p> <p>Horticulture New Zealand Code of Practice for Nutrient Management www.hortnz.co.nz/assets/Uploads/Code-of-Practice-for-Nutrient-Management-v-1-0-29-Aug-2014.pdf</p> <p>Nutrient Management for Vegetable Crops in New Zealand www.plantandfood.co.nz/page/news/media-release/story/new-nutrient-management-guidelines-for-vegetables</p> <p>Nutrient Management on your Dairy Farm www.dairynz.co.nz/publications/environment/nutrient-management-on-your-dairy-farm</p>
Select inhibitor coated N-fertilisers to reduce the amount of nitrogen applied	Use coated urea products (urease inhibitors) to increase effectiveness of urea applications.	N ₂ O	Reduce nutrient loss to waterways	A 10% reduction in urea applied can be achieved for the same production by using a coated urea product.

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Manage timing and placement of N fertiliser applications to reduce the amount of nitrogen applied	<p>For cropping, incorporate N fertiliser applied at planting and split N fertiliser applications to target specific crop growth stages.</p> <p>For pasture, only apply N fertiliser when there is a genuine feed deficit, nitrogen is the limiting nutrient, there is sufficient soil moisture, and soil temperatures are above 6°C.</p> <p>Use weather forecasts to apply N fertilisers prior to effective rainfall.</p> <p>Maintain and calibrate fertiliser spreading machinery in accordance with the manufacturers operating manual or use Spreadmark accredited contractors.</p> <p>Adopt precision fertiliser placement technologies.</p>	N ₂ O	Reduce nutrient loss to waterways	<p>The extent to which timing and placement of fertiliser applications reduces N₂O emissions can be highly variable between farms.</p> <p>Fertiliser Association of NZ Code of Practice for Fertilisers www.fertiliser.org.nz/Site/code-of-practice/</p> <p>Strategies to reduce nitrogen fertiliser use www.dairynz.co.nz/environment/nutrient-management/strategies-to-reduce-n-fertiliser-use/</p> <p>Successful soil and fertiliser management beeflambnz.com/knowledge-hub/podcast/PC42-soil-and-fertiliser-management</p>
Manage pasture and crop husbandry to optimise production	<p>Fertility is optimised for the soil type, slope, and climate.</p> <p>Pests and diseases are regularly monitored and addressed as appropriate.</p> <p>Grazing rotations are managed to optimise pasture grown.</p> <p>Pugging and compaction are minimised.</p> <p>Irrigation is well-timed and efficient.</p>	N ₂ O	Reduce nutrient loss to waterways	<p>The degree to which these practices reduce N₂O emissions depends on whether total N fertiliser inputs can be reduced through their application.</p> <p>For extensive systems, if optimised fertility results in an increased pasture production, this may result in increased CH₄ emissions through increased feed eaten.</p>
Optimise the use of lime through targeted applications	<p>Test soil regularly for pH and aim to apply lime to keep pastoral farmed soils in pH range 5.8 – 6.2.</p> <p>Use nutrient budgeting tools for crops and pasture, e.g. Crop Calculators and OVERSEER to ensure correct rates for pH correction.</p>	N ₂ O and CO ₂		<p>Whilst the application of lime does produce CO₂ emissions, optimal soil pH results in more production per unit of nitrogen applied and therefore less N fertiliser applied.</p> <p>For extensive systems, if optimised pH results in increased pasture production, this may result in increased CH₄ emissions through increased feed eaten.</p>

Opportunity 2: Reduce total feed eaten on farm

It is the total amount of feed eaten on farm that drives greenhouse gas emissions. Consideration of stocking rate at different times of the year, individual animal performance and the need for supplementary feed, can help to optimise livestock farming systems, increase or maintain profitability, and reduce on-farm greenhouse gas emissions.

