



Te Whakawhitiwhiti Kōrero Tuawaru ā-Motu o Aotearoa New Zealand's Eighth National Communication

Under the United Nations Framework Convention on Climate Change
and the Kyoto Protocol



Ministry for the
Environment
Manatū Mō Te Taiao



Te Kāwanatanga o Aotearoa
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Karakia

Whakataka te hau ki te uru,
Whakataka te hau ki te tonga.
Kia mākinakina ki uta,
Kia mātaratara ki tai.
E hī ake ana te atākura he tio,
he huka, he hauhunga.
Haumi e! Hui e! Tāiki e!

Get ready for the westerly
and be prepared for the southerly.
It will be icy cold inland,
and icy cold on the shore.
May the dawn rise red-tipped on ice,
on snow, on frost.
Join! Gather! Intertwine!

This karakia (prayer) speaks to the great natural forces, which bind us together. It portrays a Māori worldview to help frame our thinking, and our approach to huringa āhuarangi (climate change) in Aotearoa New Zealand. It speaks to the winds from the west (hau ki te uru) and from the south (hau ki te tonga). It acknowledges the growing challenges before us and the preparation needed to respond to them. It expresses the strengthening of our resilience and acknowledges that with unity we can overcome challenges and respond to ongoing changes in our environment.

In the context of te huringa āhuarangi, this narrative emphasises our ties to and reliance on the natural world, and the connection of each generation to those before and after. This includes the connectedness of ecosystems and society, and of actions and consequences across domains.

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Abbreviations

ANDRILL	Antarctic Drilling programme
AR5	<i>Fifth Assessment Report</i> (of the Intergovernmental Panel on Climate Change)
AR6	<i>Sixth Assessment Report</i> (of the Intergovernmental Panel on Climate Change)
ARC	Antarctic Research Centre
ASEAN	Association of Southeast Asian Nations
AWS	Automatic weather station
BSRN	Baseline Surface Radiation Network
CCRA	Climate Change Response Act 2002
CERF	Climate Emergency Response Fund
CGIAR	Consultative Group for International Agricultural Research
CH ₄	Methane
CIHEAM	International Centre for Advanced Mediterranean Agronomic Studies
CLIFF-GRADS	Climate Food and Farming Research Network – Global Research Alliance Development Scholarship
CNGP	Carbon Neutral Government Programme
CO	Carbon monoxide
CO ₂	Carbon dioxide
Commission (the)	He Pou a Rangī – Climate Change Commission
CORSIA	Carbon Offsetting Reduction Scheme for International Aviation
CRF	common reporting format
CTD	Conductivity, temperature, depth
CTF	Common tabular format
DIA	Department of Internal Affairs
DOC	Department of Conservation
E3	Equipment Energy Efficiency
ECFP	Erosion Control Funding Programme
ECVs	Essential Climate Variables
EECA	Energy Efficiency and Conservation Authority
EEZ	Exclusive Economic Zone
EfS	Education for Sustainability
EPA	Environmental Protection Authority – Te Mana Rauhi Taiao
EVs	Electric vehicles
F-gases	Fluorinated gases
FTS	Fourier transform spectrometer
GAW	Global Atmosphere Watch
GBIF	Global Biodiversity Information Facility

GCF	Green Climate Fund
GCMP	GCOS climate monitoring principles
GCOS	Global Climate Observing System
GDP	Gross domestic product
GEF	Global Environment Facility
GEM	Generation Expansion Model
GEMS/Water	Global Environment Monitoring System for Freshwater
GHG	Greenhouse gas
GHGIR	Greenhouse Gas Inventory Research
GIDI Fund	Government Investment in Decarbonising Industry Fund
GLOSS	Global Sea Level Observing System
GNS Science	Institute of Geological and Nuclear Sciences Limited
GNSS	Global navigation satellite system
GOA-ON	Global Ocean Acidification Observing Network
GPS	Global positioning system
GPS-LT	Government Policy Statement on Land Transport
GRA	Global Research Alliance on Agricultural Greenhouse Gases
GRUAN	GCOS Reference Upper Air Network
GSN	GCOS Surface Network
GUAN	GCOS Upper Air Network
GWP	Global warming potential
H ₂ O	Water
HDO	Semiheavy water
HFCs	Hydrofluorocarbons
IDC	International development cooperation
IGPS	Institute for Governance and Policy Studies
IMO	International Maritime Organization
IMOS	Integrated Marine Observing System
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
ISO	International Organization for Standardization
JMA	Japan Meteorological Agency
kt CO ₂ -e	Kilotonnes of carbon dioxide equivalent
LAWA	Land, Air, Water Aotearoa
LCDB	Land Cover Database
LIDAR	Light detection and ranging
LINZ	Toitū Te Whenua Land Information New Zealand
LRIS	Land Resource Information System

LUCAS	Land Use and Carbon Analysis System
LULUCF	Land use, land-use change and forestry
MBIE	Ministry of Business, Innovation and Employment
MEPL	Mandatory energy performance labelling
MEPS	Minimum energy performance standards
MetService	Meteorological Service of New Zealand Limited
MfE	Ministry for the Environment
MPI	Ministry for Primary Industries
MWLR	Manaaki Whenua Landcare Research
N ₂ O	Nitrous oxide
N-cap	Synthetic nitrogen fertiliser cap regulation
NCCRA	National Climate Change Risk Assessment
NDC	Nationally Determined Contribution
NDC1	New Zealand's first Nationally Determined Contribution
NEMS	National Environmental Monitoring Standards
NGMP	National Groundwater Monitoring Programme
NIWA	National Institute of Water and Atmospheric Research
NOAA	National Oceanic and Atmospheric Administration
NZ ETS	New Zealand Emissions Trading Scheme
NZAGRC	New Zealand Agricultural Greenhouse Gas Research Centre
NZGIF	New Zealand Green Investment Finance
ODA	Official Development Assistance
ODS	Ozone depleting substances
OECD	Organisation for Economic Co-operation and Development
PAGES	Past Global Changes
pCO ₂	Partial pressure of CO ₂
PFCs	Perfluorocarbons
PFSI	Permanent Forest Sink Initiative
PGgRc	Pastoral Greenhouse Gas Research Consortium
PRIF	Pacific Regional Infrastructure Facility
PSMSL	Permanent Service for Mean Sea Level
PSRM	Pastoral Supply Response Model
QA	Quality assurance
QC	Quality control
RCP	Representative Concentration Pathway
RGG	Reporting Governance Group
RMA	Resource Management Act 1991
RSI	Research, science and innovation

SADEM	Supply and Demand Energy Model
SEEC	Support for Energy Education in Communities
SF ₆	Sulphur hexafluoride
SLMACC	Sustainable Land Management and Climate Change
SMC	Science Media Centre
SPC	Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SSDF	State Sector Decarbonisation Fund
SSF Futures	Sustainable Food and Fibre Futures
SSIF	Strategic Science Investment Fund
TCCON	Total Carbon Column Observing Network
TMW	Te Manatū Waka – Ministry of Transport
Toitū	Toitū Envirocare
TPES	Total primary energy supply
UNFCCC	United Nations Framework Convention on Climate Change
VFEM	Vehicle Fleet Emissions Model
VKT	Vehicle kilometres travelled
VOS	Voluntary Observing Ships Scheme
VOSclim	VOS Climate Project
WAM	With additional measures
WEM	With existing measures
WKH	Warmer Kiwi Homes
WMF	Waste Minimisation Fund
WMO	World Meteorological Organization
WMO/GAW	World Meteorological Organization / Global Atmosphere Watch
WOM	Without measures
WOUDC	World Ozone and Ultraviolet Radiation Data Centre
WUNZ	Warmup New Zealand
WWW/GOS	World Weather Watch / Global Observing System

Te reo Māori glossary

Te reo Māori	English
Ākonga	Students.
Awa	River, stream, creek.
Ara whakamua	The path forward.
Hapori	Community, section of a kinship group, family, society.
Hapū	Kinship group, clan, subtribe.
Iwi	Tribe, large group descended from a common ancestor.
Kaiako	Teacher, instructor.
Kaitiaki	Guardian, caretaker, manager, trustee.
Kaitiakitanga	Guardian or guardianship, stewardship – for example, of natural resources.
Karanga	Formal call, ceremonial call, welcome call.
Kaupapa Māori	Māori approach, topic, customary practice, institution, agenda, principles, ideology – a philosophical doctrine incorporating the knowledge, skills, attitudes and values of Māori society.
Kawa	Ceremony, protocol.
Kāwanatanga	Government, dominion, rule, governorship.
Kōhanga reo	Māori language preschool.
Kura	School, education, learning gathering.
Mahinga kai	Places where traditional food and other natural resources are obtained.
Mana	Prestige, authority, control, power, influence, status, spiritual power, charisma.
Manaakitanga	Hospitality, kindness, generosity, support – the process of showing respect, generosity and care for others.
Mana motuhake	Self-determination.
Mana ōrite mō te mātauranga Māori	Equal status for Māori knowledge.
Mana whenua	Power from and/or authority over land or territory.
Marae	Courtyard – the open area in front of the whareniui (meeting house) where formal greetings and discussions take place. Often also used to include the complex of buildings around the marae.
Māramatanga	Enlightenment, clarity, understanding.
Marau ā-kura	Localised curriculum. Ministry of Education term referring to a living, breathing curriculum. Marau ā-kura reflects the expectations and aspirations of the whānau, hapū and iwi.
Mātauranga (Māori)	Māori knowledge systems and worldviews, including traditional concepts.

Te reo Māori	English
Mātauranga-a-iwi	Knowledge with an iwi-specific base.
Mauri	Life principle, life force, vital essence, special nature, a material symbol of a life principle, source of emotions – the essential quality and vitality of a being or entity. Also used for a physical object, individual, ecosystem or social group in which this essence is located.
Noa	Free from tapu, ordinary, unrestricted.
Papakainga	Original home, home base, village, communal Māori land.
Papatūānuku	Earth, earth mother and wife of Ranginui – all living things originate from Papatūānuku and Ranginui in Māori mythology.
Pou	Support, supporter, stalwart, mentor, symbol of support, metaphoric post – a person, group, iwi, gathering or object that strongly supports a cause or is a territorial symbol (such as a mountain or landmark) representing that support.
Rangatiratanga	Chieftainship, right to exercise authority, chiefly authority, ownership, leadership of a social group.
Ranginui	Atua (God) of the sky and husband of Papatūānuku – all living things originate from Papatūānuku and Ranginui in Māori mythology.
Rohe	Boundary, district, region.
Rongoā crops	Medicinal plants.
Tāne mahuta	Atua (God) of the forests and birds and one of the children of Ranginui and Papatūānuku.
Tangaroa	Atua (God) of the sea and fish. One of the offspring of Ranginui and Papatūānuku.
Tangata whaikaha	People with disabilities.
Tangata whenua	The people of the land, local indigenous people. Māori are tangata whenua of the land on which they whakapapa back to.
Taonga/taonga Māori	Treasure, anything prized – applied to anything considered to be of value, including socially or culturally valuable objects, resources, phenomena, ideas and techniques.
Tapu	Sacred, prohibited, restricted, set apart.
Te ao Māori	The Māori world.
Te ao tūroa	The natural world, the enduring world.
Te reo Māori	The Māori language
Te Taiao	World around us, earth, natural world, environment, nature.
Te Tiriti o Waitangi/ Te Tiriti	The Treaty of Waitangi. Note: While these terms are used interchangeably, the national adaptation plan acknowledges that the English version and te reo Māori translation are separate documents and differ in a number of respects.

Te reo Māori	English
Tikanga	Custom, practice, correct protocol – the customary system of values and practices that have developed over time and are deeply embedded in the social context.
Tūpuna	Ancestors, grandparents.
Tūrangawaewae	Domicile, standing, place where one has the right to stand.
Urupā	Burial ground.
Wāhi tapu	Sacred site – a place subject to long-term ritual restrictions on access or use, such as a burial ground, a battle site or a place where tapu objects were placed.
Wairua	Spirit, soul.
Wānanga	Conference, forum, seminar.
Whaikōrero	Oratory, formal speech-making.
Whakapapa	Genealogy, genealogical table, lineage, descent.
Whakataukī	Proverb, significant saying.
Whānau	Family, extended family, family connection.
Whanaungatanga	Relationship, kinship, sense of family connection.
Whenua	Country, land, nation, state.
Whenua Māori	Māori land. There are three types of whenua Māori: Māori freehold land, Māori customary land and general land owned by Māori.

Minister's foreword

In this report, the *Eighth National Communication*, Aotearoa New Zealand is fulfilling its reporting obligations under the United Nations Framework Convention on Climate Change. The report details emissions reduction policies that meet our international requirements and guide domestic climate action. These policies demonstrate our response to climate change. It is also an opportunity to take stock of what we have achieved so far, and how much work there is still to do.



New Zealand is committed to addressing the challenge of climate change. We have put the 1.5°C global warming limit into law as part of our Climate Change Response (Zero Carbon) Amendment Act. In 2019, we established the Climate Change Commission to provide government with independent, evidence-based climate advice. With the Commission's help, New Zealand has set the first three emissions budgets through to 2035, putting us on the path to our 2050 goal of net-zero emissions.

New Zealand's first emissions reduction plan was published in 2022. This plan guides actions towards lower emissions for every sector in the economy. The New Zealand Emissions Trading Scheme has been updated to ensure it remains fit-for-purpose, increasing the cost of pollution and moving us towards the Government's goal of a net-zero future. We are working together with farmers and Māori through the He Waka Eke Noa partnership to develop pricing for farm-level emissions and to help prepare the agricultural sector to meet future emissions reduction targets.

We know that there is more work to be done to reduce emissions across all sectors. We have invested in a range of measures to support New Zealanders to make more climate-friendly transport choices. This includes incentivising the switch to low-emissions vehicles via the Clean Car Discount scheme. We are supporting major energy users to switch to clean, renewable energy through the Government Investment in Decarbonising Industry fund. We are future-proofing our financial sector; it is now mandatory for large financial institutions and listed companies to report on climate-related risks. We have also allocated funding to encourage green investment in the private sector.

We now have more tools to prepare New Zealanders for the impacts of a changing climate. The national adaptation plan provides the information and support that communities will need to respond to climate change. We will conduct a new Climate Change Risk Assessment every six years to ensure our planning is responsive to the most pressing concerns.

We are committed to a just transition, so that no community or country affected by climate change is left behind. This includes working in partnership with Māori to embed te ao Māori (the Māori world) in our climate response. A new framework will be established for Māori-led solutions as part of our climate action. New Zealand has quadrupled the climate aid available to Pacific Island and other lower-income nations. These countries are making their own transition to lower-emissions economies and building more climate-resilient communities.

New Zealand has formally recognised that the world is experiencing a climate emergency. This report details our response. But this work is urgent and ongoing. We know that there is more to be done. We will continue to work with our international partners to take action on this global challenge.

A handwritten signature in black ink, appearing to read 'James Shaw', with a long horizontal stroke extending to the right.

Hon James Shaw
Minister for Climate Change, New Zealand

1 Executive summary

Climate change is one of the greatest challenges of our time. By taking action today, we can ensure we are able to adapt to climate change and limit its effects on future generations. Aotearoa New Zealand has demonstrated its commitment to addressing the challenges of climate change by taking clear actions towards creating a low-emissions, productive, resilient, sustainable and inclusive economy. These actions will enable our communities and environment to prosper for generations to come.

In December 2020, the Government declared a climate emergency. The Government has made significant progress through ratifying the Paris Agreement and putting the global goal of limiting warming to 1.5°C above pre-industrial levels into law through the Climate Change Response (Zero Carbon) Amendment Act 2019.¹ New Zealand's ratification of the Paris Agreement commits the country to update its Nationally Determined Contribution (NDC) under the Agreement. In November 2021, New Zealand updated its NDC1 to reduce net greenhouse gas emissions to 50 per cent below gross 2005 levels by 2030. New Zealand will continue to work both domestically and internationally to ensure we do our fair share to tackle and support action on climate change.

