Responding to a changing climate

Why do we need to respond to climate change?

A changing climate affects everyone; it is a global challenge. Farmers are especially affected due to farming systems being dependent on the climate and weather. Everybody has their part to play in reducing emissions and adapting to a changing climate.

There are two aspects to a response; managing greenhouse gas emissions and removals to limit the warming of our world, and building resilience to the impacts of changing climatic conditions.

Objective of this section

By completing this section you should be able to;

- Understand what New Zealand has committed to doing in response to climate change
- Understand the risks and impacts climate change may have on your farm
- Quantify the relevant emissions and sequestration from your farm ('know your numbers')
- Understand what some of the options are to manage greenhouse gas emissions
- Understand what a sink is and what sequestration opportunities are and how these apply to your farm
- Develop a plan for managing adverse events (adaptation plan).

STEP 1 RESPONDING TO A CHANGING CLIMATE

Goals or values for responding to climate change

In relation to your long-term vision and goals identified at the start, identify specific goals for climate change on your farm, and note these in **Template CC1** in "Our Plan". It may be about understanding your emissions, it may be about managing or mitigating your emissions, it may be about being prepared for an adverse event or changing climatic conditions. **By 2025, all farmers need to have a plan to measure and manage emissions and be ready to participate in a pricing mechanism as part of the industry commitment to He Waka Eke Noa - The Primary Sector Climate Action Partnership**.

Greenhouse gas and climate change values and goals

CC1 **Example**

Responding to Climate Change Goals
To gain market recognition for products with low emissions
To produce low emission and eco-efficient product valued by consumer
Know my greenhouse gas emissions numbers and have a plan to manage them
Be able to adapt and change to a range of changing climate scenarios

Blank templates can be found in **Our Plan** section

At the end of this chapter is a section containing further background information

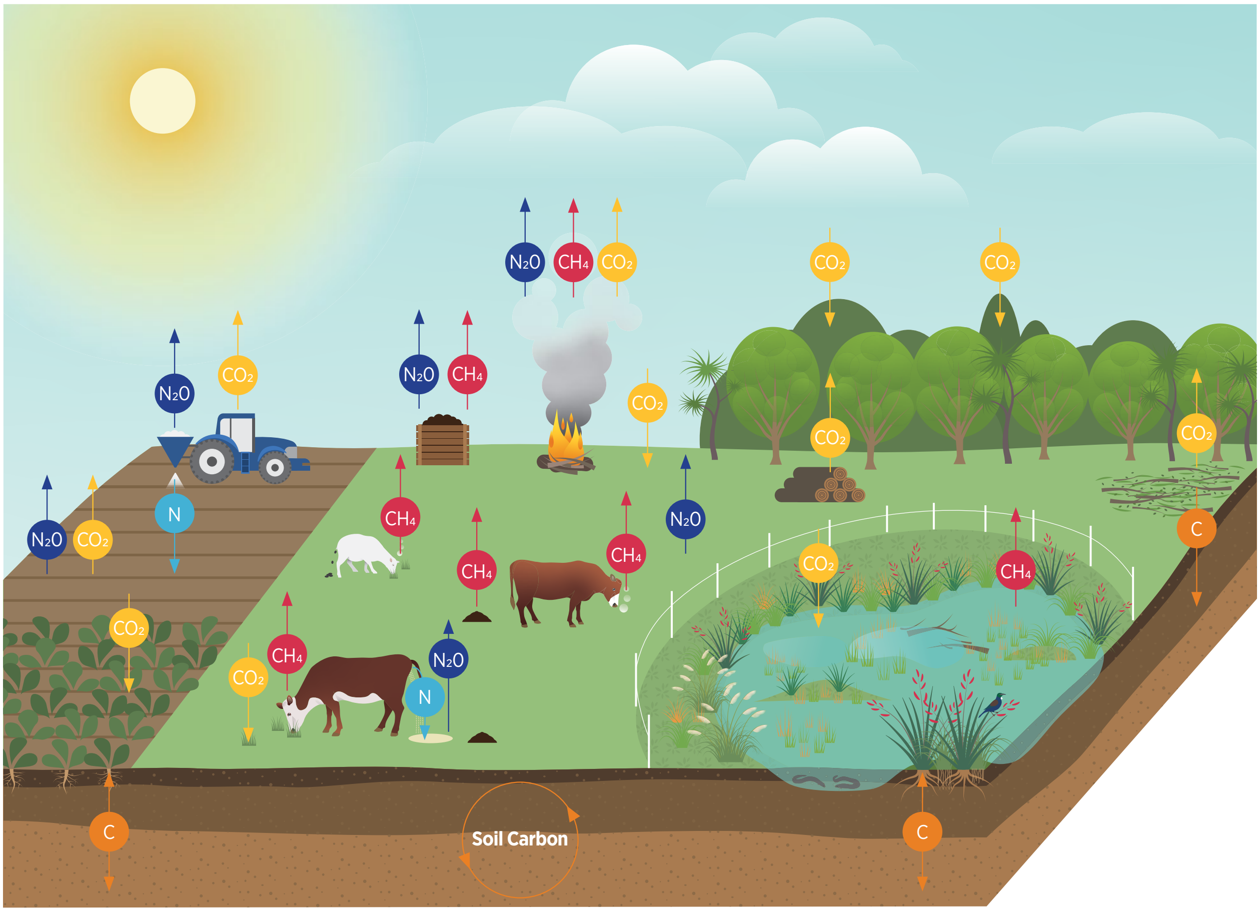
STEP 2 RESPONDING TO A CHANGING CLIMATE

What are sources and sinks of greenhouse gas emissions on farm?

Sources of emissions from your farm system may include:
Methane from ruminants (e.g. sheep, cattle, deer), effluent storage and wetlands.

Nitrous oxide from urine patches, soils, nitrogen fertilisers and effluent storage.

Carbon dioxide emissions from the decomposition of biomass, burning of fires, soil respiration, burning of fossil fuels and deforestation. Sinks of carbon dioxide, in the form of carbon, are trees, plants, pasture, soils, wetlands and in animals products (meat, milk, fibre).