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Identify and cull less productive stock early	<p>Less productive and empty dairy cows culled early in the season rather than carried through.</p> <p>Dairy herds sequentially dried off in autumn instead of using supplementary feeds or N fertiliser to boost pasture growth.</p> <p>Less productive dry ewes culled early rather than carried through.</p>	<p>CH₄</p> <p>N₂O</p>	Reduce nutrient loss to waterways	
Reduce wastage rates (unplanned losses) so replacement rates can be optimised, and total feed eaten reduced	<p>For dairy, replacement rates can only be optimised and reduced when wastage rates are minimal. If wastage rates are high through poor reproductive performance and animal health issues, this creates risk for sustaining herd numbers and profit from using low replacement rates. Reduced total feed demand from fewer replacements results in a reduction in the use of N fertiliser and/or supplementary feed.</p> <p>Increase lamb survival rates.</p> <p>Rear lambs from the sheep dairy industry.</p>	<p>CH₄</p> <p>N₂O</p>	Reduce nutrient loss to waterways	For dairy, the optimum replacement rate for maintaining genetic gain is 18 – 20% where the wastage rates are low, and the not in calf rate is less than 8%.
Adjust livestock class or ratios within the farm system to reduce the total feed eaten	<p>Increase breeding beef cow longevity or replace cows with dairy beef animals.</p> <p>Consider hogget mating to increase the lifetime efficiency.</p> <p>Increase lambing percentage and sell lambs earlier or finish lambs faster.</p>	<p>CH₄</p> <p>N₂O</p>	Reduce nutrient loss to waterways	<p>Hogget mating is only suitable for some breeds of sheep</p> <p>Sheep and beef farms may benefit by matching the farm system to the pasture growth curve.</p>

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Use genetic selection over time to increase animal performance and decrease livestock maintenance requirements	<p>Choose new genetics based on Breeding Worth. Over time this will result in higher profit and yield as less cows or sheep are required to convert the feed to profit.</p> <p>Consider sheep breed selection for lambing percentage and lamb growth rates.</p>	<p>CH₄</p> <p>N₂O</p>	<p>Reduce nutrient loss to waterways</p>	<p>For dairy, genetic gains mean a 288-cow herd today produces the same milk solids as the equivalent 300-cow herd 10-years ago (4% improvement). This reduction of 12 cows reduces CH₄ and N₂O emissions without reducing production.</p> <p>Higher per cow production using lower stocking rates requires skilled grazing management, tactical use of supplementary feed, and/or longer lactations. For grazing management, maintaining an adequate stocking rate is essential to ensure pasture quality and productivity.</p>
Manage animal health	<p>Improved animal health leads to gains in efficiency and productivity.</p>	<p>CH₄</p> <p>N₂O</p>	<p>Reduce nutrient loss to waterways</p>	
Retire less productive land from grazing	<p>Match land use with land class.</p> <p>Highly erodible, very steep, or very wet areas, retired from production or converted to forestry. Livestock numbers reduced to match feed supply.</p>	<p>CH₄</p> <p>N₂O</p>	<p>Supports Biodiversity.</p> <p>Reduce sediment and nutrient loss to waterways.</p>	<p>All land use change options require detailed analysis, including land suitability market, labour and financial.</p>
High value land use change	<p>Match land use with land class.</p> <p>Highly productive land converted to high-value crop production and livestock numbers reduced to match feed supply.</p>	<p>CH₄</p>	<p>Reduce sediment and nutrient loss to waterways</p>	<p>All land use change options require detailed analysis, including land suitability, market, labour and financial.</p>



Opportunity 3: Match feed demand with pasture growth and utilisation

Balancing pasture growth and utilisation is key to optimising stocking rates that result in the same or higher profit with lower inputs. Improved grazing management and strategic management of stocking rate throughout the year can result in less pasture wastage and lower supplementary feed inputs, reducing emissions.