New Zealand is founded on a partnership between the Crown and indigenous New Zealanders, Māori, through Te Tiriti o Waitangi (the Treaty of Waitangi) signed in 1840. Climate change will affect Māori as tangata whenua (people of the land) and kaitiaki (guardians) of their ancestral and cultural landscape. Certain whānau (families), hapū (subtribes) and iwi (tribes) will be disproportionately affected, as will Māori interests, values, practices and wellbeing. Māori are kaitiaki of their whenua (land), leaders in their communities, decision-makers about resources and infrastructure, land owners and business owners. An equitable transition for Māori, led by Māori, will require building Crown–Māori relationships and capability to work together as equal partners on our climate response.

New Zealand's small population of 5.1 million is widely dispersed across a long, narrow and mountainous country. It consists of two large islands, the North Island and the South Island, and a number of smaller islands. Located in the southwest Pacific Ocean, the country is distant from most of its trading partners. It has an export-dependent economy, with a significant reliance on the primary sector, which contributes over half of New Zealand's total export earnings. The country's geography and population distribution have contributed to a dependence on fossil fuel powered transport. As a result of this and the primary sector export base, New Zealand's emissions profile is dominated by the energy and agriculture sectors, which combined contributed 89.9 per cent of gross greenhouse gas emissions in 2020.²

New Zealand has abundant renewable energy resources and a long history of renewable energy development. As a result, 82.1 per cent of the country's electricity generation came from renewable sources in 2021 – primarily hydro-electric, with smaller contributions from geothermal and wind generation. Continued development of geothermal and wind renewables has seen the amount of electricity generated from these sources more than triple since 1990.

¹ www.legislation.govt.nz/act/public/2002/0040/latest/whole.html - LMS282014.

² Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from <https://environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020/> (17 November 2022).

Because of the high levels of agricultural activity, half of New Zealand’s gross emissions come from agriculture. Our country has made significant improvements in production efficiency across the agriculture sector. This means that while overall production has increased, emissions per unit of production have significantly decreased. As a result, gross emissions from agriculture have remained relatively stable since 2006. New Zealand continues to seek opportunities through agricultural research to create economically viable and effective technologies to reduce emissions from this sector.

In November 2017, New Zealand extended its ratification of the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement to include Tokelau, and as a result Tokelau is now included in New Zealand’s international climate change reporting. Tokelau is a non-self-governing territory of New Zealand made up of three small coral atolls. The combination of the small land area, small population and absence of industry means Tokelau contributes only a very small amount of greenhouse gas emissions. Tokelau’s low-lying atolls are extremely vulnerable to the impacts of climate change and related hazards. The Government is supporting Tokelau to strengthen its resilience and adapt to the impacts of climate change and is committed to helping achieve Tokelau’s vision for its future under its Climate Change Strategy.³

New Zealand has decoupled emissions from economic growth, meaning our economy is growing faster than our emissions. However, gross emissions have increased since 1990 on the back of strong economic and population growth. New Zealand continues to explore opportunities to further reduce our greenhouse gas emissions. Detailed information on this work to date can be found in the emissions reduction plan.⁴ Alongside this, New Zealand also continues to prioritise work on how to adapt to the effects of climate change and build a more resilient nation. Extensive information on this can be found in the national adaptation plan.⁵

1.1 New Zealand’s emissions targets

Since the *Seventh National Communication*, Aotearoa New Zealand has updated its NDC1 under the Paris Agreement.⁶ New Zealand’s increased ambition aligns with global efforts to limit global warming to 1.5°C above pre-industrial levels. New Zealand has committed to the following targets.

- 2030 NDC Target (2021–30): Under the Paris Agreement, New Zealand has set a headline target for NDC1 to reduce net greenhouse gas emissions by 50 per cent below gross 2005 levels by 2030. The NDC1 target is economy wide, covering all sectors and all greenhouse gases. New Zealand will report on the implementation and achievement of its NDC1 through the Paris Agreement’s Enhanced Transparency Framework.

³ Lefale PF, Faiva P, Anderson CL. 2017. Living with Change (LivC): An integrated national strategy for enhancing the resilience of Tokelau to climate change and related hazards, 2017–2030. Wellington: Government of Tokelau and LeA International Consultants, Ltd. Retrieved from www.tokelau.org.nz/site/tokelau/files/ClimateChange/LivCStrategy_web-2.pdf (17 November 2022).

⁴ Ministry for the Environment. 2022. Te hau mārohi ki anamata – Towards a productive, sustainable and inclusive economy: Aotearoa New Zealand’s first emissions reduction plan. Wellington: Ministry for the Environment. Retrieved from <https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissions-reduction-plan/> (17 November 2022).

⁵ Ministry for the Environment. 2022. Urutau, ka taurikura: Kia tū pakari a Aotearoa i ngā huringa āhuarangi – Adapt and thrive: Building a climate-resilient New Zealand – New Zealand’s first national adaptation plan. Retrieved from <https://environment.govt.nz/publications/aotearoa-new-zealands-first-national-adaptation-plan/> (17 November 2022).

⁶ New Zealand’s previous NDC1 target (submitted upon ratification of the Paris Agreement) was to reduce greenhouse gas emissions to 30 per cent below 2005 levels by 2030.

- **2020 Target (2013–20):** Under the UNFCCC (while applying the Kyoto Protocol framework of rules), New Zealand set a target to reduce gross greenhouse gas emissions to 5 per cent below 1990 levels by 2020. We have met this target based on the 2022 submission of *New Zealand’s Greenhouse Gas Inventory*. This will be formally confirmed following the international expert review process.
- **2012 Target (2008–12):** Under the Kyoto Protocol’s first commitment period, New Zealand’s target was to reduce greenhouse gas emissions to 1990 levels by 2012. This target was confirmed as met in 2015, when *New Zealand’s True-up Report* was reviewed by UNFCCC.
- **Domestic targets:** In 2019, the Climate Change Response Act 2002 was amended to include 2050 emissions reduction targets. These legislated targets require all greenhouse gases other than biogenic methane to reach net zero by 2050 with a minimum biogenic methane reduction of 10 per cent by 2030, and 24–47 per cent by 2050 compared with 2017 levels.

New Zealand will meet its international emissions reduction targets through a combination of domestic emissions reductions, removal of carbon dioxide via sequestration sources such as forests, and participating in international carbon markets. New Zealand uses a multi-year emissions budget approach to set and measure progress towards our targets.⁷ This means that progress towards our targets is not measured by looking at emissions in a single year but includes emissions across all years for each target period. This approach was required for countries that took a first commitment period target under Kyoto Protocol and is being used by New Zealand for its 2030 target. New Zealand will continue to regularly review its contributions to international mitigation action, considering the latest science, development of new technologies, progress by other countries and the commitments New Zealand has made.

1.2 Action on climate change

In 2019, the Government published the **Climate Change Response (Zero Carbon) Amendment Act 2019**. The Act includes the need to prepare for, and adapt to, the effects of climate change. This included provision for a climate change commission, which would provide the Government with independent expert advice and monitor and review progress towards emissions reduction and adaptation goals. He Pou a Rangi – Climate Change Commission was established in 2019.

Aotearoa New Zealand will contribute to the global effort to limit temperatures to 1.5°C above pre-industrial levels and the 2050 targets through a series of interim targets known as **emissions budgets**. An emissions budget is the total quantity of greenhouse gas emissions that are permitted during a specified time period. New Zealand’s first three emissions budgets have been developed through to 2035 (table 1.1) and are set to get smaller over time to help the country progressively step towards our 2050 targets.

⁷ The headline number for New Zealand’s NDC1 is expressed as a ‘point-year target’ for 2030. This approach matches most other countries and assists with transparency and comparability. Under an ‘emissions budget’ approach it equates to a 41 per cent net reduction on 2005 gross emissions by 2030. The two approaches are therefore different ways of expressing the same level of ambition.

Table 1.1: New Zealand’s first three emissions budgets, 2022–2035

Emissions (Mt CO ₂ -e)	First emissions budget (2022–25)	Second emissions budget (2026–30)	Third emissions budget (2031–35)
All gases, net (AR5)	290.0	305.0	240.0
Annual average	72.5	61.0	48.0

Note: Emissions in million tonnes of carbon dioxide equivalent (Mt CO₂-e) are based on the GWP100 values from the Intergovernmental Panel on Climate Change’s *Fifth Assessment Report* (AR5). Parties to the Paris Agreement decided that each Party shall use the 100-year time horizon global warming potential (GWP) values from AR5 to report aggregate emissions and removals of greenhouse gases.

New Zealand released its first **emissions reduction plan** in May 2022, setting out policies and strategies on how our country will meet its first emissions budget and ultimately the 2050 targets. Some key initiatives of the emissions reduction plan are:

- increasing access to electric vehicles, beginning the process of decarbonising heavy transport and freight, and helping more people to walk, cycle and take public transport
- supporting businesses to improve energy efficiency and move away from fossil fuels, such as coal, by continuing to roll out the Government Investment in Decarbonising Industry Fund
- banning new low- to medium-temperature coal boilers and phasing out existing ones
- introducing an emissions pricing mechanism for agriculture
- accelerating the delivery of agricultural emissions reduction tools and technologies for farmers and farming businesses through the establishment of a new Centre for Climate Action on Agricultural Emissions
- reducing the amount of waste (including food waste) going to landfills, investing in waste infrastructure and expanding landfill gas capture
- establishing native forests at scale to develop long-term carbon sinks and improve biodiversity
- accelerating the supply of woody biomass to replace coal and other carbon-intensive fuels and materials
- driving mission-led innovation in some of the most challenging parts of our economy through climate innovation platforms and the wider research, science and innovation system
- requiring refrigerants to be captured and destroyed when heating and cooling systems reach the end of their life
- establishing a platform for Māori climate action that embeds partnership and representation, supports Māori-led strategy and alignment, and activates kaupapa Māori (Māori approach or customary practice), tangata Māori (Māori people) solutions.

The **New Zealand Emissions Trading Scheme** (NZ ETS) was introduced in 2008 as the principal policy tool underpinning New Zealand’s domestic emissions reduction action. It requires emitters to report on their emissions and surrender units that correspond to their obligations. By 2025, all sectors in New Zealand will be covered by the NZ ETS or an alternative pricing system, ensuring all domestic emissions in the country will be subject to emissions pricing.

The Government has regularly reviewed the NZ ETS and made modifications as necessary to ensure the tool remains fit for purpose to confirm New Zealand is able to meet its international climate change obligations and reduce emissions. In 2020, the NZ ETS was reformed to make the tool more efficient by implementing an annually updated emissions cap, introducing an auctioning platform to sell units into the market, beginning to phase down free allocation, simplifying some forestry provisions and improving administration and transparency.

Agriculture: A key priority for New Zealand is to begin pricing agricultural emissions by 2025. The approach to pricing emissions is being developed in partnership with the agricultural and horticultural sectors and Māori through He Waka Eke Noa – Primary Sector Climate Action Partnership (He Waka Eke Noa)⁸ which was established in 2019. He Waka Eke Noa explores alternative pricing approaches to ensure the agricultural emissions pricing scheme is effective in driving emissions reduction at the farm level. The final report was provided for the Government’s consideration on 31 May 2022. The Government’s final decision on the agricultural pricing system is due in early 2023.

New Zealand continues to invest in research to improve productivity and reduce emissions from agricultural production and, building on this strong domestic research programme, has announced the establishment of a new Centre for Climate Action on Agricultural Emissions.⁹ New Zealand has an enduring commitment to providing leadership in research, innovation and technical solutions to reduce greenhouse gas emissions from agriculture and seeks to share this knowledge internationally as a leading member of the Global Research Alliance on Agricultural Greenhouse Gases.

Vulnerability and adaptation: Climate change is already having observable impacts on New Zealand’s natural and built environments and is expected to cause new risks for the country’s future as projected changes such as sea-level rise, ocean warming, more hot days and different rainfall patterns occur.

Following the introduction of the Climate Change Response (Zero Carbon) Amendment Act 2019, a National Climate Risk Assessment¹⁰ has been conducted and published covering expected risks through to 2026. New Zealand’s first national adaptation plan in response to the risk assessment was completed in August 2022. This plan sets out objectives for adapting to the effects of climate change, strategies, policies and proposals for meeting these objectives, and measures and indicators to enable regular monitoring of implementation. Four priority areas guide the plan:

- enabling better risk-informed decisions
- driving climate-resilient development in the right locations
- laying the foundations for a range of adaptation options, including managed retreat
- embedding climate resilience across government.

⁸ <https://hewakaekenoa.nz/>.

⁹ www.mpi.govt.nz/funding-rural-support/environment-and-natural-resources/centre-for-climate-action-on-agricultural-emissions/.

¹⁰ Ministry for the Environment. 2019. *Arotakenga Huringa Āhuarangi: A framework for the National Climate Change Risk Assessment for Aotearoa New Zealand*. Wellington: Ministry for the Environment. Retrieved from <https://environment.govt.nz/publications/arotakenga-huringa-ahuarangi-a-framework-for-the-national-climate-change-risk-assessment-for-aotearoa-new-zealand/> (17 November 2022).

The National Climate Risk Assessment will be updated every six years followed by the publication of national adaptation plans that respond to the new scientific information and assessment.

Financial support: New Zealand remains committed to assisting developing countries to address climate change. The Government has contributed NZ\$285.78 million in climate-related support for developing countries across 2019 and 2020. This is an increase of NZ\$26.13 million compared with 2017 and 2018. The focus of the 2019–20 period was strengthening Pacific engagement and international development cooperation to support an effective global response to climate change and improve Pacific resilience.

New Zealand delivers its international climate finance through activities in its International Development Cooperation Programme. Activities focus on agriculture, disaster prevention and preparedness, ecosystem strengthening, renewable energy and water security. The Government also continues to support multilateral climate funds, providing a total of NZ\$22.16 million including a NZ\$15 million contribution to the first replenishment of the Green Climate Fund and NZ\$3 million contribution to the Adaptation Fund.

In October 2021, New Zealand committed to spending NZ\$1.3 billion on grant-based climate finance between 2022 and 2025. This funding will be used to ensure that New Zealand's climate finance supports developing countries and communities to build resilience to climate change as well as to contribute to keeping global warming to no more than 1.5°C. To do so, there are four key goals:

- enhance resilience and adaptation
- promote quicker action on mitigation
- improve information to allow evidence-based decisions
- leverage our investment to make greater impacts.

Public awareness, education and training: The Government actively supports initiatives that encourage public awareness of climate change at national, business and household levels. In 2019 the Gen Less programme¹¹ was launched by the Energy Efficiency and Conservation Authority to support New Zealanders to reduce their personal greenhouse gas emissions and take positive climate action. The Government regularly updates *Measuring Emissions: A guide for organisations*, which outlines the steps that organisations can take to voluntarily measure and report their greenhouse gas emissions.

The Government provides resources and funding for climate change-related education and training in schools, institutes and research centres, and industry training. This support includes an updated national school curriculum, resources for teaching and learning, and continued support to Enviro Schools and Te Aho Tū Roa programmes, which are designed to work in conjunction with the national curriculum and produce various environmental, educational, social and cultural outcomes.

International engagement: New Zealand engages widely at the international level to address climate change. In addition to participating broadly in the Intergovernmental Panel on Climate Change (IPCC) working groups and UNFCCC negotiations, New Zealand contributes to several international scientific organisations and plurilateral initiatives. For example, through the Secretariat of the Pacific Regional Environment Programme (SPREP) New Zealand actively

¹¹ <https://genless.govt.nz/>.

supports Pacific Island nations to meet their commitments under UNFCCC and adapt to climate change. We also offer support to science students from developing countries who want to complete their doctorate in New Zealand through the New Zealand Global Research Alliance Doctoral Scholarship (NZ-GRADS).¹² This scholarship allows students from developing countries to build their capability as researchers on topics related to greenhouse gas emissions from agricultural systems.