Farming emissions and sinks come from a variety of sources

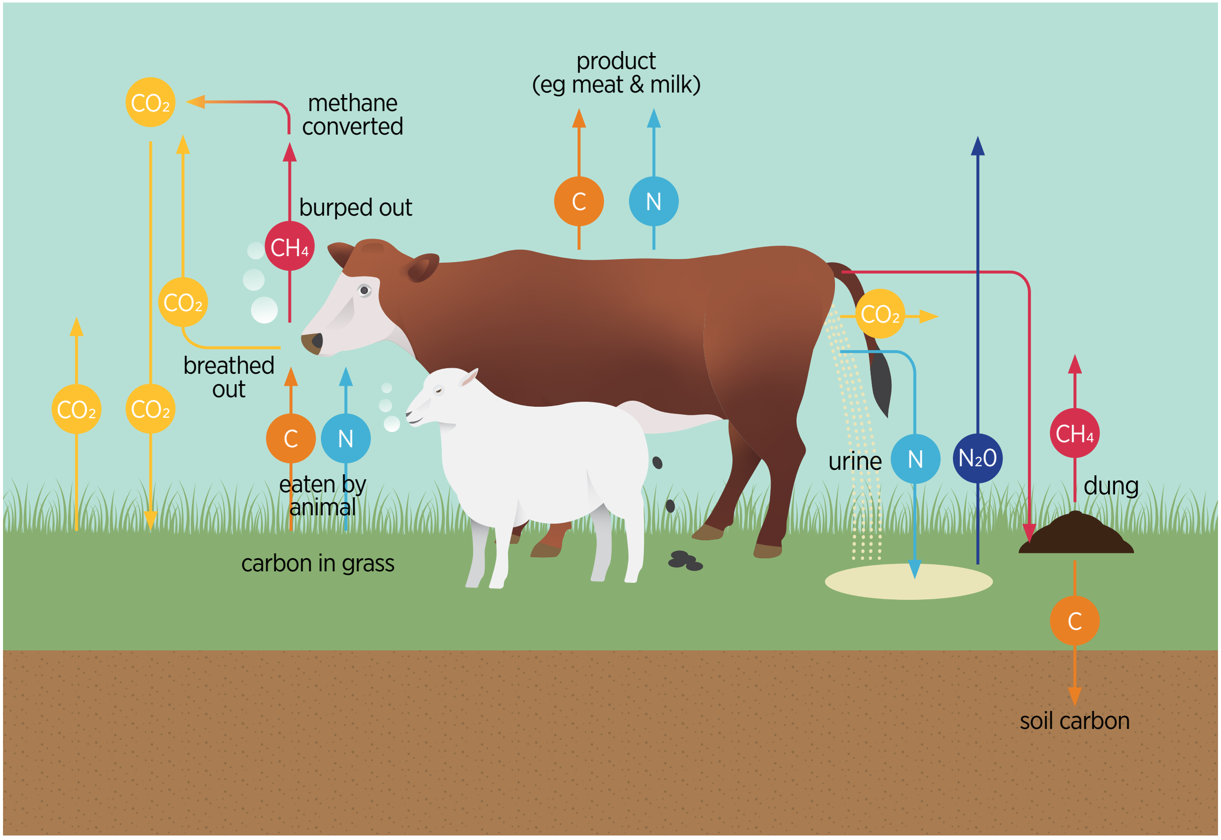
- **N_2O (nitrous oxide)**: emissions from urine patches, soils, N fertiliser, effluent storage
- **CO_2 (carbon dioxide)**: emissions from petrol and diesel use, deforestation, soil respiration, burning wood, plant decomposition; taken up by trees, plants, pasture, wetlands
- **C (carbon)**: stored in soils, plants and animal products (meat, milk, fibre)
- **CH_4 (methane)**: emissions from animal burps, wetlands, dung and effluent storage
- **N (nitrogen)**: added as fertiliser, urine, dung and effluent

Methane and nitrous oxide from livestock

Methane is produced by ruminant animals and is released into the atmosphere as burps. It is produced via a complex process that occurs when ruminants eat plant material which is eventually transformed into methane by methanogens in the gut.

With a traditional pasture-based diet there is a direct relationship between the amount of dry matter eaten and the amount of methane produced. Approximately 21-22 grams of methane is produced per kilogram of dry matter intake (DMI).

Nitrous oxide is produced when soil microbes interact with nitrogen (N) in the soil and release N_2O. The more N in the soil the more microbial activity and thus the more N_2O produced. Common sources of N on farm are urine patches and N fertiliser.



What is a sink?

Carbon sinks are natural reservoirs that absorb carbon dioxide and store more carbon than they release. On farm, the main sources of carbon sinks are actively growing trees. Soils also act as sinks, however, this is not well understood in New Zealand at the moment and they are not recognised at present. Therefore, carbon sinks focus on woody vegetation (trees). A forest acts as a sink as long as the sequestration (carbon storage) is greater than the carbon release of dead and decaying matter. Often, once a forest reaches maturity the system is in balance and is no longer a sink, if the forest is harvested it then becomes a source of carbon dioxide emissions.

Sequestration: Recording current areas of woody vegetation

Under current policy settings, land that was not in forest on 31 December 1989 (known as post-1989 land) and has been planted or is regenerating is eligible for earning credits under the New Zealand Emissions Trading Scheme (ETS); if it is greater than a hectare, average width of 30m, will reach at least 5m at maturity, and will have at least 30% canopy cover at maturity.

Land that was forested on 31 December 1989 (known as pre-1990 land) is not eligible for credits in the New Zealand Emissions Trading Scheme (although has liabilities if harvested and not replanted). However, this area may still provide carbon sequestration.

In **Template CC2** in "Our Plan", identify your current area of woody vegetation by type (regardless of whether you are registered for the New Zealand Emissions Trading Scheme). It is recommended to include all areas of woody vegetation, including those areas which may not be eligible for the Emissions Trading Scheme- such as small areas under 1ha, waterway plantings, scrub and shrubland areas. All these areas may still be sequestering carbon so it is important to account for and map these areas too. An example is given below.

Identify the following:

- Age of forest (approximate if you are unsure)
- State – consider if it is declining, static or improving. You may have identified this in the biodiversity section for native vegetation. Forest that is declining may have understory that is being impacted by stock access, pests or weeds, whereas you may be undertaking pest and weed control and have excluded stock leading to improved understory health. Plantation forests are more likely to be static, although some may have regenerating vegetation in the understory also.
- You can get a rough idea of carbon sequestration for post-1989 forest land by using the Ministry for Primary Industries (MPI) look-up tables: You can find the link to the tables on **beeflambnz.com/farmplan**.
- In your **Action Plan (Template CC6)** identify any areas suitable for new/additional planting of natives, exotics or new areas of regenerating native (including shrublands), that could meet the definitions for generating carbon credits (currently, land that was not forested on 31 December 1989, where canopy cover at maturity is 30%, is at least 1ha, trees will grow to a height of at least 5m at maturity, and the stand is at least an average of 30m wide).