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Optimise pasture quality and production to better meet feed demand	<p>Pasture-based farming systems with good grazing management that maintain year-round quality pasture production reduce total feed demand.</p> <p>Good grazing management include practices such as:</p> <ul style="list-style-type: none"> ■ Regular pasture assessments and feed budgeting ■ Setting and managing pre-grazing covers and post-grazing residuals (intensive systems) ■ Choosing rotation lengths that optimise both quality and quantity of pasture ■ Managing pests and diseases ■ Optimising soil fertility ■ Actively managing any pasture surplus 	CH ₄ N ₂ O	Reduce nutrient loss to waterways	<p>DairyNZ guide to pasture management www.dairynz.co.nz/feed/pasture-management/</p> <p>B+LNZ guide to growing and grazing pasture beeflambnz.com/knowledge-hub/module/principles-feeding-growing-and-grazing-pasture#block-1349</p>
Optimise supplementary feed inputs to better meet feed demand	<p>Adjust stocking rate (feed demand) to increase home grown feed and reduce bought-in feed. Supplements should be used tactically to address a true feed deficit or feed imbalance.</p> <p>Use low N content supplementary feeds.</p>	CH ₄ N ₂ O	Reduce nutrient loss to waterways	<p>For dairy, supplements should only be used when the marginal milk produced is adding to the farm's operating profit.</p> <p>DairyNZ Effects of removing supplementary feed www.dairynz.co.nz/news/effects-of-removing-imported-feed</p>
Use of alternative forages to reduce protein in the diet	<p>Fodder beet reduces N₂O emissions, but for CH₄ emissions it is only effective at very high rates of diet inclusion, e.g. above 80%.</p> <p>Forage rape reduces CH₄ emissions, but the rate of diet inclusion required for this is still under investigation. If intensively grazed on wet soils, increased N₂O emissions may reduce its benefits.</p> <p>Maize silage has a beneficial impact on N₂O emissions due to its lower nitrogen concentration means a slight increase in dry matter consumed and therefore CH₄ emissions.</p> <p>Hay has a beneficial impact on N₂O emissions due to its lower nitrogen concentration than pasture. Its low digestibility can also reduce feed intake and therefore CH₄ emissions.</p> <p>Plantain can reduce the nitrogen concentration in urine and therefore N₂O emissions in some circumstances. It also appears to create soil conditions that reduce N₂O production and may also reduce CH₄ emissions. Research is continuing into these, alongside how to incorporate and manage plantain persistence in pasture farming systems.</p>	N ₂ O CH ₄	Reduce nutrient loss to waterways	<p>All the alternative forages listed are already used. However, optimising their incorporation into a farming system and the long-term effects on animals, production and the environment is still under investigation.</p> <p>For some forages, the net greenhouse gas emissions need to be considered including the use of N fertiliser and potential impacts on soil carbon from more regular cultivation.</p>

Opportunity 4: Improve the management of livestock effluent

Livestock effluent can be a significant source of on-farm greenhouse gas emissions where stand-off pads or animal housing is in use. In such farming systems an increased focus on better utilisation of effluent has benefits for both on-farm emissions, and nutrient loss to water.

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/
Avoid storing effluent in anaerobic conditions	Carry out solids separation to prevent solids entering anaerobic storage ponds. Actively manage the effluent pond to its lowest level, regularly remove and apply any solids to pasture.	N ₂ O CH ₄	Reduce nutrient loss to waterways	DairyNZ guidance for dairy effluent management www.dairynz.co.nz/environment/effluent/
Methane (CH₄) capture	Capture and flare or use of CH ₄ from effluent ponds.	CH ₄		New CH ₄ capture and conversion technologies are being assessed to understand how they could be deployed for New Zealand effluent systems, feasibility and impact on emissions. Energy capture systems from effluent www.dairynz.co.nz/media/2546503/energy-capture-systems-effluent-tech-note.pdf
Use all captured effluent as a fertiliser enabling reduced N fertiliser use	Regularly monitor effluent composition and record location of effluent applications to optimise fertiliser applications on effluent blocks. A stand-off pad or barn is constructed, and the effluent from this captured and reused as fertiliser.	N ₂ O	Reduce nutrient loss to waterways. Animal care.	When animals are stood off pasture total greenhouse gas emissions are likely to increase due to CH ₄ emissions from manure management and greater N ₂ O emissions.