1.3 New Zealand's greenhouse gas emissions and removals

Aotearoa New Zealand supplies a transparent, accurate and regular national greenhouse gas inventory report, which forms one of the building blocks for effective climate change mitigation. As a developed country Party (Annex I Party) to the UNFCCC, New Zealand is obliged to prepare, publish and update *New Zealand's Greenhouse Gas Inventory* of anthropogenic greenhouse gas emissions and removals on an annual basis.

Inventory reporting under the UNFCCC considers five sectors: energy; industrial processes and product use (IPPU); agriculture; waste; and land use, land-use change and forestry (LULUCF). For Tokelau, a non-self-governing territory of New Zealand, emissions and removals are also reported separately by sector as 'Other'.

For reporting purposes, the difference between gross and net emissions is whether the LULUCF sector is included. Gross emissions exclude the LULUCF sector, while net emissions include the LULUCF sector.

In 2020, New Zealand's gross greenhouse gas emissions were 78,778.4 kilotonnes of carbon dioxide equivalent (kt CO₂-e). The sectors contributing the most to the country's emissions profile were agriculture at 50.0 per cent and energy at 39.9 per cent. Between 1990 and 2020, New Zealand's gross greenhouse gas emissions increased by 20.8 per cent due to increased agricultural activity and population growth. In 2020, the LULUCF sector offset 29.6 per cent of gross emissions. Net emissions in 2020, at 55,465.1 kt CO₂-e, were therefore lower than gross emissions. Between 1990 and 2020, the country's net greenhouse gas emissions increased by 26.1 per cent due to the underlying increase in greenhouse gas emissions.

1.4 Greenhouse gas projections

Aotearoa New Zealand uses projections to anticipate future emissions. Projections of emissions and removals are useful for policy planning and design but are inherently uncertain. Economic variables – such as commodity and oil prices, the assumed carbon price, the estimated rate of afforestation and deforestation, and the harvest age of forests – have significant impacts on projected emissions and removals. In addition, seasonal climate changes, especially variation in rainfall, can affect agriculture and electricity generation emissions.

Based on New Zealand's existing policies and measures, gross emissions are reported to be 78.8 million tonnes of carbon dioxide equivalent (Mt CO₂-e) in 2020 and estimated to decrease to 66.7 Mt CO₂-e in 2035, which will be 2.3 per cent above 1990 levels. In the short term, the decreasing trend in gross emissions is primarily due to decreasing emissions in all sectors except transport, with the agriculture and energy sectors contributing the largest decreases. In the long term, decreasing gross emissions are primarily the result of policies

¹² <https://globalresearchalliance.org/library/nz-grads/>.

and measures introduced by the Government across all sectors. These projections are based on implemented policies and measures and do not reflect all the policies included in the emissions reduction plan.

New Zealand's net emissions in 2020 were reported to be 55.5 Mt CO₂-e. Net emissions are projected to increase to 63.8 Mt CO₂-e in 2025 (45.0 per cent above 1990 levels), before decreasing to 41.2 Mt CO₂-e (6.3 per cent below 1990 levels) in 2035. Given the influence of forestry on New Zealand's total emissions, net emissions at any given time will be influenced by planting and harvesting cycles in plantation forests.

The LULUCF sector reported net removals of 23.3 Mt CO₂-e in 2020. LULUCF net removals are projected to be 9.5 Mt CO₂-e in 2025 (a 55.2 per cent decrease in net removals than in 1990); however, net removals are projected to be 25.5 Mt CO₂-e in 2035 (a 20.3 per cent increase in net removals than in 1990). Projected LULUCF emissions and removals are significantly influenced by New Zealand's planted forest age-class profile and harvesting rates. Harvest and replanting cycles of New Zealand's plantation forests will continue to affect the country's emissions and removals well into the future.

New Zealand's LULUCF sector is currently a net sink of carbon dioxide, meaning it removes more carbon dioxide from the atmosphere than it emits. Net removals from the LULUCF sector are projected to decline in the early 2020s as plantation forests established in the late 1980s and 1990s are harvested. In the late 2020s net removals are expected to increase due to the replanting of plantation forests harvested in the early 2020s and the additional sequestration from projected afforestation activities.

Comparing New Zealand's projected emissions 'with measures' demonstrates the impact of some, but not all, policies and measures. Unforeseen technological disruption may also affect greenhouse gas emissions. For example, New Zealand's investment in agricultural research may contribute to a reduction in domestic emissions and potentially contribute indirectly to reducing global agriculture emissions. However, the benefits of these contributions cannot be predicted and thus are not included within the emissions estimates.

2 National circumstances

Key points

- Aotearoa New Zealand is a long, mountainous country in the southwest Pacific Ocean with a temperate, oceanic climate.
- Due to New Zealand's widely distributed population of 5.1 million people and mountainous terrain, roads are the main form of transport.
- New Zealand has an export-dependent economy based on the services, manufacturing and primary sectors.
- The efficient, largely pastoral agricultural system is fundamental to the economy, and its products are exported to countries all over the world.
- The majority of electricity generation comes from renewable sources – primarily hydro, geothermal and wind.
- Greenhouse gas emissions are susceptible to year-to-year variation due to localised events, such as droughts and earthquakes.
- Planting and harvesting cycles in the forestry sector will affect New Zealand's net emissions well into the future.
- The COVID-19 pandemic and related restrictions have had an impact across the country, particularly on international tourism.

2.1 Geographic profile

Aotearoa New Zealand is a long, narrow and mountainous country. It consists of two large islands, the North Island and the South Island, and a number of smaller islands. The two main islands are located in the southwest Pacific Ocean between 33 and 47 degrees latitude south. The nearest large land mass (Australia) is more than 2000 kilometres away.

New Zealand has a combined land area of around 27 million hectares and is similar in size to Japan or the United Kingdom. It has approximately 15,000 kilometres of coastline and its Exclusive Economic Zone (EEZ) is the fourth largest in the world.¹³ Combined, New Zealand's EEZ and territorial sea cover 4.4 million square kilometres.

New Zealand straddles the boundary of the Pacific and Australian tectonic plates. The resulting earth movements have produced hilly and mountainous terrain over two-thirds of the land. Earthquakes occur frequently in most parts of the country. There is also a zone of volcanic and geothermal activity in the central North Island. The diverse topography and climate have created a variety of diverse ecosystems ranging from high alpine to warm temperate forests, including 72 types of naturally uncommon ecosystems.¹⁴ After New Zealand's land mass broke away from the Gondwana supercontinent around 80 million years ago, plants and animals evolved in isolation for millions of years almost entirely without

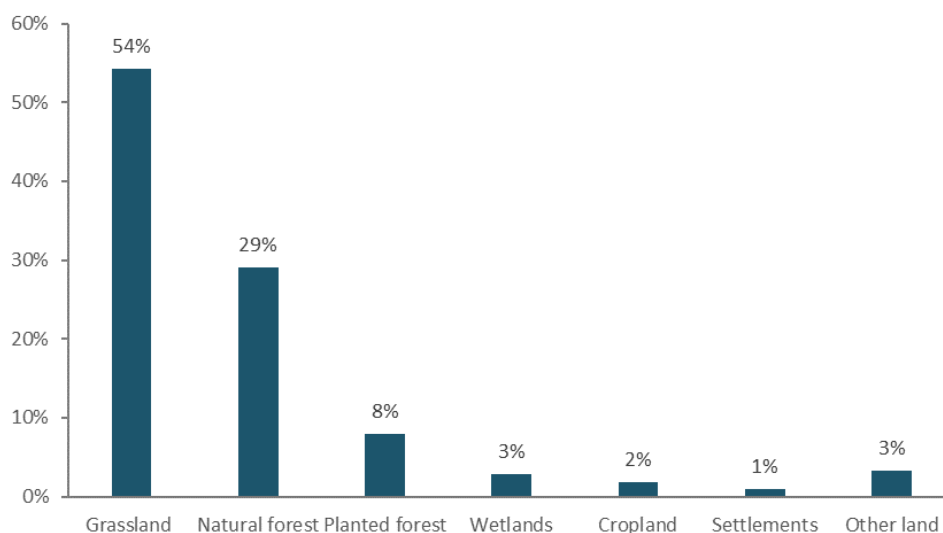
¹³ Ministry for the Environment and Stats NZ. 2019. *New Zealand's Environmental Reporting Series: Our marine environment 2019*. Wellington: Ministry for the Environment and Stats NZ.

¹⁴ Williams PA, Wiser A, Clarkson B, Stanley MC. 2007. New Zealand's historically rare terrestrial ecosystems set in a physical and physiognomic framework. *New Zealand Journal of Ecology* 31(2): 119–128.

the presence of mammals. As a result, many of the country’s estimated 80,000 species of native animals, plants and fungi are found nowhere else in the world.¹⁵

Today, grassland for agriculture, natural forest and planted forestry form New Zealand’s main land covers (figure 2.1). Around one-third of the land area is protected for conservation purposes.

Figure 2.1: Land covers in New Zealand, 2020



Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

2.2 Population profile

Aotearoa New Zealand’s resident population – the population living in New Zealand – was 5.1 million at 30 June 2021.¹⁶ The majority of the population is urbanised and 76.6 per cent live in the North Island; the largest city is Auckland and 33.3 per cent of the total population live within the greater Auckland area (as at June 2021).¹⁷ Population density is relatively low, with an average of 19 people per square kilometre.^{4, 18}

New Zealand’s population is growing. It has increased by an average of 1.3 per cent a year between 1953 and 2022.¹⁹ The population grew fastest in the 1950s, but the growth rate slowed as fertility rates fell and the population’s age structure changed. During the 1980s the annual growth was only 0.6 per cent on average (figure 2.2). Despite relatively high population growth between 2013 and 2020 (1.8 per cent per year on average), growth has slowed since then, provisionally at 0.4 per cent in 2021 and 0.3 per cent in 2022.^{7, 20}

¹⁵ Convention on Biological Diversity. *New Zealand – Main Details*. Retrieved from www.cbd.int/countries/profile/?country=nz.

¹⁶ Stats NZ. 2022. *Table Reference: DPE055AA*. Retrieved from www.stats.govt.nz/infoshare.

¹⁷ Stats NZ. 2021. *Table Reference: DPE051AA*. Retrieved from www.stats.govt.nz/infoshare.

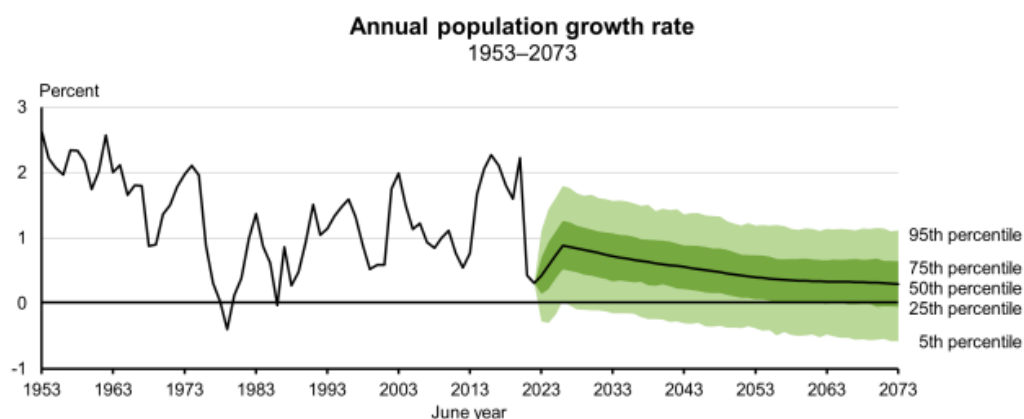
¹⁸ Walrond C. 2005. Natural environment: Geography and geology. *Te Ara – the Encyclopedia of New Zealand*. Retrieved from www.TeAra.govt.nz/en/natural-environment/page-1.

¹⁹ Stats NZ. 2022. *National population projections: 2022(base)–2073*. Retrieved from www.stats.govt.nz/information-releases/national-population-projections-2022base2073/.

²⁰ Stats NZ. 2022. *Table reference: DPE070AA*. Retrieved from www.stats.govt.nz/infoshare.

COVID-19 had a significant impact on international travel and migration from 2020, which accounts for some of the decrease in population growth rate.²¹ Figure 2.2 shows that the population growth rate is projected to increase in the 2020s, before slowing in the long term out to 2073. The long-term trend is driven by the narrowing gap between births and deaths (natural increase).

Figure 2.2: Annual population growth rate, 1953–2073



Source: Stats NZ. 2022. National Population Projections: 2022(base)–2073.

Net migration (migrants entering New Zealand, minus those leaving) has varied greatly over the years as a result of economic factors, labour market conditions, and immigration policy in New Zealand and other countries. As noted, more recently COVID-19 also had a significant impact.

In the 12 months ended June 2022, there was a provisional net migration loss of 12,960 people.²² Monthly net migration losses have occurred in most months since November 2020. As New Zealand’s border restrictions ease through 2022, net migration is expected to gradually rise from the current losses to the long-term median net migration gain of 25,000 people in 2026 and beyond.²³ Annual net migration will of course fluctuate around this median, but the median indicates the average net migration gain based on historical trends and current policy settings.

Census data

Many figures in this chapter are derived from the New Zealand Census of Population and Dwellings, the official count of people and dwellings collated by Statistics New Zealand. The latest Census was conducted in 2018. The next Census will be conducted in 2023.

The collection rate for the 2018 Census was lower than expected, with one in six New Zealand residents not completing a questionnaire. Methods to produce the final dataset included using data from alternative sources. The 2018 Census external data quality panel assessed the methodologies and the methods to produce the final data.²⁴

²¹ Stats NZ. 2022. *National population projections: 2022(base)–2073*. Retrieved from www.stats.govt.nz/information-releases/national-population-projections-2022base2073/.

²² Stats NZ. 2022. *Table reference: ITM406AA*. Estimates published 12 September 2022.

²³ National population projections: 2022(base)–2073 Retrieved from www.stats.govt.nz/information-releases/national-population-projections-2022base2073/.

²⁴ Stats NZ. *Data Quality for 2018 Census*. Retrieved from www.stats.govt.nz/2018-census/data-quality-for-2018-census.

2.3 Climate

2.3.1 Current climate

Aotearoa New Zealand has climate zones ranging from subtropical to subantarctic. The climate is heavily influenced by the country's location in a latitudinal zone with prevailing westerly winds and by the surrounding ocean. It is also influenced by mountain chains that modify the weather systems as they sweep eastward. This leads to more rainfall in the west and drier conditions in the east.

The average rainfall in most areas is between 600 and 1600 millimetres a year. In the mountain ranges, annual rainfall often exceeds 5000 millimetres, and in the Southern Alps it can be more than 10,000 millimetres. However, areas to the east of the main ranges have an average rainfall of less than 600 millimetres a year.^{25, 26, 27}

Average annual temperatures range from 10°C in the southern part of New Zealand to 16°C in the north.¹⁴ In areas inland and to the east of the main ranges, temperatures fluctuate by up to 14°C between seasons, but generally the changes between summer and winter temperatures are small.¹⁴ On average, most of the country receives between 1700 and 2100 sunshine hours annually.²⁸

New Zealand is already experiencing changes in climate due to climate change, with an increase in average annual temperature of 1.1°C over the past 100 years.²⁹ 2021 was the warmest year on record, surpassing the previous record set in 2016.¹⁴

Sea-level rise is accelerating globally, with an average rate of 3.7 millimetres per year between 2006 and 2018.³⁰ New Zealand's long-term records show rising coastal sea levels (relative to land) of 1.81 millimetres per year from the start of our records in 1901 to 2018.³¹ The rate of sea-level rise has also increased. Between 1961 and 2018, the mean rate of sea-level rise was 2.44 millimetres per year.³² This rate is more than double the mean rate in the 60 years before this time period, which was 1.22 millimetres per year between the start of our records and 1960.³³

²⁵ National Institute of Water and Atmospheric Research. 2017. *Overview of New Zealand Climate*. Retrieved from www.niwa.co.nz/education-and-training/schools/resources/climate/overview.