Current Areas of Woody Vegetation

CC2 **Example**

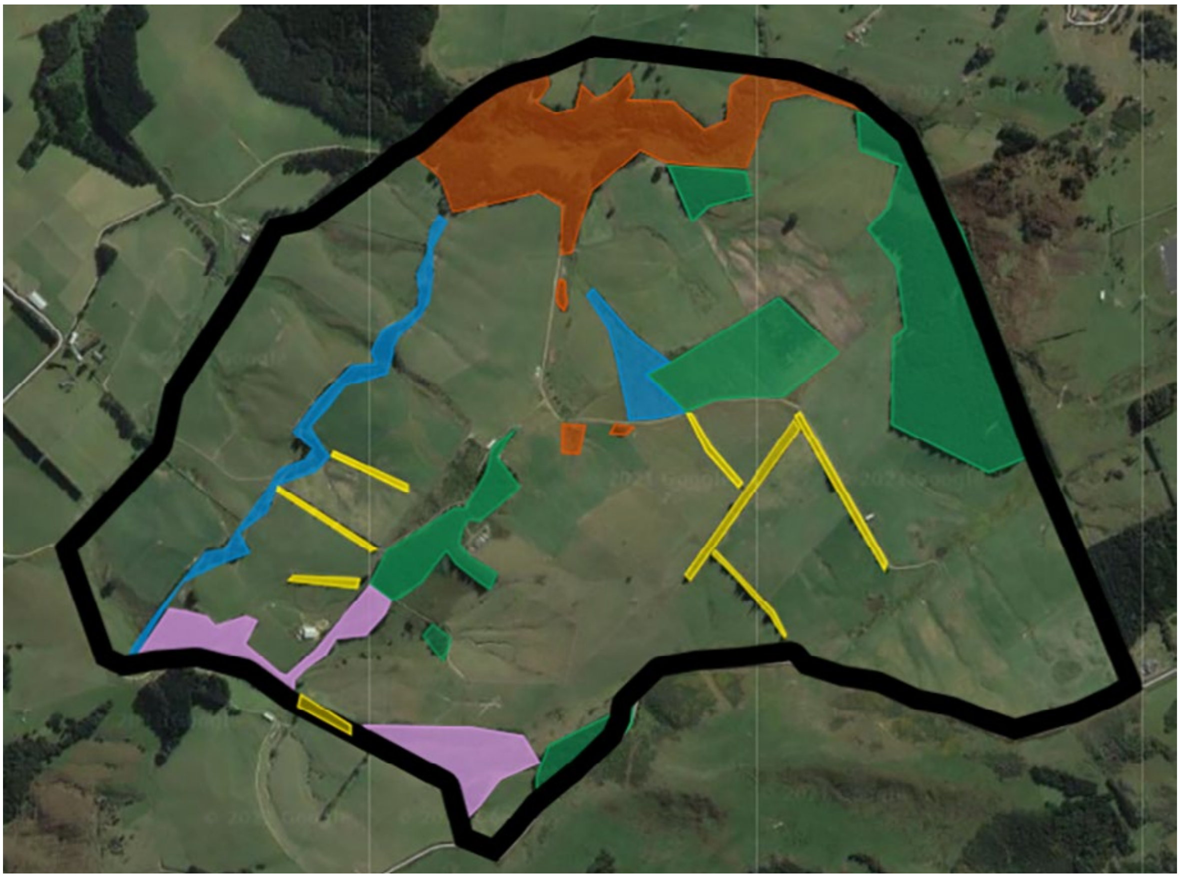
Vegetated area type and description (native, exotic, shrubland)	Approx age or year of planting	Area (ha) Pre-1990	Area (ha) Post-1989	Approx canopy cover (%)	Annual sequestration if known (kg CO_2 provided from some calculators)	ETS eligible? Y/N	State (declining, static, improving)
Planted pine plantation- exotic	19 years (planted 2002)		18	100%		Y	Improving
Regenerating manuka in step south facing middle country- native	25		20	70%	114		Improving
Old growth Kahikatea- native	100+	35				N	Static
Shelter belts	15 years		3.4	80%		N	Improving
TOTAL		35	41.4		114		

Blank templates can be found in **Our Plan** section

In this section (**Template CC3**) please include a map of your farm to identify areas of sequestration. These may include planted forest blocks, native bush and scrub blocks and also other areas of woody vegetation such as waterway plantings and shelterbelts. A useful way to do this is on a copy of your farm map or using an aerial photograph. Mapping can also be done online using various free tools and then printed out. These tools can also help to calculate the size of different areas.

Areas of sequestration map

CC3 **Example**



Key

- Shelterbelts = 3.3ha
- Waterway and wetland plantings = 5.3ha
- Planted pine blocks = 27.5ha
- Native Forest = 16.9ha
- Scrub = 7.9ha

Total farm area = 263ha

Assessment of greenhouse gas emissions and sinks on farm

Know your number

There are a range of free tools available to calculate your emissions and sinks and most align their approach to the National Greenhouse Gas Inventory (the National Standard). If you are using OverseerFM for nutrient budgeting, it will have also calculated your emissions and sinks.

Note: greenhouse gas emissions are not actually measured at farm scale, as the technologies to do this do not exist. Instead, measurements are carried out under experimental conditions and the resulting data are used as proxies to estimate emissions on farm.

Some of the tools include:

- **B+LNZ GHG calculator:** provides a free, farmer facing tool to report the on-farm sequestration and emissions of the business, and reflects the individual farm's livestock and production system. The tool is designed to help the red meat sector's reporting requirements to satisfy He Waka Eke Noa regulations.
- **OverseerFM:** more complex calculator that estimates on-farm emissions and their sources. It can be used to test the impact of farm management changes on emissions (and nutrient flows) before those changes are made. It also accounts for sequestration by trees.
- **Farmax 8:** provides an estimate of on-farm emissions. It can be used to test the impact of farm management changes on emissions as well as animal production and profitability. It also accounts for sequestration.

Follow the link on **beeflambnz.com/farmplan** to find links to access the tools.

Benchmarks will shortly be available from the B+LNZ Economic Service Survey Farm Data.

In **Template CC4** in "Our Plan", identify your emissions and sinks. An example is given below.

For the table below fill out the numbers that are provided from your greenhouse gas calculator. If your tool does not provide emission numbers for methane and nitrous oxide on a per hectare basis, you can convert them by dividing by your total farm area (not effective area).

CC4 **Example**

Our Farm's Emissions and Sinks

Production/ Financial Year and Date Calculated	Emissions – Methane		Emissions – Nitrous oxide		Emissions – Carbon dioxide	Defor-estation	Gross emissions	Seques-tration or sinks	Net emissions	Tool used for calculations
	$kgCH_4$/ ha/year	$kgCO_2e$/ ha/year	kgN_2O/ ha/year	$kgCO_2e$/ ha/year	$kgCO_2e$/ ha/year	$kgCO_2e$/ ha/year	$kgCO_2e$/ ha/year	$kgCO_2e$/ ha/year	$kgCO_2e$/ ha/year	
2019/2020 season Nov 2020	78.6 kg	1965 kg	2.06 kg	615 kg	36 kg		2615 kg	691 kg	1924 kg	B+LNZ GHG Calculator

Note - some tools only provide values for methane and nitrous oxide in CO_2e. Fill in what you can, CO_2e gives enough information to complete the calculations of gross and net emissions.