Opportunity 5: Capture and store carbon in vegetation

Planting or restoring woody vegetation on-farm can improve erosion control, waterway enhancement, biodiversity, shade and shelter, commercial gain, and aesthetic appeal. These activities may also capture and store carbon. The capture and storing of carbon (sequestration) is typically a secondary benefit from undertaking these activities.

Only land that meets certain criteria can currently be entered in the New Zealand Emissions Trading scheme. Consider the minimum standards to qualify for sequestration rewards against the risks and benefits of entering the scheme. Engaging a forestry expert to help you with this is advisable. Find more information at www.teururakau.govt.nz/growing-and-harvesting/forestry/forestry-in-the-emissions-trading-scheme/

Through He Waka Eke Noa, the primary sector is working with government to explore the potential for the inclusion of non-ETS plantings into on-farm emissions reporting. Once this has been agreed this guidance will be updated.

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Consider converting less productive land into indigenous vegetation	Change land use of less productive land within the farm system, allowing natural regeneration to occur or by replanting with indigenous species. Consider whether the land planted would be suitable for entry into the New Zealand Emissions Trading Scheme.	CO ₂	Support Biodiversity. Reduce sediment and nutrient loss to waterways. Commercial.	Department of Conservation (DoC) guide to protecting and restoring indigenous vegetation www.doc.govt.nz/about-us/science-publications/conservation-publications/protecting-and-restoring-our-natural-heritage-a-practical-guide Regional guides to planting natives www.treesthatcount.co.nz/resources/regional-guides-for-planting-natives/
Consider converting less productive land into exotic forest	Change land use of less productive land within the farm system by planting exotic forest. Consider whether the land planted would be suitable for entry into the New Zealand Emissions Trading Scheme.	CO ₂	Reduce sediment and nutrient loss to waterways. Support Biodiversity. Commercial.	MPI guide to planting forestry www.mpi.govt.nz/growing-and-harvesting/forestry/getting-started-in-farm-forestry/what-to-think-about-before-you-plant-forest/ Farm Forestry guide to planting forestry www.nzffa.org.nz/farm-forestry-model/the-essentials/
Consider establishing wetland forests	Change the land use of less productive wet areas within the farm system and establish wetland forests. Consider whether the land planted would be suitable for entry into the New Zealand Emissions Trading Scheme.	CO ₂ and CH ₄	Support Biodiversity. Reduce sediment and nutrient loss to waterways.	DoC guide to wetland forests www.doc.govt.nz/nature/native-plants/wetland-forests Opportunities for wetland forests include Kahikatea swamp forests, peatland forests (poorly drained areas of the west coast and central plateau) and Mangroves.