²⁶ National Institute of Water and Atmospheric Research. 2022. *Aotearoa New Zealand Climate Summary: 2021*. Retrieved from niwa.co.nz/sites/niwa.co.nz/files/2021_Annual_Climate_Summary_NIWA11Jan2022.pdf.

²⁷ National Institute of Water and Atmospheric Research. 2016. *West Coast*. Retrieved from niwa.co.nz/our-science/climate/publications/regional-climatologies/west_coast.

²⁸ Stats NZ. 2017. *Sunshine Hours*. Retrieved from www.stats.govt.nz/indicators/sunshine-hours.

²⁹ Bodeker G, Cullen N, Katurji M, McDonald A, Morgenstern O, Noone D, Renwick J, Revell L, Tait A. 2022. *Aotearoa New Zealand Climate Change Projections Guidance: Interpreting the Latest IPCC WG1 Findings*. Prepared for the Ministry for the Environment.

³⁰ Intergovernmental Panel on Climate Change. In press. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

³¹ Ministry for the Environment. 2022. *About sea level rise*. Retrieved from About sea level rise | Ministry for the Environment.

³² Ministry for the Environment. 2020. *National Climate Change Risk Assessment for Aotearoa New Zealand: Main report – Arotakenga Tūraru mō te Huringa Āhuarangi o Āotearoa: Pūrongo whakatōpū*. Wellington: Ministry for the Environment.

³³ Stats NZ. 2022. *Coastal sea-level rise*. Retrieved from www.stats.govt.nz/indicators/coastal-sea-level-rise.

2.3.2 Projected changes in climate³⁴

The mid-range estimate for projected temperature change in New Zealand is for an expected increase of about 0.8°C by 2040, 1.4°C by 2090 and 1.6°C by 2110, relative to the 1986–2005 period.³⁵ Because of the different possible pathways for the concentrations of greenhouse gases in the atmosphere, as well as the differences in climate model response to those pathways, the possible projections for future warming span a wide range: 0.2–1.7°C by 2040, 0.1–4.6°C by 2090 and 0.3–5.0°C by 2110.

Projected changes in rainfall show a marked seasonality and variability across regions. It is very likely that for winter and spring, rainfall will increase in the west of both the North and South Islands, while the east and north will have drier conditions, caused by a projected increase in the westerly winds over New Zealand during these seasons. For summer, conditions are likely to be wetter in the east of both islands and drier in the west and central North Island.

Extreme weather events, such as storms, heat waves and heavy rainfall, are likely to be more frequent and intense. Tropical cyclones are likely to have increased wind intensity and rain rates, and to be stronger and cause more damage. Drought severity is projected to increase in most areas of the country, except for Taranaki-Manawatu, West Coast and Southland.

2.4 Government structure

2.4.1 Te Tiriti o Waitangi – New Zealand’s founding document

Aotearoa New Zealand is founded on a partnership between the Crown and indigenous New Zealanders, Māori, through Te Tiriti o Waitangi (the Treaty of Waitangi) signed in 1840. It establishes the principles of the relationship between Crown and Māori: partnership, participation and protection.

The climate change legislation administered by the Ministry for the Environment contains clauses requiring the Crown to take into account the principles of Te Tiriti. Te Tiriti o Waitangi has significant implications for climate change policy because the Crown has a duty to actively protect Māori lands, estates, forests, fisheries and other taonga (treasures), and must enable Māori to protect these taonga.³⁶

In 1989 the Crown established the Office of Treaty Settlements (now Te Kāhui Whakatau within The Office for Māori Crown Relations – Te Arawhiti). Treaty settlements are intended to address the historical grievances of iwi and hapū groups that resulted from the Crown’s breaches of Te Tiriti o Waitangi.³⁷ Enacted settlements establish legal rights and obligations that the Crown must be aware of when developing new policy to ensure it does not

³⁴ For more information on projected climate impacts for New Zealand, see chapter 6.

³⁵ All information for this section comes from for this section from: Ministry for the Environment. 2018. *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment* (2nd edn). Wellington: Ministry for the Environment.

³⁶ Jones C. 2016. *New Treaty New Tradition: Reconciling New Zealand and Māori Law*. Wellington: Victoria University Press.

³⁷ An iwi (tribe) is one of the largest kinship groupings and is generally made up of several hapū that are all descended from a common ancestor. Hapū are clusters of whānau where the whānau is usually an extended family grouping consisting of children, parents, often grandparents, and other closely related kin.

inadvertently breach these rights. Policies that do not consider Treaty settlements have the potential to undermine the relationship between settled groups and the Crown.

Climate change will affect Māori as tangata whenua (people of the land) and kaitiaki (guardians) of their ancestral and cultural landscape. Certain whānau, hapū and iwi will be disproportionately affected, as will Māori interests, values, practices and wellbeing. Many Māori communities are located in rural and remote locations, and are particularly vulnerable to the effects of climate change on their homes, infrastructure and sites of cultural significance to Māori – including marae (courtyard), urupā (burial grounds), wāhi tapu (sacred sites) and mahinga kai (food-gathering places).

In keeping with the principles of Te Tiriti o Waitangi, the Government and Māori will together need to make climate change decisions in a way that balances kāwanatanga (the Government's right to govern) with rangatiratanga (the Māori right to make decisions for Māori).

2.4.2 Central government

New Zealand's central government is formed from a democratically elected House of Representatives. The Government advises New Zealand's head of state, King Charles III (the Sovereign). The King is the source of all executive legal authority in New Zealand but acts on the advice of the Government in all but the most exceptional circumstances. This system is known as a constitutional monarchy. The King is represented in New Zealand by a Governor-General, currently Her Excellency The Right Honourable Dame Cindy Kiro.³⁸ The Governor-General carries out the King's constitutional and ceremonial duties.

In New Zealand, the meaning of 'the Crown' differs depending on context, but generally refers to the Government as the successor of the British Crown and Queen Victoria, who was party to Te Tiriti o Waitangi. After becoming a British colony in 1840, New Zealand gradually gained independence. A 'Crown entity' is an organisation that is part of the state sector and operates with some independence from the Government. Government Ministers oversee Crown entities within their portfolio, but a board governs a Crown entity's operations.

Parliament consists of the House of Representatives and the Sovereign. The principal functions of Parliament are to enact laws and to hold the Government to account over its policies, actions and spending. Since 1996 members of Parliament have been elected using a mixed member proportional representation system. There are five parliamentary parties in the current 53rd Parliament.³⁹

2.4.3 Central government roles and responsibilities in relation to climate change

Central government agencies

The **Ministry for the Environment (MfE)** was established under the Environment Act 1986 and is the New Zealand Government's primary advisor on the environment, including on global challenges affecting the environment and climate change. In relation to climate change, MfE's key roles include: advising the Government on the New Zealand Emissions Trading Scheme (NZ ETS) and the development of regulations under the scheme, administering the Waste

³⁸ See gg.govt.nz/governor-general.

³⁹ See www.parliament.nz/en/mps-and-electoralates/political-parties. This information was accurate as at 10 August 2022.

Minimisation Act 2008 and advising on waste management and minimisation, implementing several schemes to reduce fluorinated gases; monitoring the implementation and setting out national direction under the Resource Management Act 1991 (RMA); participating in He Waka Eke Noa – the Primary Sector Climate Action Partnership (He Waka Eke Noa) and providing advice on an agricultural emissions pricing mechanism jointly with the Ministry for Primary Industries; and international negotiations and reporting under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol.

MfE supports the Minister of Climate Change’s duties to set emissions budgets, prepare and publish emissions reduction plans and national adaptation plans. MfE advises the Government more broadly on mitigation measures, the impacts of climate change on New Zealand, and New Zealand’s response to these. MfE is also responsible for coordinating climate change policy across government.

The **Department of Conservation (DOC)** manages public conservation land, which includes national parks and reserves, and has responsibilities for wildlife. DOC provides policy advice for protecting and enhancing native carbon sequestration and on climate change issues, including planning for adaptation measures where they relate to and intersect with conservation issues. DOC supports the Minister of Conservation’s role in sustainable coastal management under the RMA, which includes preparing a New Zealand Coastal Policy Statement to set national priorities for the coastal environment.

The **Department of Internal Affairs (DIA)** leads the central government’s relationship with local government in New Zealand. DIA’s community resilience programme was established in 2018 to look at how central government could better work with local government to address the challenges of reducing natural hazard risks and adapting to climate change. The programme focuses on shifting the system from disaster response towards a more proactive risk response before disasters occur. The community resilience programme partners with local government and other central government agencies to ensure policy levers, regulatory frameworks and tools support natural hazard risk reduction and climate change adaptation objectives.

The **Energy Efficiency and Conservation Authority (EECA)** is the primary government agency responsible for encouraging energy efficiency in homes and businesses and the uptake of renewable energy. EECA provides information, resources and tools, regulates the energy performance of appliances and equipment, and runs co-investment and other programmes in various sectors. EECA’s goal is for Aotearoa New Zealand to have a sustainable energy system that supports the prosperity and wellbeing of current and future generations.

The **Environmental Protection Authority – Te Mana Rauhi Taiao (EPA)** is the government agency responsible for regulatory functions concerning New Zealand’s environmental management. The EPA is responsible for the operation of the New Zealand Emissions Trading Register and the administration of all the non-forestry sectors in the NZ ETS.⁴⁰ This includes emissions reporting by NZ ETS participants and applications for industrial allocation under the NZ ETS.

The **Ministry of Business, Innovation and Employment’s – Hīkina Whakatutuki’s (MBIE)** overarching purpose is to “grow New Zealand for all”. It plays a central role in shaping and delivering a strong New Zealand economy, with a focus on shifting New Zealand to a low-emissions, climate-resilient and high-wage economy.

⁴⁰ The Ministry for Primary Industries has responsibility for the forestry sector.

MBIE's responsibilities include advising on economic strategy with the Treasury, energy policy, building and construction policy, science and innovation policy, research funding, economic and regional development, labour market policy and economic transitions policy. It is also involved in designing and delivering various regulatory systems, leadership for New Zealand Government property and procurement, and supporting business growth.

The **Ministry of Foreign Affairs and Trade (MFAT)** is responsible for leading New Zealand's international climate change negotiations, and it coordinates inputs from experts from MfE, the Ministry for Primary Industries, the Treasury and other government agencies for this purpose. MFAT also delivers the majority of New Zealand's climate-related support to other countries as part of our bilateral, regional and multilateral assistance managed through New Zealand's International Development Cooperation programme.

The **Ministry of Health (MOH)** is New Zealand's principal advisor on health and disability. It works to improve, promote and protect the health of all New Zealanders, including by addressing the human health impacts of climate change.

Te Tūāpapa Kura Kāinga – the Ministry of Housing and Urban Development (HUD) shapes the strategies and work programmes for housing and urban development in Aotearoa New Zealand. HUD is responsible for developing climate change policy in relation to housing and urban development and has a key role in working with other agencies to ensure climate change policy is joined up across the system.

Te Manatū Ahu Matua – the Ministry for Primary Industries (MPI) contributes to Government policy development for the primary sector, primarily forestry and agriculture. MPI has particular responsibility for the implementation of the NZ ETS in relation to forestry, and it administers other climate-relevant, forestry-related initiatives. MPI also provides advice on an agricultural emissions pricing mechanism jointly with MfE, including through participation in He Waka Eke Noa. MPI collects data on national annual greenhouse gas emissions for the agricultural and forestry sectors to support reporting and accounting under the UNFCCC, Kyoto Protocol and Paris Agreement. MPI also provides direct funding for some elements of climate change research (including for the national greenhouse gas inventory and mitigation practices and technologies) and sustainable farming. MPI hosts the Secretariat and Special Representative of the Global Research Alliance on Agricultural Greenhouse Gases, supporting international agriculture mitigation science and capability building. It has a further role of extending research knowledge on climate change to farmers and foresters. In addition, it is responsible for maximising the sustainable use of fish stocks within environmental limits, including through research on climate change and its effects on the ocean environment, aquaculture and wild fish stocks.

The Ministry of Social Development (MSD) helps New Zealanders to be safe, strong and independent. MSD is centred on helping people, whānau and communities, and contributing positively to the wellbeing of people today and into the future.

MSD's core responsibilities include providing New Zealanders with:

- employment services
- income support
- housing services
- supporting communities.

MSD also supports youth, students, people of working age and seniors through delivering a wide range of services and funding community providers.

Te Manatū Waka – Ministry of Transport (TMW) is the Government’s principal advisor on transport policy in New Zealand. It advises the Government on enhancing domestic transport efficiency. TMW is responsible for developing climate change policies specific to transport and it is the lead agency for the Clean Vehicles Programme, with Waka Kotahi administering it. TMW also works with other ministries, such as the Ministry of Housing and Urban Development, to ensure joined-up approaches to addressing climate change. TMW also represents the New Zealand Government at international forums related to transport, such as the International Maritime Organization and the International Civil Aviation Organization.

The Treasury – Te Tai Ōhanga is the Government’s lead economic and financial advisor and steward of the public sector financial management and regulatory systems. The Treasury provides advice to Ministers on the performance of companies and entities in which the Crown has full or partial ownership. The Treasury also monitors and appoints people to governance roles on these boards.

The **Waka Kotahi NZ Transport Agency (Waka Kotahi)** is a Crown entity governed by a statutory board. Its primary objective on behalf of the Government is to contribute to an effective, efficient and safe land transport system in the public interest. Waka Kotahi’s main functions are to give effect to Government transport policy. It does this through regulating access to and use of the land transport system, including through the use of standards, vehicle and driver licensing; planning and overseeing delivery of the public transport system and the state highway system, and managing investment in the multi-modal land transport system alongside local government.

Central government working groups

The **Climate Change Chief Executives Board (the Board)** is responsible to the Prime Minister and is made up of the chief executives of New Zealand government agencies with key roles in mitigating and/or adapting to climate change. The Board has been formalised as an interdepartmental executive board under the Public Service Act 2020.

The **Climate Response Ministerial Group** was established in 2020 and is chaired by the Prime Minister. This group meets regularly to progress and direct the climate change work programme, including the emissions budgets and sector sub-targets.

2.4.4 Local government

New Zealand has 78 local authorities, comprising 11 regional councils, 61 territorial authorities and six unitary councils (which are territorial authorities with regional council responsibilities).⁴¹ Due to devolved decision-making, local authorities are largely independent of the central executive government. They have their own sources of income independent of central government, from council-owned enterprises and from taxes on land and property.

Local government plays an important role in achieving a thriving, climate-resilient and low-emissions New Zealand. Local government makes decisions in many sectors, including land use planning, transport and waste management, that are relevant to climate mitigation and

⁴¹ For more information on the role of local government bodies, see www.lgnz.co.nz.

adaptation. Local authorities are also the owners of a significant amount of assets (including infrastructure and forestry) at risk from the impacts of climate change.

Local government has functions and responsibilities relating to managing natural hazard and climate change effects under the Local Government Act 2002, the Resource Management Act 1991 and other legislation. These include a requirement to plan for the future in terms of managing the effects of land use, avoiding and mitigating natural hazards, and having specific regard to the effects of climate change. In particular, regional councils have responsibility for: managing water, air and land resources where there are regionally significant management issues; biosecurity; natural hazards; emergencies; and regional land transport. For city and district councils, responsibilities include: land use planning; building control; emergency management; waste management and minimisation; and the provision of local infrastructure and community services.

2.4.5 Independent Crown entity

He Pou a Rangi – Climate Change Commission is an independent Crown entity that delivers evidence-based advice to the Government to guide climate change action for New Zealand. The Commission was established in 2019 to:

- provide independent advice to the Government on climate change mitigation and adaptation
- monitor and review the Government’s progress towards the meeting the emissions budgets and 2050 target, as well as the implementation of emissions reduction and national adaptation plans.