Blank templates can be found in **Our Plan** section

STEP 3 RESPONDING TO A CHANGING CLIMATE

Risks of greenhouse gas emissions and impacts of a changing climate

More information is available in a set of GHG Factsheets which can be found on the B+LNZ website. Visit **beeflambnz.com/farmplan**.

Farmers are adapting to different climatic conditions and weather patterns all the time; it is the nature of farming. The future impacts of climate change are based on modelled predictions and extensive knowledge and understanding of the impact of climate and temperature on weather patterns. This modelling suggests more frequent and more prolonged adverse events such as drought, floods, and snowstorms.

While we cannot predict when these events will occur, we can develop plans to manage them when they do. Having a plan in place can make dealing with an adverse event a little bit easier, and provides a starting point to respond.

Consideration of risks for climate change and greenhouse gas emissions

Identifying the risks of climate change and greenhouse gas emissions on farm and to the environment can help to prioritise actions or identify opportunities that will reduce the risk. This can help create a more resilient and sustainable business.

Below are some of the potential risks that you may want to consider, but there may be others that you identify for your farm system. There are additional risk areas listed in tables 4.1-4.5 that you may want to consider.

Potential risks from climate change impacts may include:

- Not being resilient or adaptable to climate change, including being ready for the opportunities it may create
- More frequent extreme events such as flooding or droughts or storms
- Coastal areas susceptible to inundation, erosion or flooding
- Changes in growing seasons or areas suitable for particular crops or species
- Changes in distribution and prevalence of pests, weeds and diseases
- Changes in water supply availability and increased need for irrigation
- Human and animal health impacts
- Increased risks of fires
- Changes in potential production

There are also risks factors that are related to greenhouse gas emissions from your farm. These can be direct risks to your business or risks to the environment.

Potential greenhouse gas emissions risks may include:

Risks to business – for example:

- Not knowing or measuring greenhouse gas emissions sources and sinks on farm
- Not having a plan to manage on farm emissions or adapt to a changing climate
- Lack of eco-efficiencies in the farming system- such as genetics, animal health and productivity
- Lack of access to domestic and international markets due to market requirements and consumer expectations
- Changes in legislative and financial obligations for greenhouse gas emissions

Methane emission risks – for example:

- Lack of eco-efficiencies (production system not optimised)
- Poor genetics of stock
- High proportion of capital stock
- Poor animal health
- Feed type and wastage

Nitrous oxide emissions risks – for example:

- Fertiliser type and rate used
- Urinary nitrogen from stock
- Emissions from soils
- Feed type

Carbon dioxide emissions risks – for example:

- Fertiliser and lime use
- Fuel and electricity use
- Excessive agrichemical use

Carbon sequestration risks – for example:

- Deforestation or woody vegetation removal
- Lack of sequestration opportunities on farm
- Woody vegetation areas not mapped or quantified

Identify the risk factors and complete the risk assessment for your farm

Consider the risks of greenhouse gas emissions and impacts of climate change on your farm and complete the Risk Assessment (**Template CC5**) in "Our Plan". This will inform your action plan. For each risk factor you identify on your farm use the following Risk Assessment Matrix to assess the likelihood and consequence of greenhouse gas emissions or impacts of climate change on your farm business and/or environmental risk to determine the overall risk for each factor. An example is shown below.

Risk Assessment Matrix

Likelihood	Consequence		
	Slight	Serious	Major
Low	Low	Low	Medium
Medium	Low	Medium	High
High	Medium	High	High

Climate change and Greenhouse gas emissions risk template

CC5 **Example**

Climate change and GHG emissions risks	Potential risks on farm	Overall risk rating
Climate change impacts	• *Pests more prolific* • *New diseases in stock and pasture* • *Weeds* • *More frequent extreme climatic events* • *Changes to weather patterns* • *Different growing seasons*	*Low* *Medium* *Medium* *High* *Medium* *Low*
Risk to business	• *Market access*	*Medium*
Methane	• *Poor genetics* • *Inefficiency in system*	*Medium* *High*
Nitrous Oxide	• *Urine patch emissions* • *Nitrogen fertiliser emissions* • *Soil emissions*	*Medium* *Low* *Low*
Carbon dioxide	• *Use of fossil fuels* • *Lime use* • *Electricity use*	*Low* *Medium* *Low*
Carbon sequestration	• *Woody vegetation not mapped* • *Riparian laneways not mapped*	*High* *High*

Blank templates can be found in **Our Plan** section

Develop an action plan to manage emissions and respond to climate change impacts

Managing greenhouse gas emissions on-farm

Every kg of Dry Matter Intake (DMI), consumed by a ruminant animal, results in the production of methane (and indirectly the production of nitrous oxide). Therefore, it is important to maximise the amount of product per unit of feed eaten.

A continued focus on capturing efficiencies in the farm system ensures feed eaten is used as efficiently as possible to contribute to the production of meat and wool on farm. The following areas (see **Table 4.1**) can impact productivity and therefore may offer scope for increased on-farm efficiency – enabling more production from the current feed supply, or maintaining production from a smaller feed supply (in either case reducing the amount of methane produced per kilogram of product). This idea of "achieving more with less" is often termed '**eco-efficiency**'. More, or the same, agricultural product with less input of land, water, nutrient and less GHG emissions with less impact on water quality, soil health and biodiversity, and with improvements in animal wellbeing.

At present there are limited options available to reduce emissions in more extensive grass based farming systems. Some of the options are presented in **Tables 4.2, 4.3 and 4.4**. In some instances, these can be implemented while maintaining or even increasing profitability (as shown by modelling work). It is important to assess options in relation to your overall business goals and other goals within your farm plan as some may lead to increased impacts elsewhere.

These potential mitigation and management options need to be carefully considered within the context of the whole farm system. While some strategies may reduce emissions in one area of the farm system, they have the potential to increase emissions overall depending on the farm management response. The impacts of changes to farm management practices must also be considered in the context of impacts on nutrient losses to water, soil health and biodiversity. Testing scenarios in Overseer or within farm system modelling software such as Farmax is beneficial to understand the potential outcomes across the farm business.

Consider the following mitigation practices and develop plans to measure and manage (over time) the on-farm greenhouse gas emissions from your farm system. Additional guidance is also available on the He Waka Eke Noa website, and an example follows this table. Record this into **Template CC6** in "Our Plan".

Mitigation strategies and practices are outlined on **www.agmatters.nz** and will be updated as the science advances and more activities are included in the national Greenhouse Gas Inventory. The site also includes case studies and videos of farmers.

More information is available in a set of GHG Factsheets which can be found on the B+LNZ website. Visit **beeflambnz.com/farmplan**.