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Consider planting riparian setbacks	<p>Plant riparian setbacks to achieve freshwater benefits through stock exclusion and ground cover.</p> <p>Plant trees to stabilise banks and provide stream shading.</p> <p>If the riparian setback is greater than 1 hectare and has an average width of more than 30 metres or adjoins an area of forest that is to be entered, consider whether the land planted would be suitable for entry into the New Zealand Emissions Trading Scheme.</p>	CO ₂	<p>Support Biodiversity.</p> <p>Reduce sediment and nutrient loss to waterways.</p>	<p>DairyNZ guide to planting waterways www.dairynz.co.nz/environment/waterways/planting-waterways/</p> <p>DairyNZ riparian planner www.dairynz.co.nz/environment/waterways/riparian-planner/</p> <p>Some regional councils provide advice and support for riparian planting and also fund plantings. Visit your regional council website for more information.</p>
Consider planting erosion control trees where erosion is active or could occur	<p>Plant spaced poplars and willows, or other species with known root stabilising impact, on slopes to control and reduce erosion.</p> <p>Gully plant willows to control and reduce erosion.</p> <p>If the erosion control planting is greater than 1 hectare, has a tree crown cover of greater than 30% and has an average width of more than 30 metres, consider whether the land planted would be suitable for entry into the New Zealand Emissions Trading Scheme.</p>	CO ₂	<p>Support Biodiversity.</p> <p>Reduce sediment and nutrient loss to waterways.</p> <p>Animal welfare.</p>	<p>Poplar & Willow Research Trust guide to poplars and willows www.poplarandwillow.org.nz/farmer-guides/why-plant-poplars-and-willows</p> <p>Farm Forestry guide to poplars and willows for erosion control www.nzffa.org.nz/farm-forestry-model/resource-centre/tree-grower-articles/november-2010/use-of-poplars-and-willows-for-erosion-control</p> <p>Some regional councils provide advice and support on planting trees for erosion control and also fund plantings. Visit your regional council website for more information.</p>
Consider planting trees for animal welfare and pasture protection	<p>Plant shelterbelts within the farming landscape to provide shade and shelter for livestock.</p> <p>Plant shelterbelts within the farming landscape to protect from wind erosion.</p> <p>If the shelterbelt is greater than 1 hectare and has an average width of more than 30 metres, consider whether the land planted would be suitable for entry into the New Zealand Emissions Trading Scheme.</p>	CO ₂	<p>Animal welfare.</p> <p>Support Biodiversity.</p> <p>Reduce sediment loss to waterways.</p>	<p>Farm forestry guide to shade and shelter www.nzffa.org.nz/farm-forestry-model/why-farm-forestry/trees-for-shade-and-shelter/</p> <p>DairyNZ guide to shade and shelter www.dairynz.co.nz/media/5447838/Trees_for_shelter.pdf</p>

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Consider diversifying land use by establishing perennial tree crops (fruit or nut trees for example)	<p>Planting perennial tree crops will sequester carbon when growing but lose carbon when they are pruned or replanted.</p> <p>This is unlikely to be a viable stand-alone option to sequester carbon and is not eligible for inclusion the New Zealand Emissions Trading Scheme.</p>	CO ₂	Commercial	<p>Tree Crops – Fruits treecrops.org.nz/tree-information/fruit</p> <p>Tree Crops – Nuts treecrops.org.nz/tree-information/nuts/</p>
Consider fencing and pest control for existing and newly planted indigenous vegetation	Any activity which improves growth of existing indigenous vegetation or reduces losses will increase net sequestration.	CO ₂	<p>Support Biodiversity.</p> <p>Reduces sediment loss to waterways.</p>	<p>DoC guide to protecting and restoring indigenous vegetation www.doc.govt.nz/about-us/science-publications/conservation-publications/protecting-and-restoring-our-natural-heritage-a-practical-guide/</p>



Opportunity 6: Capture and store carbon in soils

Research on ways to maintain and increase soil carbon under New Zealand conditions is currently underway. New Zealand currently has high soil carbon levels compared to other countries globally. Any disturbance of soil leads to soil carbon loss. Except for changes in land use (e.g. cropping to pasture), no management practices have been widely proven to increase soil carbon under New Zealand conditions, but some practices have been proven to help minimise the risk of soil carbon losses. Quantifying changes in soil carbon is possible but can be labour-intensive and expensive, requiring repeated measurements over long time intervals, e.g., 3-10 years. For many of the options included in the table the net impact on greenhouse gas emissions must also be considered.

Through He Waka Eke Noa the primary sector is working with government to explore the potential for the inclusion of soil carbon into on-farm emissions reporting. Once this has been agreed this guidance will be updated.