2.5 Buildings and urban structure

The 2018 Census recorded almost 1.7 million occupied dwellings (of which about 9600 were non-private dwellings) and approximately 191,600 unoccupied private dwellings.^{42, 43} The majority (83.6 per cent) of occupied dwellings were separate houses, 15.1 per cent were two or more flats or apartments joined together, and the remaining 1.2 per cent were a mixture of other types of dwellings, including holiday homes, mobile homes and improvised dwellings.⁴⁴ The number of private dwellings was estimated to be 2.0 million at 30 June 2022.⁴⁵

At the time of the 2018 Census, Aotearoa New Zealand’s homeownership rates were at their lowest since the 1950s.⁴⁶ Homeownership peaked in the 1990s, at 73.8 per cent of households, but by 2018 it had decreased to 64.5 per cent of households. The proportion of households who rent their dwelling increased from 22.9 per cent in 1991 to 31.9 per cent in 2018.³³ The 2018 Census showed a 16.5 per cent increase in the number of households renting since 2013

⁴² Stats NZ. 2021. *2018 Census Urban Accessibility Dataset*. Retrieved from www.stats.govt.nz/information-releases/2018-census-urban-accessibility-dataset.

⁴³ Stats NZ. 2019. 2018 Census Population And Dwelling Counts. Retrieved from www.stats.govt.nz/information-releases/2018-census-population-and-dwelling-counts. Unoccupied dwellings include dwellings temporarily unoccupied on Census night because the residents were away.

⁴⁴ Stats NZ. 2021. *2018 Census Urban Accessibility Dataset*. Retrieved from www.stats.govt.nz/information-releases/2018-census-urban-accessibility-dataset.

⁴⁵ Stats NZ. 2022. *Dwelling and Household Estimates: June 2022 Quarter*. Retrieved from www.stats.govt.nz/information-releases/dwelling-and-household-estimates-june-2022-quarter.

⁴⁶ Stats NZ. 2020. *Housing in Aotearoa: 2020*. Retrieved from www.stats.govt.nz/reports/housing-in-aotearoa-2020.

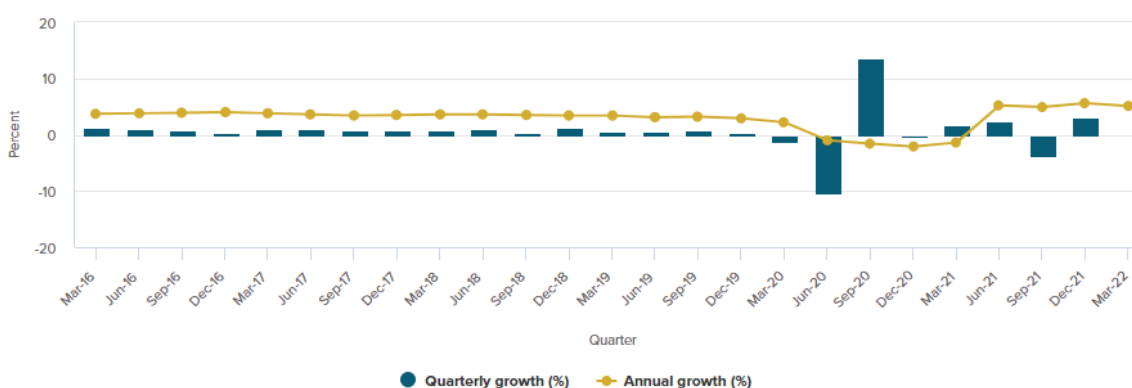
(from 453,135 in 2013 to 527,853 in 2018). This apparent increase, however, may partly reflect improved data quality due to the use of administrative data.⁴⁷

2.6 Economy and industry

Aotearoa New Zealand has an export-dependent economy that operates on free market principles. In the year ended March 2020, nominal gross domestic product (GDP) was NZ\$324.0 billion.⁴⁸ The economy has grown at an average annual rate of 2.8 per cent since 1990.⁴⁹

The COVID-19 pandemic and associated responses have generated unprecedented changes in the measured GDP.⁵⁰ New Zealand went into a nationwide lockdown in March 2020, which significantly impacted economic activity in the June 2020 quarter with a large decline in GDP. As COVID-19 alert levels have lowered, economic activity experienced an historically large increase in the September 2020 quarter. A similar pattern was observed in the lockdown-affected September 2021 quarter and then the December 2021 quarter when restrictions were eased (figure 2.3).

Figure 2.3: Gross domestic product, quarterly and annual growth rates, March 2016 – March 2022



Source: Stats NZ. 2022. Gross Domestic Product (GDP).

The economy is based on the provision of services (roughly two-thirds of the total GDP) and the manufacturing and primary sectors (figure 2.4). The primary sector (agricultural, horticultural, forestry, mining and fishing industries) plays a fundamental role in the export sector and in employment. The primary sector directly accounts for around 6.5 per cent of GDP (figure 2.4) and contributes over half of New Zealand’s total export earnings.⁵¹ In 2021 the primary sector employed 174,200 people, accounting for 6.2 per cent of all employed people.⁵²

⁴⁷ Administrative data include data collected by government agencies on private organisations in the course of conducting their business or services. They are not data collected primarily for statistical purposes.

⁴⁸ Stats NZ. 2021. *National accounts (industry production and investment): Year ended March 2020*. Retrieved from www.stats.govt.nz/information-releases/national-accounts-industry-production-and-investment-year-ended-march-2020/

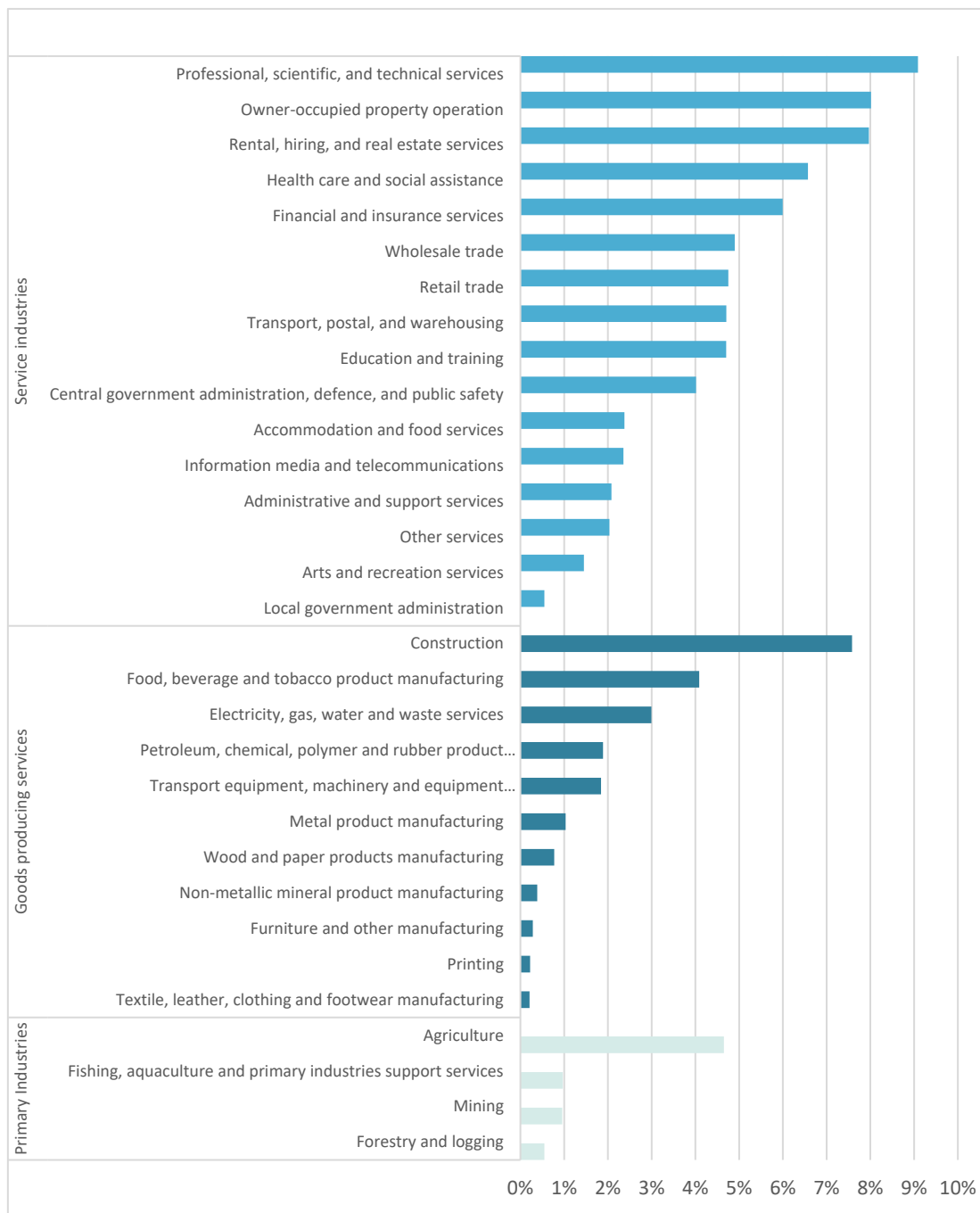
⁴⁹ Annual average calculated based on percentage change from same quarter previous year, ie, 2022Q1 vs 2021Q1. Stats NZ. 2022. *Table Reference: SNE181AA*. Retrieved from www.stats.govt.nz/infoshare.

⁵⁰ Stats NZ. 2022. *Gross Domestic Product: March 2022*. Retrieved from www.stats.govt.nz/information-releases/gross-domestic-product-march-2022-quarter.

⁵¹ Stats NZ. *New Zealand Trade Dashboard*. Retrieved from statisticsnz.shinyapps.io/trade_dashboard.

⁵² Stats NZ. 2022. *Table Reference: HLF137AA*. Retrieved from www.stats.govt.nz/infoshare.

Figure 2.4: Contribution of different industries to New Zealand's GDP (year ending March 2020)



Note: Percentages calculated using the sum of the categories as the total GDP.

Source: Stats NZ. 2021. National Accounts (industry production and investment): Year ended March 2020.

2.6.1 Exports

New Zealand's total exports of goods and services were valued at NZ\$79.4 billion for the year ended March 2022. China was its main export market, worth NZ\$21.3 billion, followed by the United States (NZ\$11.2 billion), Australia (NZ\$11.2 billion) and Japan (NZ\$4.0 billion).⁵³

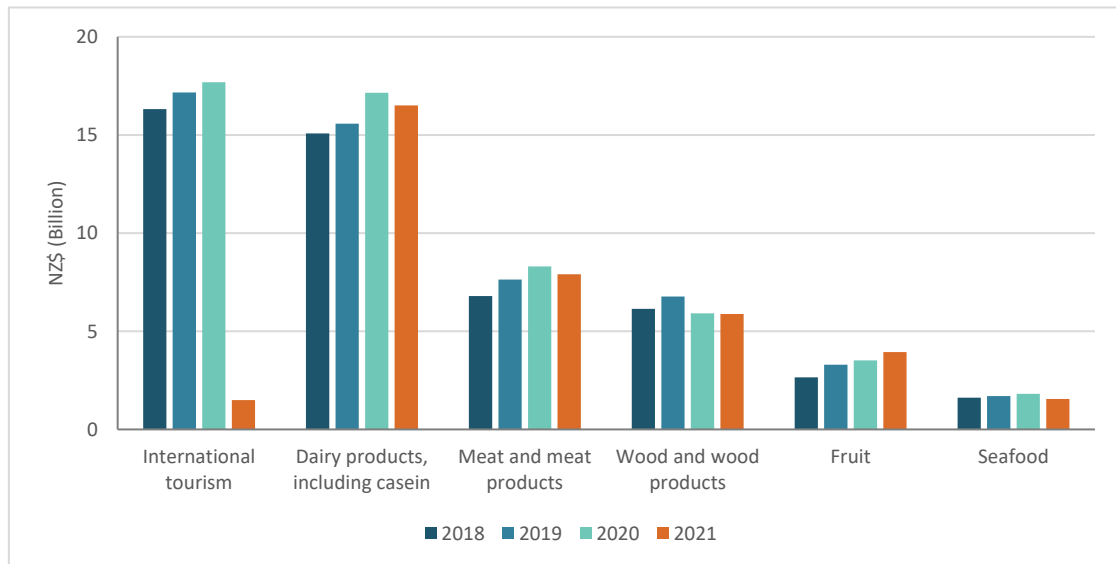
⁵³ Stats NZ. *New Zealand Trade Dashboard*. Retrieved from statisticsnz.shinyapps.io/trade_dashboard.

New Zealand is the world’s largest single-country exporter of dairy products and sheep meat, and among the largest exporters of forestry products in the Organisation for Economic Co-operation and Development (OECD).⁵⁴ It is also a significant exporter in the kiwifruit, pip fruit and wool industries.

Dairy products were New Zealand’s largest export earner in the year ending March 2022, accounting for 23.0 per cent of exports at NZ\$18.3 billion.⁵⁵ In the same year the next three largest groups of export goods were meat products at 11.4 per cent of total exports, wood products at 6.8 per cent and fruit at 4.8 per cent. The largest service export was the travel service, which contributed NZ\$3.8 billion (4.8 per cent) of total export goods and services.

Before 2021, international tourism was a significant export earner for New Zealand, compared with traditional export products in the primary sector. In 2019, international tourism expenditure was NZ\$17.2 billion.⁵⁶ Due to COVID-19 border restrictions, and the subsequent decline in international tourism, this number has dropped significantly (figure 2.5). In 2021, the provisional international tourism expenditure was NZ\$1.5 billion.⁵⁷

Figure 2.5: International tourism expenditure compared with value of selected primary exports (NZ\$), 2018–21 (year ended March)



Source: Stats NZ. 2021. Tourism satellite account: Year ended March 2021.

⁵⁴ OECD. 2017. *OECD Environmental Performance Reviews: New Zealand 2017*. Paris: OECD Publishing. Retrieved from dx.doi.org/10.1787/9789264268203-en.

⁵⁵ Stats NZ. *New Zealand Trade Dashboard*. Retrieved from statisticsnz.shinyapps.io/trade_dashboard.

⁵⁶ Stats NZ. 2022. *Tourism Satellite Account: Year Ended March 2021*. Wellington: Stats NZ. Retrieved from www.mbie.govt.nz/assets/tourism-satellite-account-year-ended-march-2021.pdf.

⁵⁷ Stats NZ. 2022. *Tourism Satellite Account: Year Ended March 2021*. Wellington: Stats NZ. Retrieved from www.mbie.govt.nz/assets/tourism-satellite-account-year-ended-march-2021.pdf.

2.6.2 Imports

New Zealand's goods and services imports were valued at NZ\$90.32 billion in the year ending March 2022.⁵⁸ China was the country's largest source of imports, accounting for 19.0 per cent of the total, followed by the European Union (14.7 per cent) and Australia (14.0 per cent).

In the same year, the vehicles and mechanical machinery categories contributed the most to New Zealand's total imports, both at 10.9 per cent, followed by the electrical machinery and equipment category at 6.9 per cent.

2.7 Energy

Aotearoa New Zealand's total primary energy supply (TPES) was 872 petajoules in 2021.^{59, 46} This is calculated as domestic production plus imports, less exports and energy used for international transport. Renewable energy contributed 40.8 per cent of the 2021 TPES. The remainder of the TPES was dominated by oil (34.0 per cent) and gas (17.6 per cent).⁶⁰

Figure 2.6 provides an overview of primary energy inputs required for the energy system in New Zealand. From 1990, primary energy has increased steadily, and geothermal energy and fossil oil have been the main source of growth. Looking out to 2050, TPES has peaked at around 925 petajoules in 2019 and then declines slowly to 832 petajoules in 2050 on average at an annual rate of 0.3 per cent per year.⁶¹

The energy sector (including transport) is the second-largest contributor to New Zealand's gross greenhouse gas emissions, at 39.9 per cent in 2020.⁶² Since 1990, GDP has grown at a greater rate than the amount of energy used by consumers. As a result, the overall energy intensity of the economy has improved by 1.5 per cent on average per year between the years 1990 and 2019. In 2021, energy intensity decreased by 4.7 per cent compared with 2020.