Table 4.1 Options for eco-efficiency benefits

Areas for consideration	Some suggested actions on-farm to achieve the list on the left. These are not exhaustive and are for guidance only
Genetics	• Selection for low methane sheep (and in the future cattle and potentially deer) • Genetic improvement of stock for lamb/calf survival and maternal ability • Improved pastures – careful selection of pasture mixes for pasture renewal (select those appropriate for the region taking in to account future changes in climate) • Terminal sires to increase young stock growth rates (effectively allow more production per unit of feed)
Animal health	• Prepare and follow a comprehensive animal health plan in consultation with a vet or other expert • Reduction of drench resistance/failure • Adequate shelter and shade to reduce animal stress in winter and peak summer (region dependent) • Identification and treatment of subclinical disease
Improved lambing, calving and fawning percentages	• Ensure animals are at optimal mating weight/condition score • Adequate and appropriate shelter on lambing, calving and fawning paddocks • Checking rams/stags/bulls for reproductive fitness (improved pregnancy rates) • Flushing ewes
Improved growth rates and reduced time to slaughter	• Pregnancy scanning and preferential treatment of multiples • Adequate and appropriate shelter on lambing paddocks • Routine lambing beats to increase lamb survival
Pasture and soil management	• In conjunction with agrichemical and seed suppliers create a pasture renewal programme • Liaise with a qualified fertiliser specialist to prepare a fertiliser plan in combination with a soil nutrient budget • Pasture and soil management to optimise utilisation • Reticulated water and improved subdivision (smaller paddocks) to improve pasture efficiency and stock management • Early identification and management of soil, pasture and crop pests • Utilise tools and expertise to create a feed budget, with regular reviews and refinements

Table 4.2 Options to manage methane production

Areas for consideration	Some suggested actions on-farm to achieve the list on the left. These are not exhaustive and are for guidance only
Genetics	• Select rams for low methane production
Low emission feeds	• Forage rape (30% less methane per kg DMI when fed as a sole feed). • Fodder beet (needs to be more than approx. 75% of the diet which may cause animal health concerns)
Options for high input systems	• Better manage nitrogen fertiliser • Reduce bought in supplementary feed and/or analyse efficiency of alternative supplementary feeds • Improved effluent storage management • Farm to the grass curve/grazed forage supply and optimise feed efficiency
Changes to the stock ratio	• Optimise stock policy to pasture growth curve • Improve productivity of beef cattle
Future options	• Vaccine • Bolus • Drench • Feed additives (compounds that reduce methane production in the rumen) • Genetic selection for low methane emitting animals of other livestock species

Table 4.3 Options to manage nitrous oxide emissions

Areas for consideration	Some suggested actions on-farm to achieve the list on the left. These are not exhaustive and are for guidance only
Low emission feeds	• Plantain (research continuing but indications are it requires at least 30% of the pasture to be plantain to be effective) • Fodder beet has a lower N content resulting in lower urinary N and thus lower N_2O (although in wet conditions nitrous oxide can increase)
Reduce urinary N lossess - either per animal or in the whole system	• Change to low N feeds to reduce urinary N • Reduce stocking rate to reduce total urine • Use nitrification inhibiters (if/where available)
Fertiliser	• Liaise with a qualified fertiliser specialist to prepare a fertiliser plan in combination with a soil nutrient budget. • Appropriate timing and rate of application • Optimise total N fertiliser inputs • Use of urease inhibitors
Future options	• Widespread use of nitrification inhibitors

Table 4.4 Options to manage carbon dioxide emissions

Areas for consideration	Some suggested actions on-farm to achieve the list on the left. These are not exhaustive and are for guidance only
Electricity use	• 'Green' electricity sources (e.g. solar panels)
Reduce fuel use	• Electric vehicles • Drones • Ensure full truckloads carting produce / livestock • Reduced transportation of animals, feed, fertiliser
Optimise fertiliser use	• Liaise with a qualified fertiliser specialist to prepare a fertiliser plan in combination with a soil nutrient budget. • Appropriate timing of applications • Optimise total N fertiliser inputs • Use of urease inhibitors
Targeted lime use	• Soil test and target lime applications to maximise effectiveness. Excess/ineffective liming adds CO_2 emissions from manufacturing.
Reduce chemical use	• This reduces CO_2 produced in manufacturing, transport and application.
Future options	• Electric tractors, utes, farm bikes and other vehicles.

Identify sequestration opportunities

While you may be able to achieve small emission reductions through some of the changes above, you may also have opportunities to sequester carbon through woody vegetation – exotics or natives, permanent forest or plantation forestry. See **Table 4.5** for examples. This can also enhance biodiversity outcomes for your farm and depending on the location, can also support healthy freshwater outcomes by reducing erosion risk or providing riparian habitat.

Table 4.5 Options for increased sequestration

Areas for consideration	Some suggested actions on-farm to achieve the list on the left. These are not exhaustive and are for guidance only
Increased sequestration	• Retiring less productive areas (where applicable) and planting in natives or exotic forestry • Planting shelter belts for improved animal production and sequestration • Collaborate with neighbours and council to form catchment groups for a cohesive catchment approach to planning riparian plantings or other areas such as eco-corridors • Planting of riparian areas and retiring critical source areas for dual sequestration and water quality outcomes • Control pests, diseases, and weeds in planted areas to maximise survival and sequestration of planted areas

Climate resilience and adaptation

Outlined below are some things to consider in building a resilient and adaptable farm system.

- Know the signs of stress and have some strategies to manage stress for you and your team
- Secure water supply and water reticulation for stock (year-round)
- Ensure adequate shade and shelter for stock
- Have a proactive animal health plan
- Maintain healthy, well-fed stock year round
- Budget for adverse events – even budgeting a small amount each year can take a bit of pressure off when an adverse event hits
- Source access to a generator or back-up option for extended power loss
- Back-up for communication (e.g. old-style phone)
- Maintain regular feed budgeting
- Retain a buffer of supplementary feed on-hand
- Consider the use of summer crops, cereal crops, specialist dryland species such as lucerne, strategic use of winter crops can add resilience
- Review alternative/more flexible farming systems with diverse production types, including aspects such as timing and how this may impact your stock classes
- Consider irrigation and water storage options
- Be proactive with erosion management to limit the damage and soil loss from storms.