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Minimise time soils are left fallow, i.e., with no growing vegetation.	Sow cover crops or minimise the time between crops.	CO ₂	Reduce sediment and nutrient loss to waterways	When soils are bare, there is no carbon input from photosynthesis, but losses of CO ₂ from microbial respiration continues, so there is a net loss of soil carbon.
Increase the duration of pasture in crop rotations	The crop rotation has a longer pasture phase included within it.	CO ₂	Soil health	The net greenhouse gas impact must be considered - if pastures are grazed, increases in CH ₄ and N ₂ O may negate any soil carbon increases.
Retain and incorporate crop residues where possible	Avoid stubble burning unless necessary for pest and disease management.	CO ₂	Soil health	Retaining material 'on-farm' provides the opportunity for it to be incorporated into soil organic matter.
Add external organic amendments such as manure, compost, or biochar	This approach is only likely to lead to measurable increases in soil carbon if large quantities are added. If amendments stop being added, soil carbon will likely decrease back towards the original equilibrium over time.	CO ₂	Soil health	The net greenhouse gas benefit must be considered - emissions associated with production, transport and spreading.
Optimise water table depth for peat soils	Actively manage the water table, keeping it as high as practically possible.	CO ₂		Drainage of peat soils exposes large amounts of carbon to oxygen which accelerates microbial decomposition and CO ₂ release. Further research is required to identify the optimum water table depth to minimise net emissions, i.e., including consideration of CH ₄ and N ₂ O.

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Restore or create wetlands	Restoration of large wetlands that act as a long-term carbon sink.	CO ₂	Reduce sediment and nutrient loss to waterways. Support Biodiversity.	The net greenhouse gas benefit must be considered as CH ₄ and N ₂ O emissions may increase in the short term and net carbon sequestration is highly uncertain. Further research is required to determine the long-term net effect of wetland restoration and construction under New Zealand conditions. Large natural peat bogs in the Waikato have been shown to be net greenhouse gas sinks.
Protect and manage erosion prone land	See Opportunity 5 – Erosion control plantings.	CO ₂	Reduce sediment loss to waterways. Support Biodiversity.	
Increase the different types of plant species in pasture swards	Adding deeper rooted species like lucerne, chicory and plantain to traditional ryegrass and clover swards.	CO ₂	Reduce nutrient loss to waterways.	This is an area of active research in New Zealand. Diversity of functional groups (e.g. grass, legumes, and forbs/herbs) is generally considered more important than the number of species present. Current evidence is largely from overseas experiments in un-grazed grasslands.
For pasture renewal, use full inversion tillage every 30-years	The principle is that carbon rich topsoil is buried, and the carbon stabilised lower in the soil profile, while carbon is rebuilt on subsoil material brought to the surface.	CO ₂		This is an area of active research in New Zealand. Early results are promising, but information on the long-term implications across a range of situations are needed before the practice can be recommended.



Future opportunities: Technologies that reduce methane or nitrous oxide production

A range of developing technologies are focused on reducing livestock methane production per unit of feed consumed or nitrous oxide production. These include alternate forages, additives, inhibitors, vaccines, genetic selection and genetic modification. New nitrification inhibitors are also still under development. None of these is currently available for use in New Zealand, but some may become viable within the next 5-10 years. For the latest science, see www.nzagrc.org.nz and www.pggrc.co.nz

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Application of feed additives and rumen methane inhibitors, and vaccines	Several products have been shown to reduce CH ₄ production (per kilogram dry matter intake) from ruminants when fed as part of a total mixed ration. To date there is no robust demonstration or approval (where required) for their use in a New Zealand pasture-based system.	CH ₄	Reduce nutrient loss to waterways.	Delivery may require changes in farm practices (longer lasting products in the rumen, use of boluses, in shed or in-pasture feeding or water trough distribution). There may be regulatory barriers and requirements, e.g., withholding periods, and potential negative market reactions to the use of feed additives.
Application of feed additives that bind surplus dietary N and render it indigestible	Use of tannins to reduce protein digestion, which increases faecal N and reduces urine N.	N ₂ O and CH ₄	Reduce nutrient loss to waterways.	Some of these binding agents will reduce production if offered in too great a quantity.
Genetic selection for lower-emissions animals	Genetic breeding values for low CH ₄ sheep are currently being rolled out to breeders and will soon to be available to farmers. Work is continuing to identify low CH ₄ cattle and testing is underway on potential benefits from low-N emitting cattle.	CH ₄ N ₂ O	Reduce nutrient loss to waterways.	Genetic selection takes time but is permanent and cumulative. Environmental indexes are now being incorporated as part of Breeding Worth programmes. There may be trade-off's with productivity traits by adding an additional selection trait.



Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Potential development of genetically modified plants	<p>The CH₄ reducing effects of High Metabolisable Energy rye grass are yet to be proven in animals.</p> <p>Genetically modified high lipid ryegrass cultivars are in development. High lipid diets have been shown to reduce CH₄ emissions in some circumstances. They may also reduce N₂O emissions due to the reduced plant nitrogen concentrations.</p> <p>Genetically modified high tannin-containing white clover is yet to be tested for effects on greenhouse gas emissions.</p>	CH ₄ N ₂ O	Reduce nutrient loss to waterways	Proof of concept, regulatory barriers and potential market reactions for the use of genetically modified plants in New Zealand.
Application of nitrification inhibitors to the soil that slow the nitrification of ammonia and reduces N₂O emissions	The next generation of inhibitors are now under development.	N ₂ O	Reduce nutrient loss to waterways	



Other considerations:

Reduce fossil fuel related emissions

On-farm greenhouse gas emissions from fossil fuels are already accounted for through the New Zealand Emissions Trading Scheme and are not part of the on-farm emissions reporting and verification requirements. However, they are a key consideration in improving your farm's carbon footprint. It is also important to understand current and future non-renewable energy farm inputs when exploring on-farm greenhouse gas reduction opportunities.

Explanation of action	Example	Greenhouse gases	Other benefits	Further Information/ Sector Guidance
Reduce fossil fuel use by minimising machinery usage	Minimum tillage cultivation techniques are adopted. Correct tyre pressures.	CO ₂ and N ₂ O	Reduce sediment loss to waterways	
Reduce fossil fuel use through selection of more efficient or electric machinery	Upon replacement, a more efficient pump motor is selected for the irrigation and stock water system.	CO ₂		DairyNZ energy efficiency information www.dairynz.co.nz/milking/the-milking-plant/electricity-efficiency/ Irrigation NZ energy efficiency information www.irrigationnz.co.nz/practical-resources/irrigator-risk-advice/ Attachment?Action=Download&Attachment_id=73 Saving electricity on the farm www.smallerherds.co.nz/knowledge-hub/infrastructure/some-observations-on-saving-electricity-on-the-farm/
Reduce electricity use from the grid through more efficient energy use, and/ or on-farm solar/ wind and water generation	Installation of a wind turbine or solar panels on farm buildings and/ or dairy sheds.	CO ₂		Sustainable Energy Association www.seanz.org.nz/public_resources

Climate change adaptation

Incorporating a long-term risk-based approach to farm planning is key to building farm resilience to climate change.

While farmers and growers are already well practiced in managing climatic risk, future changes in the climate, including more frequent occurrence and severity of extreme events, will require an increased focus on adaptation.

This guidance is to help farmers and growers better consider climate change adaptation when identifying options to reduce their on-farm greenhouse gas emissions.

Incorporating a long-term risk-based approach to farm planning is key to building farm resilience to climate change. The steps in this process include:

1 Understand the likely future climatic and extreme events scenarios for your farm

2 Understand the risks and opportunities this creates for your farm:

- biophysical characteristics
- farming system
- infrastructure

3 Assess and implement options to increase your farms resilience, including understanding the benefits of these to your wider farming business

4 Monitor and adapt your approach over time.

Strategies to increase climate change resilience will differ for each farm, however they will likely contain a mixture of the following approaches:

- Increased monitoring and awareness to identify and manage impacts
- Actions to reduce specific exposure to likely impacts
- Contingency planning
- Income diversification.

More comprehensive guidance will be provided for climate change adaptation in early 2022.