New Zealand's total energy self-sufficiency was 72.4 per cent in 2021.⁶³ Energy self-sufficiency peaked in 2010 at 92.0 per cent due to historically high oil, gas and coal production. The country meets all of its gas and waste heat needs through indigenous production. For other energy types, it engages in trade through exporting and importing. This means that changes in New Zealand's energy self-sufficiency are driven by changes in the balance between imports and exports of tradeable commodities.

⁵⁸ Stats NZ. *New Zealand Trade Dashboard*. Retrieved from statisticsnz.shinyapps.io/trade_dashboard.

⁵⁹ 1 petajoule = 10¹⁵ joules.

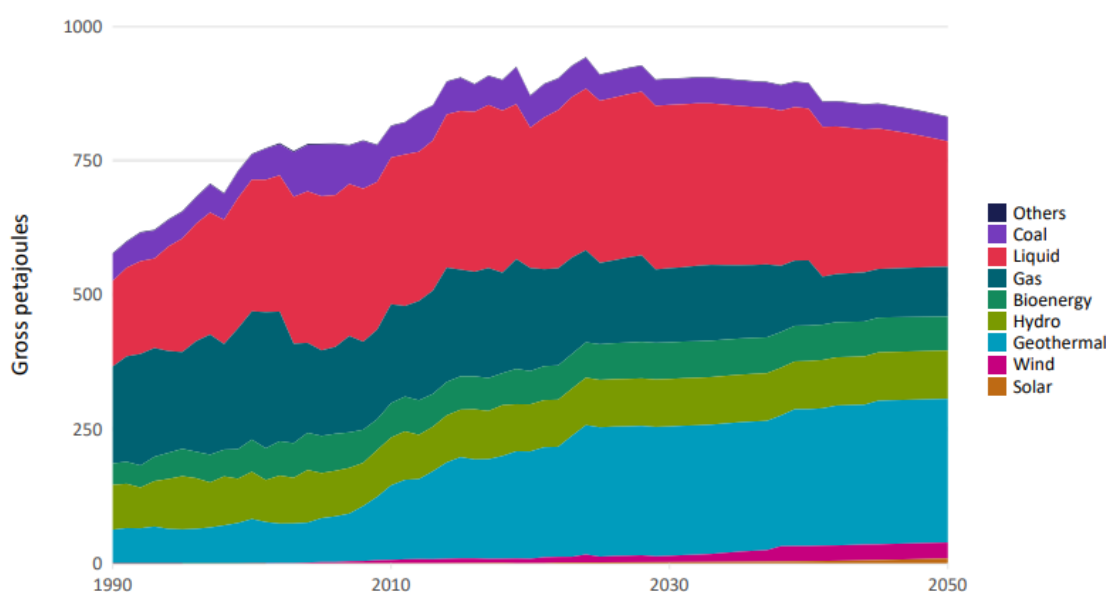
⁶⁰ Unless otherwise specified, all information in this section comes from: Ministry of Business, Innovation and Employment. *Energy in New Zealand 2022*. Wellington: MBIE. Retrieved from www.mbie.govt.nz/dmsdocument/23550-energy-in-new-zealand-2022-pdf.

⁶¹ Ministry of Business, Innovation and Employment. *Energy in New Zealand 2021*. Wellington: MBIE. Retrieved from www.mbie.govt.nz/assets/energy-in-new-zealand-2021.pdf

⁶² All greenhouse gas emissions data in this section are from: Ministry for the Environment. 2021. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

⁶³ Energy self-sufficiency, the ratio of indigenous energy production to total primary energy supply, is a measure of a country's ability to meet its own energy supply requirements.

Figure 2.6: New Zealand’s estimated and projected total primary energy supply by fuel, 1990–2050



Source: Ministry of Business, Innovation and Employment. 2021. *Energy in New Zealand 2021*. Wellington: MBIE.

2.7.1 Electricity

New Zealand has abundant renewable energy resources and a long history of renewable energy development. As a result, the majority of New Zealand’s electricity generation comes from renewable sources (82.1 per cent in 2021).⁶⁴ For the 2021 calendar year, hydro generation provided 55.5 per cent of New Zealand’s electricity. A further 18.4 per cent came from geothermal, 6.0 per cent from wind, 1.1 per cent from wood, 0.6 per cent from biogas and 0.5 per cent from solar. The remaining 17.9 per cent came from fossil fuel thermal generation plants using gas, coal and oil.

Electricity consumption decreased by 0.1 per cent between 2020 and 2021.⁶⁵ The industrial sector accounted for the largest share of consumption in 2021 at 36.1 per cent, followed by the residential sector at 33.4 per cent. In 2020 the public electricity and heat production category contributed 5.9 per cent of New Zealand’s gross greenhouse gas emissions, an increase of 32.3 per cent since 1990.⁶⁶ However, New Zealand’s electricity generation emissions per capita are low compared with many other countries because of the high share of renewable energy.

The proportion of electricity that is generated by hydro power each year changes depending on rainfall. In a dry year, low rainfall affects the majority of New Zealand’s hydro lake levels. During these years the shortfall is made up by non-renewable electricity generation. Figure 2.7 shows the close inverse relationship between non-renewable and hydro generation. This

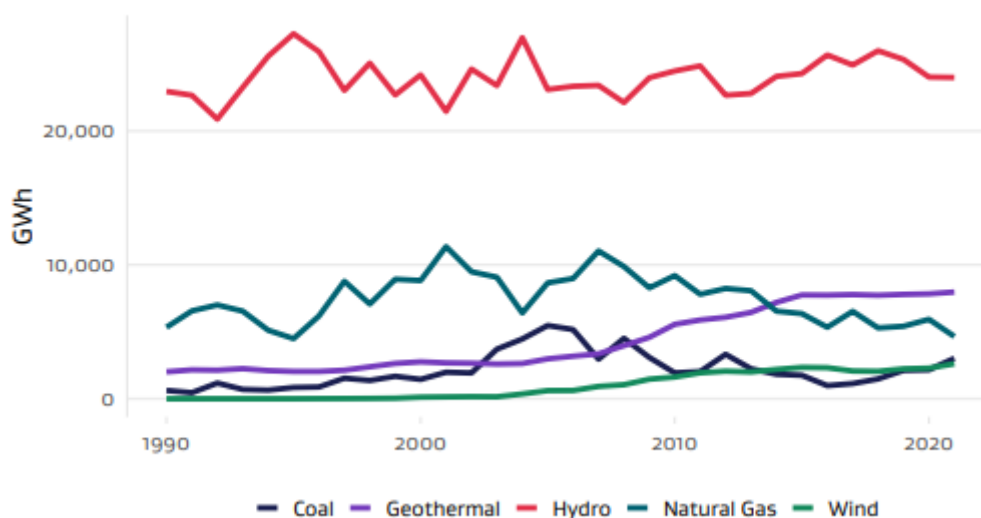
⁶⁴ Ministry of Business, Innovation and Employment. *New Zealand Energy Dashboard*. Retrieved from energydashboard.mbie.govt.nz.

⁶⁵ Ministry of Business, Innovation and Employment. *New Zealand Energy Dashboard*. Retrieved from energydashboard.mbie.govt.nz.

⁶⁶ Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

relationship has historically influenced the yearly fluctuations seen in the country's total energy and gross greenhouse gas emissions. The Government is currently investigating options to address the 'dry year problem'. The NZ Battery Project will provide comprehensive advice on the technical, environmental and commercial feasibility of pumped hydro and other potential energy storage projects.⁶⁷ Figure 2.7 also shows that the amount of electricity generated by renewable sources other than hydro power has more than tripled since 1990.

Figure 2.7: New Zealand's electricity generation by main source, 1990–2020



Source: Ministry of Business, Innovation and Employment. *Energy in New Zealand 2022*. Wellington: MBIE.

The electricity industry has gone through a long process of reform. Competition in the generation sector was introduced in 1996 with the establishment of a wholesale electricity market. Wholesale electricity is sold by generators and bought by retailers and large industrial users under rules that the Electricity Authority, an independent Crown entity, now administers.⁶⁸

The state-owned enterprise Transpower operates the national transmission grid, which conveys electricity from most of the major power stations around the country to local distribution lines. It also conveys electricity directly to major users, such as the New Zealand Aluminium Smelter. There are 27 local distribution network companies in New Zealand, which have a variety of ownership models. Electricity consumers can choose between competing retailers of electricity. There are currently five main generation companies.

2.7.2 Natural gas

Natural gas is produced in the Taranaki region and is transmitted by pipelines across the North Island to various distribution networks. In 2021 New Zealand produced 157.5 petajoules of gas. The majority of this (99.6 per cent) was from 10 gas fields. Of the country's total consumption in 2021 (68.7 petajoules), 76.6 per cent was used by the industrial sector. The remainder

⁶⁷ For more information on the NZ Battery Project, see www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/low-emissions-economy/nz-battery.

⁶⁸ For a detailed account, see: Ministry of Business, Innovation and Employment. 2015. *Chronology of New Zealand Electricity Reform*. Wellington: MBIE. Retrieved from www.mbie.govt.nz/info-services/sectors-industries/energy/electricity-market/electricity-industry/chronology-of-new-zealand-electricity-reform.

was consumed by the commercial and residential sectors, and the agriculture, forestry and fishing industries.⁶⁹ In 2020 combustion of natural gas contributed approximately 8 per cent of New Zealand's gross greenhouse gas emissions.⁷⁰

2.7.3 Oil

All crude oil extraction (crude, condensate, naphtha and natural gas liquids) occurs in the Taranaki region, with the Maari and Pohokura oil fields making up over half of domestic production. In 2020 New Zealand produced 39.0 petajoules of crude oil. Oil production peaked in 2008, with an annual production of 128.2 petajoules.⁷¹ The country's energy emissions are dominated by liquid fuels. These account for over half of all energy sector emissions and have been steadily increasing since 1990.

In 2020, COVID-19 reduced transport demand and caused changes in the mix of transport activity (most significantly lowering aviation use). This reduced the need for New Zealand to refine crude oil into oil products, leading to a 15 per cent fall in the import of crude oil and oil. The month of July 2020 saw no crude oil imports for the first time in 34 years.⁷² In 2021 Refining NZ, now Channel Infrastructure NZ, decided to cease oil refining activities at Marsden Point, which was New Zealand's only oil refinery. In April 2022 the refinery was shut down, switching to an import-only terminal.

2.7.4 Coal

New Zealand's coal resources are distributed widely on both main islands: in the Waikato and Taranaki regions of the North Island; and in the West Coast, Otago and Southland regions of the South Island. In 2021 there were 15 operating coal mines. The estimated in-ground resources for all coal types are over 15 billion tonnes. Approximately 80 per cent of this is lignite (low grade).⁷³ Bituminous and sub-bituminous in-ground resources are around 4 billion tonnes. Most of the country's bituminous coal production is exported, accounting for 95 per cent of total coal exports in 2021. In 2021 New Zealand exported 1.2 million tonnes (36.9 petajoules) of coal. In 2021 it produced 2.9 million tonnes of coal, an increase of 1.7 per cent on the previous year.

In 2021 New Zealand transformed and consumed 3.2 million tonnes of coal, an increase of 12 per cent from the previous year. The coal was mainly used for electricity generation (38 per cent) and industrial purposes (29 per cent).

⁶⁹ Ministry of Business, Innovation and Employment. *New Zealand Energy Dashboard*. Retrieved from energydashboard.mbie.govt.nz.

⁷⁰ Ministry of Business, Innovation and Employment. 2022. *New Zealand Energy Sector Greenhouse Gas Emissions*. Retrieved from www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/new-zealand-energy-sector-greenhouse-gas-emissions.

⁷¹ Ministry of Business, Innovation and Employment. 2021. *Data Tables for Oil*. Retrieved from www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/oil-statistics.

⁷² Ministry of Business, Innovation and Employment. *Energy in New Zealand 2021*. Wellington: MBIE. Retrieved from www.mbie.govt.nz/assets/energy-in-new-zealand-2021.pdf

⁷³ Ministry of Business, Innovation and Employment. *Energy in New Zealand 2021*. Wellington: MBIE. Retrieved from www.mbie.govt.nz/assets/energy-in-new-zealand-2021.pdf

Unfavourable hydrological conditions and a natural gas shortage caused an increase in coal use for electricity generation in 2021. This, and constraints on the capacity of domestic coal production to meet the energy demand at short notice, caused an increase in coal imports, which remained at the highest level since 2006. In 2021 electricity generated from coal made up 7.0 per cent of all electricity. This is the highest share of electricity generated from coal since 2012.

2.8 Transport

International aviation and shipping are critical due to Aotearoa New Zealand’s isolated location in the Pacific Ocean and the importance of primary industry exports and tourism to the economy. Domestically, road transport is the central element of the country’s transport system, reflecting the small but widely distributed population and long, narrow geography. Due to its sparse population and rural-based economy, New Zealand’s domestic transportation emissions per capita are high when compared with many other developed countries. New Zealand has one of the highest rates of car ownership globally, with 796 light vehicles per 1000 people in 2020.⁷⁴ As a result, transport is energy intensive and relies on fossil fuels. In 2020 transport contributed 16.7 per cent of gross domestic greenhouse gas emissions, an increase of 62.1 per cent from 1990.⁷⁵ The great majority (91.2 per cent) of these emissions are from road transport (table 2.1 and figure 2.8).

Table 2.1: Transportation emissions, 2020

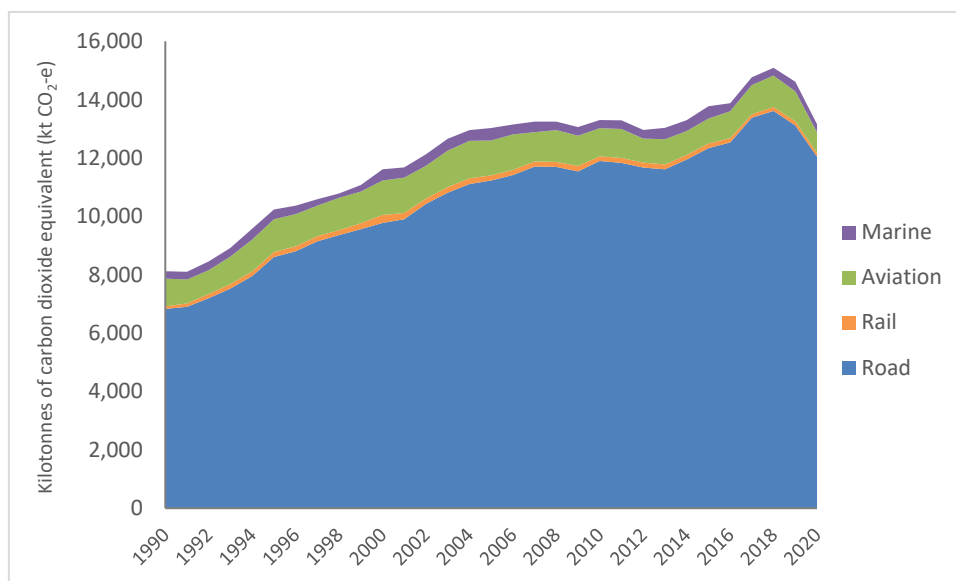
Category	Emissions (kilotonnes of carbon dioxide equivalent)	Percentage of total transport emissions	Percentage of total energy sector
Road transportation	12,023.2	91.2%	38.2%
Domestic aviation	709.8	5.4%	2.3%
Domestic navigation	274.5	2.1%	0.9%
Railways	126.2	1.0%	0.4%
Other transportation	42.8	0.3%	0.1%
Total	13,176.4	100.0%	41.9%

Note: Columns may not total due to rounding.