Action plan to manage emissions and respond to climate change impacts

CC6 **Example**

Blank templates can be found in **Our Plan** section

	Areas to consider	Action to address risk	Location, Land Management Unit or paddock	Timeframe or date implemented	Person responsible/ Others involved	Budget	Priority (Low, Medium, High)	Evidence of completion and storage location e.g. photo	Date completed
Eco-efficiency	*Eco-efficiency gains* *Pasture and soil management*	*Prepare an animal health plan* *Early identification of soil and pasture pests* *Create a feed budget and review regularly.*	*Whole farm*	*Nov 2021*	*Manager and Vet* *Manager and agronomist* *Manager*		*Medium*		
Methane	*Low emission feeds*	*Investigate winter crops that have lower emisssions*		*Before sowing next spring*	*Manager and farm advisor*		*Medium*	*Emails with Fert rep*	
Nitrous Oxide	*Fertiliser use*	*Talk with fert rep or specialist and come up with plan reduce N fert or use urease inhibitators*		*September 2022*	*Manager and fert rep*	*To be determined after consultation*	*High*		
Carbon dioxide	*Reduce fuel use*	*Over time replace older vehicles with more fuel efficient vehicles*		*Next 5 years*	*Manger*	*Build costs into long term budget*	*Low*		
Carbon sequestration	*Identify areas of woody vegetation on farm and retire less productive areas on farm*	*Carry out mapping of shelter belts and other woody vegetation* *Look at retiring part of top block*	*Whole farm* *Top Block*	*September 2022* *Next 3 years*	*Manager* *Manager and ecologist*	*$500*	*Medium*		
Climate change impacts	*Erosion management* *Backup Generator*	*Erosion management with plantings* *Buy backup generator incase of power outages*	*Top Block*	*Next 3 years* *December*		*$3000*	*Medium* *Low*		
Other									

You may already have made changes to your farm system or are carrying out actions that are already helping to manage your greenhouse gas emissions and/or are making your farm more resilient to climate change impacts. Use tables 4.1-4.5 to help you identify these actions and write them into **Template CC7** (Example below). This will help create a recored of climate change and emissions management actions to date.

Actions to date: Climate Change and Greenhouse Gas emissions management

CC7 **Example**

	Areas considered	Action	Location or Land management unit (if applicable)	Date or year
Eco-efficiency		New ram selection criteria (including n-prove) for improved genetics and breeding	Whole farm	2020
Methane	Eco-efficiency gains	Increased lambing percentage to be more efficient with feed Sheep to cattle ratio changed		2002
Nitrous oxide	Fertiliser	Targeted fertiliser use and started using urease	Lower flats	2010
Carbon dioxide	Fuel and electricity use	More fuel efficient vehicles Solar-powered fencing		2019 2020
Carbon sequestration	Increase sequestration	More shelterbelts planted Riparian areas fenced and planted Some of marginal land on top block retired	Lower flats Top Block	Started in 2002
Climate change impacts	Resilience and adaptaion	Erosion prone land planted with open tree plantings to stabilise land incase of heavy rain events	Top Block	2010

Blank templates can be found in **Our Plan** section

Develop a regular monitoring programme for your climate change response

In the **monitoring plan (Template CC8)**, outline your monitoring programme for your climate change response. Your ongoing monitoring should include include:

- calculating and documenting your agricultural greenhouse gas emissions and sinks annually
- review and revise plans to measure and manage GHG emissions
- updating on any regulatory requirements associated with this.

Additionally, following an adverse event, it is useful to update your adaptation plans to incorporate anything you have learned from your response. It is also beneficial to periodically review your adaptation plan to ensure it is still fit for purpose in relation to your farm system and environmental conditions.

Set out your monitoring plan in **Template CC8** in "Our Plan". An example is below.

Monitoring Plan - to manage emissions and respond to climate change impacts

CC8 **Example**

Monitoring or review action	Evidence	Monitoring frequency	Due Date to monitor	Assessment	Person respon-sible	Notes	Date completed
Complete GHG calc	*Diary GHG calculator Stock numbers Weaning weights Fert use Deforestation*	*Annual*	*June each year*	*B+LNZ GHG Calculator*	*Manager*		
Review areas of woody vegetation	*Aerial farm map in Climate change chapter of farm plan*	*Annual*	*June each year*	*Aerial map*	*Manager*	*Use updated aerial map or map*	

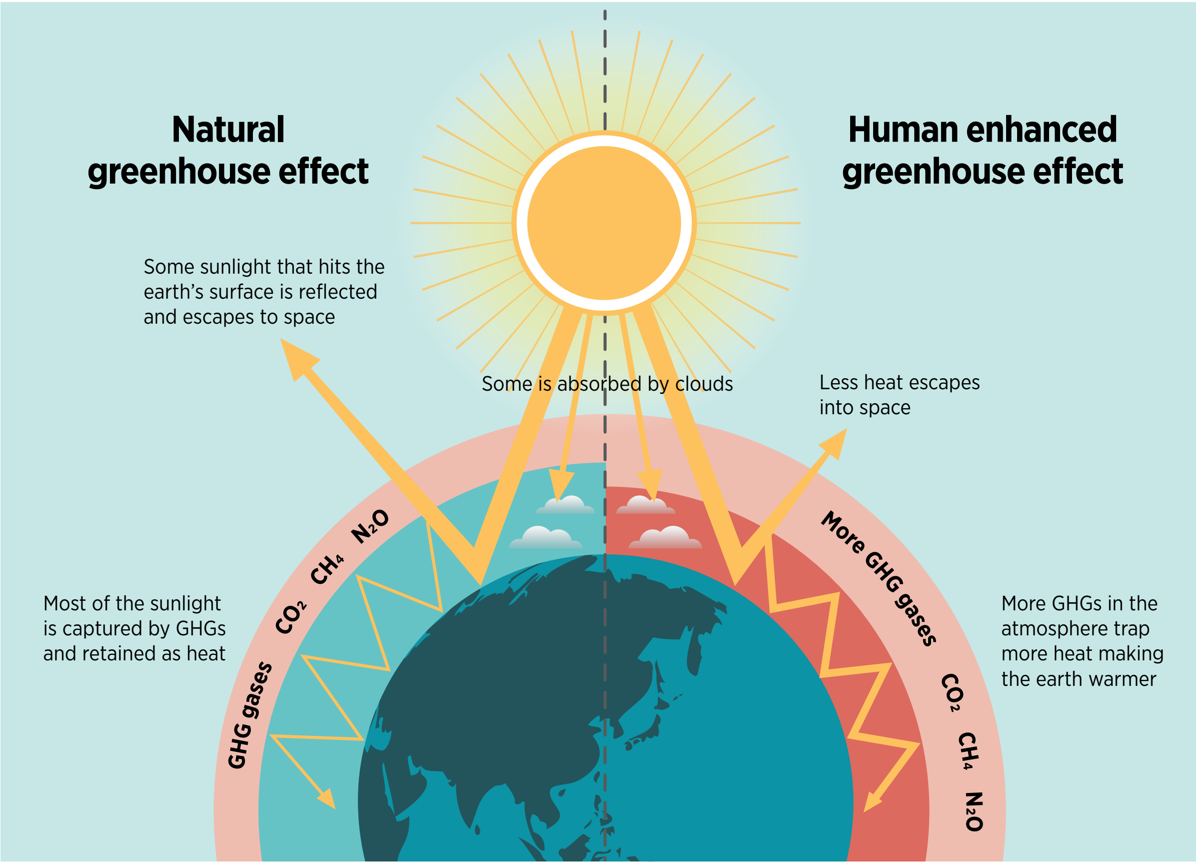
Blank templates can be found in **Our Plan** section

Background information

More information is available in a set of GHG Factsheets which can be found on the B+LNZ website. Visit **beeflambnz.com/farmplan**.

Greenhouse gases

A number of the gases in the atmosphere act like a blanket around the earth, trapping warmth from the sun. For this reason, we call them greenhouse gases. Greenhouse gases exist naturally in low concentrations and maintain the earth's average temperature at around 15˚C. Without them, too much heat would escape, and the temperature at the surface of the planet would be -18˚C. Human activities are rapidly increasing the amount of these gases in the atmosphere, which is causing the temperature to increase and the climate to change.



Many gases created by human activities act as greenhouse gases, but the three most important from a New Zealand perspective are:

- **Carbon dioxide (CO_2):** Carbon dioxide enters the atmosphere when fossil fuels (oil, natural gas and coal), solid waste, trees and wood products burn, and during other chemical reactions such as manufacturing cement. Carbon dioxide is removed from the atmosphere by growing plants, which absorb and store it in their tissue. It gets released again when plants decay as part of the **biological carbon cycle**. Carbon dioxide from fossil fuels makes up 44% of New Zealand's gross annual greenhouse gas emissions. This is **new** carbon dioxide that **adds** to the total amount of carbon dioxide in the atmosphere.
- **Methane (CH_4):** Methane is emitted during the extraction and transportation of coal, natural gas and oil. Methane emissions also come from ruminant livestock and agricultural practices such as growing rice, and by the decay of organic waste in landfills. It makes up 43% of New Zealand's gross emissions, mainly from cattle and sheep.
- **Nitrous oxide (N_2O):** Nitrous oxide is emitted during agricultural and industrial activities, and when fossil fuels and solid waste burn. It makes up 12% of New Zealand's gross emissions and is emitted from urine patches as well as fertiliser.

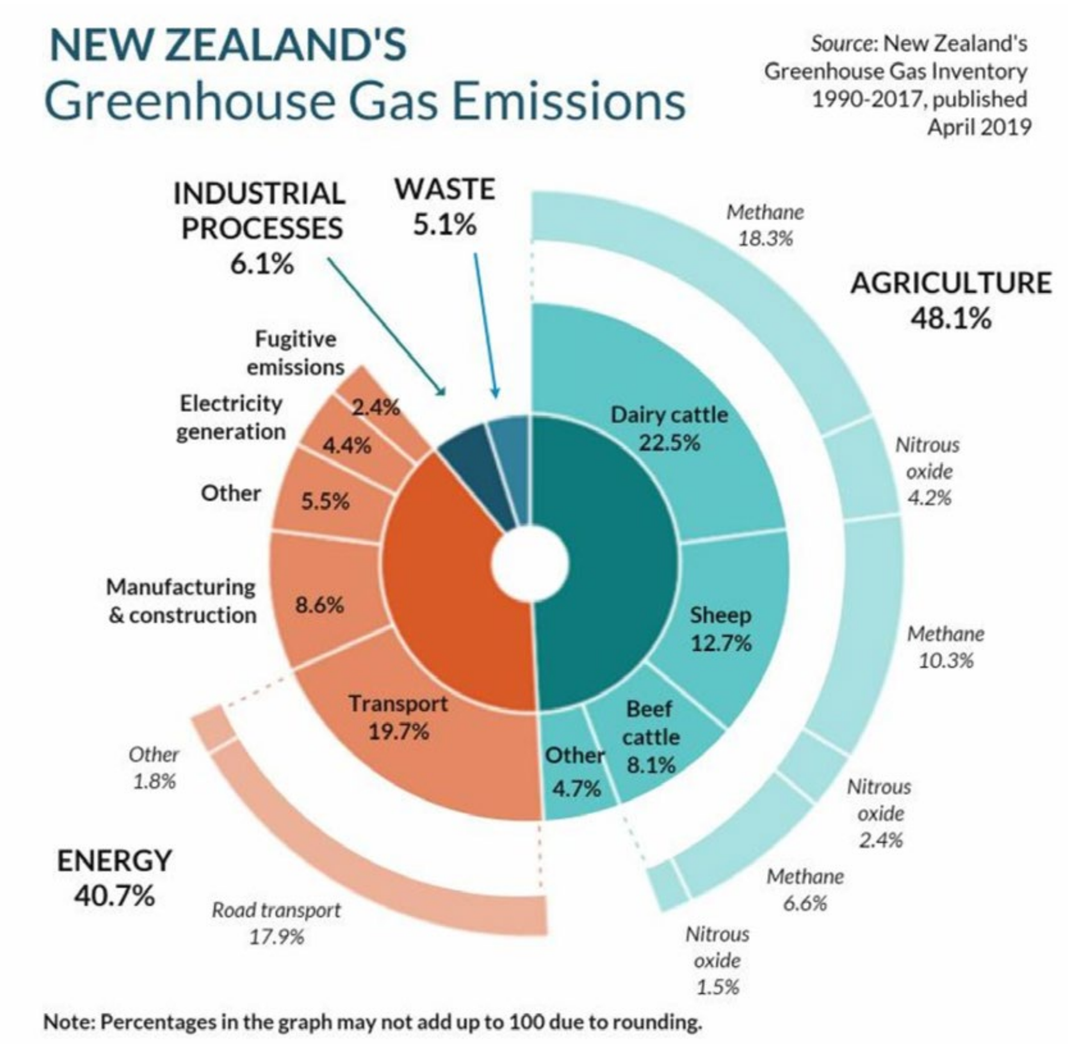
Short-lived verses long-lived gases

Methane is a **short-lived gas** and degrades in the atmosphere in decades. **Biogenic methane** from animals is formed when animals eat plants that have taken up carbon dioxide already in the atmosphere. The gut microbes in the ruminant animal convert excess carbon to methane which is more potent than CO_2 BUT over a relatively short time it decays back to CO_2 without adding to the atmospheric concentration of CO_2. This is a cycling of existing CO_2 that is producing a valuable commodity product and supporting our economy at the same time. Because methane is a short-lived gas, if animal numbers remain relatively stable, then so does the concentration of methane in the atmosphere. This is because as methane declines it is replaced by the newly emitted methane from animals, but the process is in a steady state.

Carbon dioxide, on the other hand is a **long-lived gas** and it stays in the atmosphere for hundreds to thousands of years. This means that continuing to burn fossil fuels and continuing to increase fuel consumption will continue to increase the concentration of CO_2 in the atmosphere.

More information is available in a set of GHG Factsheets which can be found on the B+LNZ website. Visit **beeflambnz.com/farmplan**.

New Zealand's Greenhouse Gas Emissions by sector



New Zealand's greenhouse gas emissions

Not all emissions are created equal. The emissions from the agricultural sector are made up of predominantly methane and nitrous oxide. Emissions from the energy sector by comparison are primarily carbon dioxide from the burning of fossil fuels. There is an important differentiation between biological greenhouse gases from animals (biogenic methane and nitrous oxide) and carbon dioxide from the burning of fossil fuels.