⁷⁴ Unless otherwise specified, all data in this section are from: Ministry of Transport. 2021. *New Zealand Vehicle Fleet Annual Statistics*. Retrieved from www.transport.govt.nz/statistics-and-insights/fleet-statistics/2020-annual-fleet-statistics.

⁷⁵ All greenhouse gas emissions data in this section are from: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

Figure 2.8: Domestic transport emissions by mode (kt CO₂-e), 1990–2020



Source: Ministry of Business, Innovation and Employment. *New Zealand Energy Sector Greenhouse Gas Emissions*. Retrieved from www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/new-zealand-energy-sector-greenhouse-gas-emissions.

2.8.1 Road transport

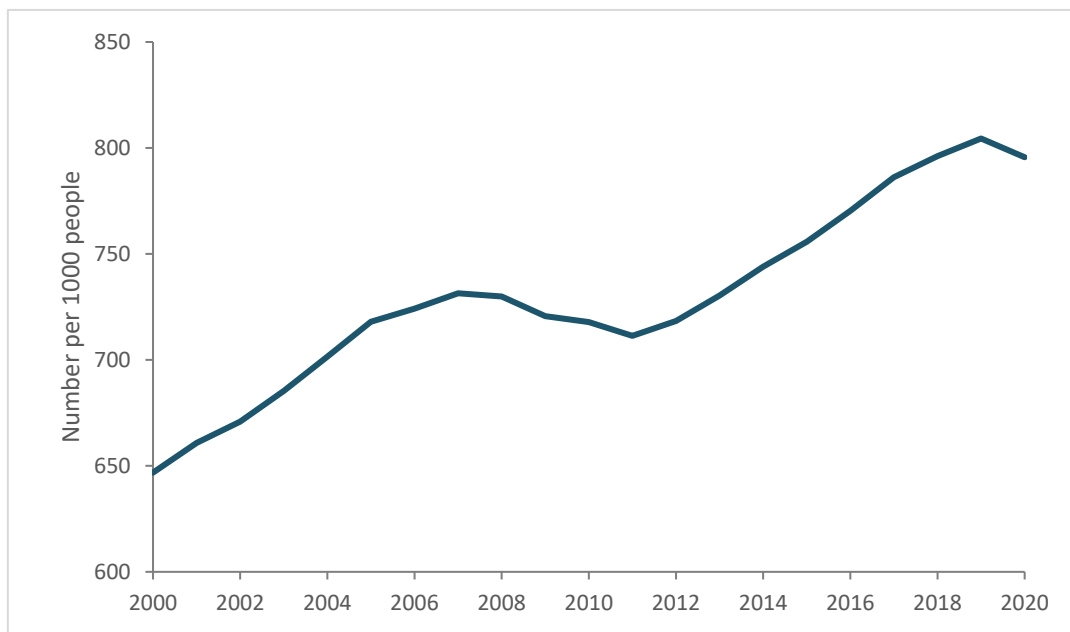
New Zealand has 94,000 kilometres of roads with over 4200 bridges on the state highway network. The majority of its vehicles (91.2 per cent in 2020) are light vehicles (those that have a gross vehicle mass of less than 3.5 tonnes). In 2020, 77 per cent of the light vehicle fleet was powered by petrol and 20 per cent by diesel, while about 2 per cent were petrol/electric hybrid and 0.5 per cent were fully electric vehicles.

The country has a relatively old vehicle fleet: in 2020 on average the age of the light vehicle fleet was 14.3 years and the age of the truck fleet was 18.0 years. New Zealand's light vehicle fleet is older compared with the fleets in other OECD countries that have similar high levels of motorisation and similar patterns of development, including the United States (11.8 years for light vehicles in 2019), Australia (10.4 years for all vehicles in 2019) and Canada (9.7 years for light vehicles in 2017).

In 2020 there were approximately 4.0 million light vehicles in New Zealand, which is the equivalent of 797 light vehicles for every 1000 people. This number increased between the years 2000 and 2007 due to the entry of a large number of used vehicles from Japan. The number of light vehicles per person decreased after the 2007 peak until 2011 due to the global financial crisis, but the number has been increasing significantly since 2011. However, 2020 had a slight decrease in ownership, likely to be influenced by the COVID-19 pandemic (figure 2.9).

Heavy vehicles represent only 3 per cent of New Zealand's vehicle fleet, but deliver 93 per cent of freight volume and contribute around 25 per cent of total transport emissions. The emissions reduction plan sets targets for reducing freight sector emissions by 2035 and puts the sector on a path to meeting New Zealand's net zero target by 2050. The Government has pledged that zero-emissions heavy vehicles entering the new vehicle fleet will make up 30 per cent of sales by 2030 and 100 per cent by 2040.

Figure 2.9: Light vehicle fleet per 1000 people in New Zealand, 2000–20



Source: Ministry of Transport. 2021. *New Zealand Vehicle Fleet Annual Statistics*. Wellington: Ministry of Transport.

2.8.2 Aviation

Domestic and international aviation has been increasing, in part due to a reduction in the real cost of airfares. Before the COVID-19 pandemic and associated border restrictions, international flights had been increasing at a rate of 5 per cent per year since 1990. At the same time, the fuel efficiency of air travel has increased due to higher load factors, advances in aircraft design and improvements in air traffic management for aircraft approaches to airports.

Almost all passenger travel to and from New Zealand is by air. There were 6,809,964 air passenger arrivals into the country in the year ended March 2020, an increase of 50 per cent in 10 years (since the year ended March 2010).⁷⁶ Due to COVID-19 border restrictions in New Zealand, where borders were closed to international travellers, international travel has decreased. In the year ending March 2022 there were 459,682 arrivals, up from the low of 127,559 in the year ending March 2021.⁷⁷

Aviation is also important for the export and import of time-sensitive goods and high-value goods. Freight exports by air made up 14 per cent of exports by value in the year ending June 2022; however, they contributed only 0.25 per cent by tonne.⁷⁸ Freight imports by air made up 23 per cent of imports by value and 0.4 per cent by tonne.⁷⁹

⁷⁶ Stats NZ. 2022. *Table Reference: ITM051AA*. Retrieved from www.stats.govt.nz/infoshare.

⁷⁷ Stats NZ. 2022. *International Travel: March 2022*. Retrieved from www.stats.govt.nz/information-releases/international-travel-march-2022.

⁷⁸ Stats NZ. 2022. *Table Reference: OSC004AA*. Retrieved from www.stats.govt.nz/infoshare.

⁷⁹ Stats NZ. 2022. *Table Reference: OSC008AA*. Retrieved from www.stats.govt.nz/infoshare.

2.8.3 Maritime

New Zealand relies on domestic shipping for transporting some freight within the country, including across the Cook Strait between the North and South Islands. Coastal shipping transports 1.6 per cent of domestic freight volumes. The domestic coastal shipping fleet consists of about 13 vessels, of which only one is a container ship. Cargo moved by coastal shipping includes bulk commodities like cement, grain, fertiliser and aggregate. Containerised cargo includes domestic goods, and export and import transshipments, as well as empty containers. Two competing companies operate daily ferry services across the Cook Strait using a total of five vessels. These ferries transport passengers and freight, with a journey time of around three hours. A small number of passenger ferries operate in coastal cities (mainly Auckland and Wellington), which provide commuter and recreational services.

International shipping is crucial to New Zealand's trading. Sea freight carries 99.7 per cent of the country's trade by volume and around 86 per cent by value. New Zealand is serviced by international container shipping lines and other bulk ships. In the year to June 2022, it exported 39.9 million tonnes (with a real value of NZ\$61.2 billion) by sea.⁸⁰ In the same year, imports by sea totalled 24.8 million tonnes, worth NZ\$61.8 billion.⁸¹ International shipping is responsible for about 3 per cent of the world's carbon emissions and this is expected to grow.⁸²

New Zealand has 15 ports of varying sizes and stages of development, through which most of its imports and exports flow. Nine of them are international container ports. The majority of imports arrive through the ports of Auckland and Tauranga, and are bound for main centres in the upper North Island, while the Port of Tauranga is the largest export port. Exports are more evenly spread across the North and South Islands. The biggest container ports are Tauranga (39 per cent of container volumes), Auckland (22 per cent) and Lyttelton (14 per cent). In 2020, containerised exports made up 29 per cent of New Zealand's sea export tonnage but 83 per cent of the value. In 2019 coastal shipping contributed 2.1 per cent of New Zealand's total transport emissions.⁸³

New Zealand's Climate Change Commission has been tasked to provide advice to the Government on the inclusion of international aviation and maritime emissions within our emissions budgets. This advice is due in 2024.

2.8.4 Rail

The national rail network totals approximately 3700 kilometres, which includes more than 1300 bridges and almost 100 tunnels.⁸⁴ The Government, through the state-owned enterprise KiwiRail, owns and controls the rail infrastructure and the majority of the rolling stock. There are urban rail networks in both Wellington and Auckland, which together provide approximately 35.7 million passenger trips annually: approximately 14.3 million trips in

⁸⁰ Stats NZ. 2022. *Table Reference: OSC004AA*. Retrieved from www.stats.govt.nz/infoshare.

⁸¹ Stats NZ. 2022. *Table Reference: OSC008AA*. Retrieved from www.stats.govt.nz/infoshare.

⁸² International Transport Forum. 2018. *Decarbonising Maritime Transport: Pathways to Zero-carbon Shipping by 2035*. Paris: OECD Publishing. Retrieved from www.itf-oecd.org/sites/default/files/docs/decarbonising-maritime-transport.pdf.

⁸³ Ministry for the Environment. 2021. *New Zealand's Greenhouse Gas Inventory 1990–2019*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2019.

⁸⁴ Ministry of Transport. 2021. *The New Zealand Rail Plan*. Wellington: Ministry of Transport. Retrieved from www.transport.govt.nz/assets/Uploads/Report/The-New-Zealand-Rail-Plan.pdf.

Wellington and 21.4 million trips in Auckland.⁸⁵ Within the country, 5.6 per cent of freight volumes are transported by rail. Rail carried 18.4 million tonnes of domestic freight in 2020.⁸⁶ In 2019 rail contributed 0.9 per cent of New Zealand's total transport emissions.⁸⁷ The inaugural Rail Network Investment Programme, arising from the New Zealand Rail Plan, targets an increase in rail mode share from 12 per cent of total freight task in 2020 to 14 per cent by 2030.

2.9 Agriculture

Agriculture in Aotearoa New Zealand is dominated by pastoral farming of dairy cattle, beef cattle, sheep and deer. As at June 2021 the country had 6.2 million dairy cattle, 4.0 million beef cattle, 25.7 million sheep and 0.8 million deer.⁸⁸ The country also produces a number of different horticultural products, including kiwifruit, pip fruit, wine, and fresh and processed vegetables.

Because of the temperate climate, the majority of animals are fed on grass outside all year round and are rarely housed inside. Pastures have four primary sources of nitrogen: nitrogen fixed by legumes, nitrogen fertiliser, nitrogen from external supplementary feeds and nitrogen from atmospheric sources. The use of synthetic nitrogen-containing fertiliser on agricultural soils increased by 693 per cent between 1990 and 2020.⁸⁹

The impacts of climate change are already being felt across New Zealand's agriculture sector. Across all regions, the incidence and severity of drought (including in regions that have not previously experienced drought) and flooding and extreme weather events have increased.⁹⁰ Increased rainfall events are projected across the country and increased drought severity is projected to increase in almost all regions. Droughts can result in reduced pasture production, lower livestock performance and the need to reduce livestock numbers, which in turn leads to lower greenhouse gas emissions.

⁸⁵ Ministry of Transport. *Boardings: All Modes*. Retrieved from www.transport.govt.nz/statistics-and-insights/public-transport/sheet/boardings-all-modes.

⁸⁶ Ministry of Transport. *Freight and logistics: FIGS: Rail*. Retrieved from <https://www.transport.govt.nz/statistics-and-insights/freight-and-logistics/sheet/figs-rail>.

⁸⁷ Ministry for the Environment. 2021. *New Zealand's Greenhouse Gas Inventory 1990–2019*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2019.

⁸⁸ Stats NZ. 2022. *Agricultural Production Statistics – June 2021*. Retrieved from www.stats.govt.nz/information-releases/agricultural-production-statistics-year-to-june-2021-final.

⁸⁹ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

⁹⁰ Ministry for the Environment. 2022. *Te Hau Mārohi ki Anamata – Aotearoa New Zealand's First Emissions Reduction Plan*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/assets/publications/Aotearoa-New-Zealands-first-emissions-reduction-plan.pdf.

2.9.1 Agricultural exports

Agricultural exports accounted for over half of the total value of New Zealand's goods exported in the year to 30 June 2022. The highest-earning export sectors were dairy (NZ\$22.0 billion), meat and wool (NZ\$12.3 billion) and horticulture (NZ\$6.8 billion).⁹¹ The top five export destinations for the year to 30 June 2022 by value for dairy products, in order, were China, Australia, Indonesia, United States and Japan.⁹²

Over 2021/22, demand for dairy products was strong, driven by increased demand for dairy imports from China and other Asian countries, as well as reduced supply from key dairy exporting regions. Strong export revenue in 2021/22 was achieved despite ongoing headwinds, especially from rising farm input costs, labour shortages, disruptions related to COVID-19 and high freight costs. Over the medium term, a decline in global prices and flattening milk production are expected to result in a slight decline in export revenue. For 2022/23 export revenue is estimated to decrease by 2 per cent compared with the previous year.⁹³

2.9.2 Changes in the agricultural industry

Triggered by the removal of agricultural subsidies in 1984, New Zealand's agricultural sector transformed to become highly competitive and efficient.⁹⁴ It is now the least subsidised agriculture sector in the OECD.⁹⁵ Agricultural productivity has increased due to advances in technology, farm management and animal breeding, the expansion of the average size of farms and improved animal health, animal fertility and plant nutrition.⁹⁶

The proportions of the main livestock species farmed in New Zealand have also changed. From the early 1990s to the present, sheep numbers have declined steadily (figure 2.10) due to low sheep meat and wool prices, while sheep farms have converted to dairying, viticulture, cropping and forestry. The dairy cattle herd grew significantly between 1990 and 2014 but has stayed relatively stable since then (figure 2.12). The growth was due to the increasing profitability of dairy products compared with sheep and beef products over that period.

⁹¹ Stats NZ. *Overseas Merchandise Trade Datasets*. Retrieved from www.stats.govt.nz/large-datasets/csv-files-for-download/overseas-merchandise-trade-datasets. Analysis used MPI's Situation and Outlook for Primary Industries (SOPI) categorisation of sectors.

⁹² Stats NZ. *Overseas Merchandise Trade Datasets*. Retrieved from www.stats.govt.nz/large-datasets/csv-files-for-download/overseas-merchandise-trade-datasets. Analysis used MPI's SOPI categorisation of sectors.