Often gases are referred to by their Global Warming Potential (GWP) as this allows the different gases to be compared to each other as these gases differ in their ability to absorb energy (radiative forcing) and how long they stay in the atmosphere (lifetime). GWP is a measure of how much energy the emissions of 1 tonne of a gas will absorb over a given timeframe compared to 1 tonne of carbon dioxide. The GWP that is most often used in New Zealand (including in the reports we publish internationally) is *GWP100*, which is a measure of how much energy 1 tonne of gas will absorb over 100 years.

Thus, gases can be reported in carbon dioxide equivalents by converting the amount of the gas to the equivalent amount of carbon dioxide with the same global warming potential. This is often written as CO_2e, for example a farm may have an emissions profile of 3000 kg CO_2e/ha/yr made up of methane (2300 kg CO_2e/ha/yr), nitrous oxide (610 kg CO_2e/ha/yr), and carbon dioxide (90 kg CO_2e/ha/yr).

Using *GWP100*, New Zealand's gross emissions in 2018 consisted of:

- 44% from carbon dioxide
- 43% from methane
- 12% from nitrous oxide

The balance (about 1% of total emissions) was from less common gases such as hydrofluorocarbons.

Using *GWP100*, New Zealand's greenhouse gas emissions profile for 2018 was dominated by emissions from the Agriculture (48%) and Energy (41%) sectors. This is different to the greenhouse gas profile for most other developed countries where 80% of the emissions come from the energy and transport sectors and only 11% from agriculture.

It is important to note that the science around gases is rapidly evolving and there is growing recognition that *GWP100* is not the best way to represent the warming impact of different gases. Other metrics may be more suitable to use, however for now *GWP100* is the metric New Zealand is committed to using.

Source: https://www.otago.ac.nz/oerc/symposia/archives/otago735003.pdf

Changing climate and conditions

Source: www.agmatters.nz

Here in New Zealand, temperatures are about 1°C hotter than they were a century ago, with three of the hottest years on record occurring since 2014. Effects are already being felt in land, freshwater and marine environments:

- Sea levels have risen 14–22cm since the early 1900s.
- Our glaciers have lost 25% of their ice in the past 40 years.
- The country is experiencing fewer frost days and more warm days. Some locations are also experiencing drier soils and altered precipitation patterns.
- More intense weather events (droughts and storms) have occurred in many parts of the country in the last few years, and at unexpected times of the year. Some recent events were more intense because of the warmer climate.

These conditions and trends are set to continue.

As our climate changes, it might not be possible to farm in the same way or the same places as we can now. A couple of degrees of warming might not seem much, but it can have a big effect on crop and pasture growth, and on pests and diseases. Here are some predictions:

- Many places will see more than 80 days per year above 25°C by 2100, which will have a significant impact on ryegrass growth (which prefers temperatures in the range of 5–18°C), animal performance and staff welfare/working conditions.
- Annual average rainfall is expected to decrease in the north-eastern South Island and northern and eastern North Island and increase in other parts of New Zealand.
- Farmers in dry areas can expect up to 10% more drought days by 2040.

The Ministry for the Environment (MfE) have a resource available that outlines likely future changes to the climate of each region and what that means for each region. Follow the link on **beeflambnz.com/farmplan** to find the MfE resource.

Responding to adverse events

Drought

Droughts are very challenging to deal with as they can have long-term impacts and there is no predictable ‘end-point’. Even when it rains it can take several months or more to recover. The key to drought management is looking after yourself, your family and team and making decisions to protect your capital breeding stock.

There is a saying to keep in-mind when managing a drought: ‘it’s better to make the wrong decision too early, than the right decision too late’.

For more information on drought management follow the link on **beeflambnz.com/farmplan** and check out Beef + Lamb New Zealand’s Extreme Dry Management Toolkit.

Flood

There is usually some warning or indication of a flood. There will always be unknown factors to deal with but having a checklist that you can work through when a flood is likely and then in response can help. For more information on flood management follow the link on **beeflambnz.com/farmplan** to read more, including a checklist for preparataion for and management of floods.

Snowstorm

Snowstorms are generally forecast although not always. Farmers in parts of the country where snowstorms are common are usually experienced in managing them. It may be beneficial to get some advice from other farmers. For more information on snowstorm management follow the link on **beeflambnz.com/farmplan** to read more.

What has New Zealand committed to do to respond to climate change?

The Paris Agreement on climate change

New Zealand signed the Paris Agreement on climate change in 2016. It is an international agreement that aims to hold the global average temperature increase to well below 2°C above pre-industrial levels, pursuing efforts to limit the increase to 1.5°C above pre-industrial levels. Under the Paris Agreement countries also agreed to increase their ability to adapt to the adverse impacts of climate change and respond to climate change in a manner that does not threaten food production.

New Zealand has a role to play to contribute to the global effort to achieve these goals. To do this, New Zealand has set a target under the Paris Agreement to reduce our greenhouse gas emissions, as a country, to 30% below 2005 levels by 2030.

The Zero Carbon Act

In order to achieve its commitments under the Paris Agreement, the Government passed the Zero Carbon Act in 2019. The Government set three domestic greenhouse gas emissions reduction targets in the Zero Carbon Act:

1. Reduce emissions of long-lived gases (mainly carbon dioxide and nitrous oxide) to net zero by 2050
2. Reduce emissions of biogenic methane to 10% below 2017 levels by 2030
3. Reduce emissions of biogenic methane to 24 – 47% below 2017 levels by 2050.

Targets 2 and 3 that focus on biogenic methane (which comes mainly from the belching of ruminant animals) are likely to be the ones that have the most impact on sheep and beef farmers.

He Waka Eke Noa – the Primary Sector Climate Action Partnership

The agriculture sector, like all other parts of the economy, has a role to play to contribute to meeting these international and domestic targets. To do this, primary sector leaders have come together to make an unprecedented commitment from across the pastoral, horticultural and arable sectors to achieving enduring progress towards the goals of managing agricultural emissions and building resilience of our primary sectors.

This includes a commitment to mitigating (reducing) the primary sector’s contribution to climate change through actions that manage, reduce or offset emissions, in support of the Paris Agreement and Zero Carbon Act goals. Through He Waka Eke Noa – the Primary Sector Climate Action partnership, the sector will respond to the threats of climate change in a way that is environmentally, socially, culturally and economically sustainable.

The following milestones for He Waka Eke Noa are legislated through the Climate Change Response (Emissions Trading Reform) Amendment Act:

- By 31 December 2021, 25% of farms in New Zealand hold a documented annual total of on-farm greenhouse gas emissions and have a written plan in place to measure and manage these emissions.
- By 31 December 2022, all farms in New Zealand hold a documented annual total of on-farm greenhouse gas emissions and
- By 1 January 2025, all farms have a written plan in place to measure and manage these emissions.

Further details are available at **hewakaekenoa.nz**