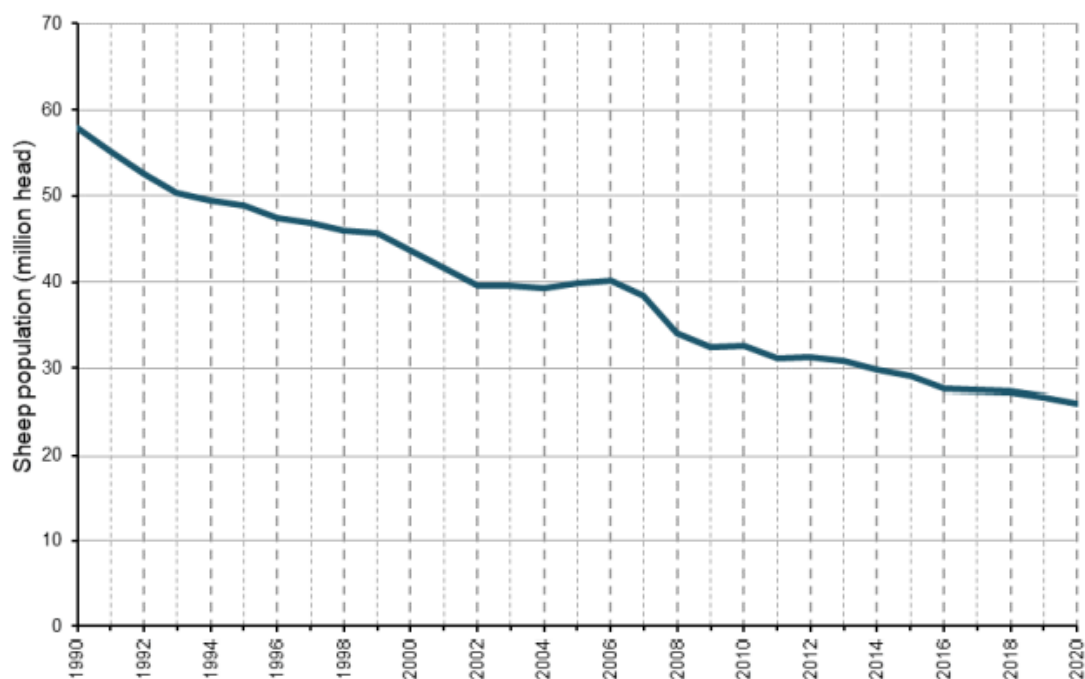
⁹³ Ministry for Primary Industries. 2022. *Situation and Outlook for Primary Industries*. Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/dmsdocument/51754-Situation-and-Outlook-for-Primary-Industries-SOPI-June-2022.

⁹⁴ Lattimore R. 2006. *Farming Subsidy Reform Dividends* (No. 45). New Zealand Trade Consortium Working Paper.

⁹⁵ OECD. 2022. *Agricultural Support* (indicator). Retrieved from data.oecd.org/agrpolicy/agricultural-support.htm.

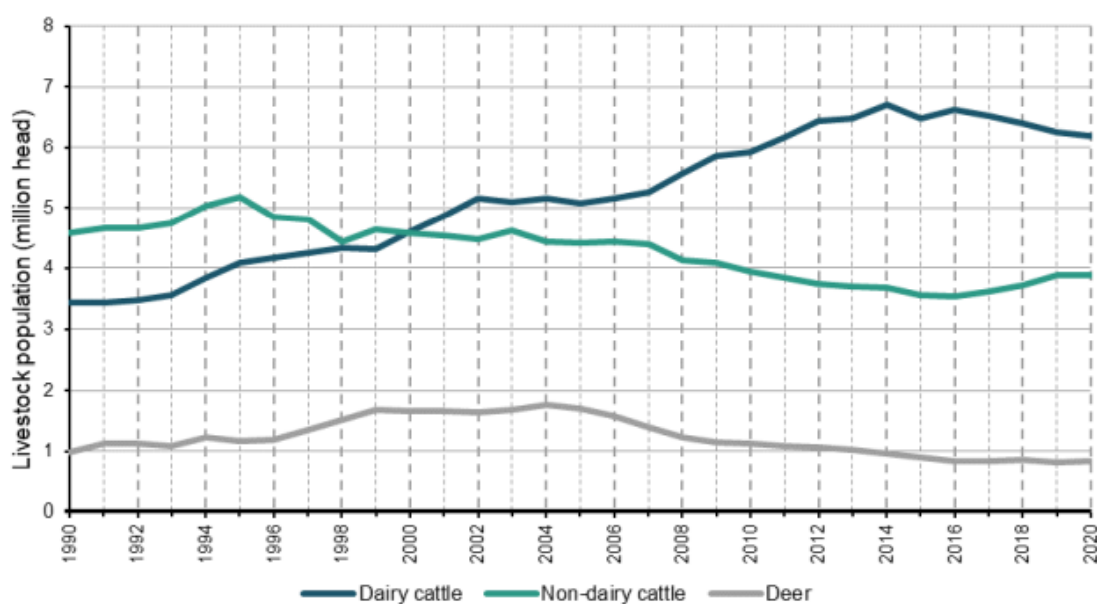
⁹⁶ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

Figure 2.10: Changes in New Zealand’s sheep population, 1990–2020 (year to 30 June)



Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

Figure 2.11: Changes in New Zealand’s dairy, beef and deer populations, 1990–2020 (year to 30 June)



Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

In 2019, He Waka Eke Noa – the Primary Sector Climate Action Partnership between the Government, the primary sector and Māori was established. Its goal is to equip farmers and growers to measure, manage and reduce on-farm agricultural greenhouse gas emissions and adapt to climate change. This is to enable sustainable food and fibre production for future generations. The partnership’s work includes developing an effective system for pricing agricultural emissions from 2025, as an alternative to bringing agriculture into the New Zealand Emissions Trading Scheme.

2.9.3 Emissions

High levels of agricultural activity mean half of New Zealand's gross greenhouse gas emissions come from agriculture, compared with an average of 13 per cent in other developed countries.⁹⁷ Most of those emissions (73.1 per cent of agriculture emissions in 2020) come from methane from enteric fermentation.

Livestock numbers are a significant determinant of New Zealand's gross primary sector emissions. Greenhouse gas emissions from the agriculture sector increased by 16.0 per cent between 1990 and 2006. The increase was mainly due to an 80 per cent increase in the national dairy herd population within that period and an increase in the application of synthetic nitrogen fertiliser by 693 per cent.⁹⁸ These increases in emissions have been partially offset by decreases in the populations of sheep (by 55 per cent), beef cattle (by 15 per cent) and deer (by 15 per cent) since 1990. Since 2006, emissions from the primary sector have been relatively stable, with some variations from year to year based on product prices and seasonal climate events, for example drought.

In 2020 emissions from the agriculture sector decreased very slightly (by 0.2 per cent) from 2019 because of a decline in production. This decrease was mainly due to a reduction in the sheep population, as well as decreases in the use of lime and urea fertiliser. Emissions from other sources rose, such as inorganic fertiliser, and beef and dairy cattle, but these increases were not enough to offset the overall decrease in agricultural emissions between 2019 and 2020.

2.10 Fisheries

Approximately 410,000 tonnes of seafood (excluding aquaculture) is harvested from Aotearoa New Zealand waters each year. The seafood industry employs over 16,000 people.⁹⁹ Seafood exports earned \$1.73 billion in the year ending March 2022.¹⁰⁰

New Zealand's marine fisheries waters (EEZ and territorial sea) measures 4.4 million square kilometres and is the world's fourth-largest EEZ. Fish stocks are managed through a Quota Management System that controls harvest levels for each fish species and area. Each year, the Ministry for Primary Industries reviews the Total Allowable Catch for fish stocks and sets limits.

⁹⁷ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990 – 2020 snapshot*. Retrieved from: environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020-snapshot.

⁹⁸ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

⁹⁹ Seafood New Zealand. *Key Facts*. Retrieved from www.seafoodnewzealand.org/industry/key-facts.

¹⁰⁰ Stats NZ. *New Zealand Trade Dashboard*. Retrieved from statisticsnz.shinyapps.io/trade_dashboard.

Climate and oceanographic conditions play an important role in driving the productivity of the oceans and the abundance and distribution of New Zealand's fish stocks and fisheries. The ocean surrounding the country plays a major role in moderating the climate on land, and evidence indicates that the chemistry of seawater is changing (eg, ocean acidification) in line with other parts of the globe.¹⁰¹ Long-term measurements off the Otago coast show an increase of 8.6 per cent in ocean acidity between January 1998 and December 2020.¹⁰² Marine heatwaves are also becoming more persistent throughout New Zealand,¹⁰³ with major impacts on fisheries and associated habitats.

2.11 Forestry

Aotearoa New Zealand has one of the highest rates of exotic forest growth among developed countries, due to favourable climate and fertile soils combined with intensive forest management. Forestry is economically important to the country as it is the third-biggest export earner at 6.8 per cent of total exports.¹⁰⁴ An estimated 37,800 people work in the forestry and wood processing sector.¹⁰⁵

New Zealand has 10.0 million hectares of forest, covering approximately 37 per cent of land.¹⁰⁶ Of this, 7.8 million hectares are natural (indigenous) forest. Two-thirds of this natural forest is protected within public conservation land. The two main types of natural forest are beech and podocarp/broadleaf forest. In addition, shrublands (mainly mānuka and kānuka) and retired grasslands are classified as forests when they meet New Zealand's forest definition.¹⁰⁷

¹⁰¹ For more information, see the chapter on ocean and climate conditions in: Ministry for Primary Industries. 2021. *Aquatic Environment and Biodiversity Annual Review 2021*. Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/science/fisheries-research-and-science/about-our-fisheries-research/aquatic-environment-and-biodiversity-annual-review-aebar; and Ministry for the Environment and Stats NZ. 2019. *Our Marine Environment*. Wellington: Ministry for the Environment and Stats NZ. Retrieved from environment.govt.nz/publications/our-marine-environment-2019.

¹⁰² Stats NZ. 2022. *Ocean Acidification*. Retrieved from www.stats.govt.nz/indicators/ocean-acidification.

¹⁰³ Salinger MJ, Diamond HJ, Behrens E et al. 2020. Unparalleled coupled ocean–atmosphere summer heatwaves in the New Zealand region: drivers, mechanisms and impacts. *Climatic Change* 162: 485–506. DOI: 10.1007/s10584-020-02730-5.

¹⁰⁴ Stats NZ. *New Zealand Trade Dashboard*. Retrieved from statisticsnz.shinyapps.io/trade_dashboard. The percentage represents year ended March 2022 data.

¹⁰⁵ NZIER. 2021. *Forestry and Wood Processing Labour Force Survey*. Report prepared for Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/dmsdocument/48667-2021-Forestry-and-wood-processing-labour-force-survey.

¹⁰⁶ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

¹⁰⁷ Under the UNFCCC, the figures collected for planted and natural forest area equate to the area of 'forest land'. 'Forest land' is defined as: an area of at least 1 hectare and 30 metres in width that is expected to have at least 30 per cent canopy cover and the potential to exceed 5 metres in height.

Planted production forests account for 1.66 million hectares of land in New Zealand as of 1 April 2020.¹⁰⁸ New Zealand's forestry industry is largely based around plantation forests. Approximately 90 per cent of plantation forests is radiata pine (*Pinus radiata*), followed by Douglas fir (*Pseudotsuga menziesii*) at 6 per cent.¹⁰⁹ There are smaller amounts of eucalyptus, and other softwood and hardwood species.

New Zealand's forests are currently a net carbon sink. The land use, land-use change and forestry sector offset 30 per cent of New Zealand's gross emissions in 2020. In 2020 approximately 41,111 hectares of new forest were planted and 2506 hectares were deforested.¹¹⁰

Net emissions from the land use, land-use change and forestry sector have decreased by 9.8 per cent since 1990.¹¹¹ The main reason for the decrease is that the production of harvested wood products has increased.¹¹² Yearly fluctuations in emissions and removals from forestry are mainly driven by harvesting and deforestation in production forests, and historically variable rates of new forest plantings. Historical planting peaks and the resulting harvest and replanting cycles will affect New Zealand's plantation forestry emissions and removals profile well into the future.

Forest planting rates were particularly high in the 1980s and 1990s (figure 2.12). This followed on from a change in the taxation regime, an unprecedented price spike for forest products and subsequent favourable publicity, a Government focus on forestry as an instrument for regional development, and the conclusion of the state forest assets sale. The removal of agricultural subsidies and generally poor performance of the New Zealand and international share markets also encouraged investors to seek alternative sectors for investment.¹¹³ After the late 1990s the rate of planting declined. The increase in planting between 2008 and 2012 is largely due to the first Afforestation Grant Scheme and market-based measures for forest carbon (the NZ ETS and the Permanent Forest Sink Initiative), which were introduced by the New Zealand Government to encourage the planting of new forests and the regeneration of natural forests.

¹⁰⁸ Ministry for Primary Industries. *New Zealand Forest Data*. Retrieved from www.mpi.govt.nz/forestry/forest-industry-and-workforce/forestry-wood-processing-data/new-zealand-forest-data.

¹⁰⁹ Ministry for Primary Industries. *About New Zealand's forests*. Retrieved from www.mpi.govt.nz/forestry/new-zealand-forests-forest-industry/about-new-zealands-forests.

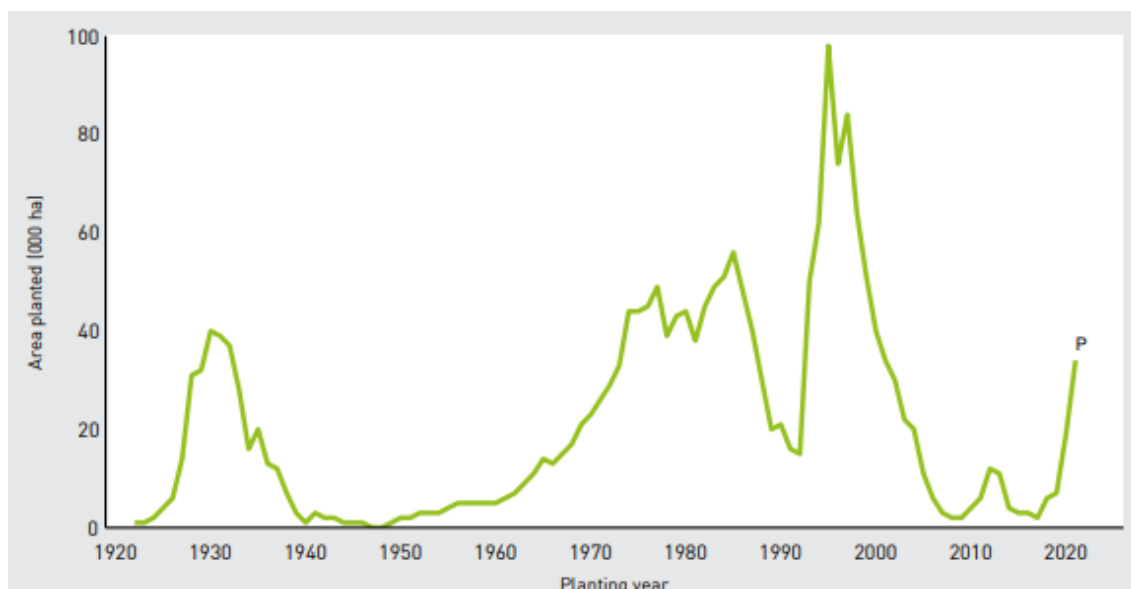
¹¹⁰ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

¹¹¹ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

¹¹² Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

¹¹³ Rhodes D, Novis J. 2002. *The Impact of Incentives on the Development of Plantation Forest Resources in New Zealand*. MAF Information Paper No. 45. Wellington: MAF Policy Division.

Figure 2.12: New Zealand’s historical new production forest planting, 1920–2020



Note: ha = hectares.

Source: Ministry for Primary Industries. *National Exotic Forest Description*, page 19, as at 1 April 2021. Wellington: Ministry for Primary Industries.

Between 2013 and 2018 new forest planting rates dropped back to pre-2008 levels.¹¹⁴ This is likely due in part to a significant drop in the price of carbon in the NZ ETS and the increase in profitability of other non-forest land uses. In 2019 and 2020, afforestation and reforestation activities significantly increased again, with 27,070 hectares of new planting occurring in 2019 and 40,887 hectares in 2020. This increase is likely due to planting of seedlings funded by the One Billion Trees programme and the higher carbon prices in the NZ ETS that resulted from the announcements leading up to the Climate Change Response (Emissions Trading Reform) Amendment Bill and its passing in June 2020.

2.12 Waste

Aotearoa New Zealand generates an estimated 17.5 million tonnes of waste per year, of which an estimated 12.6 million tonnes are sent to landfill.¹¹⁵

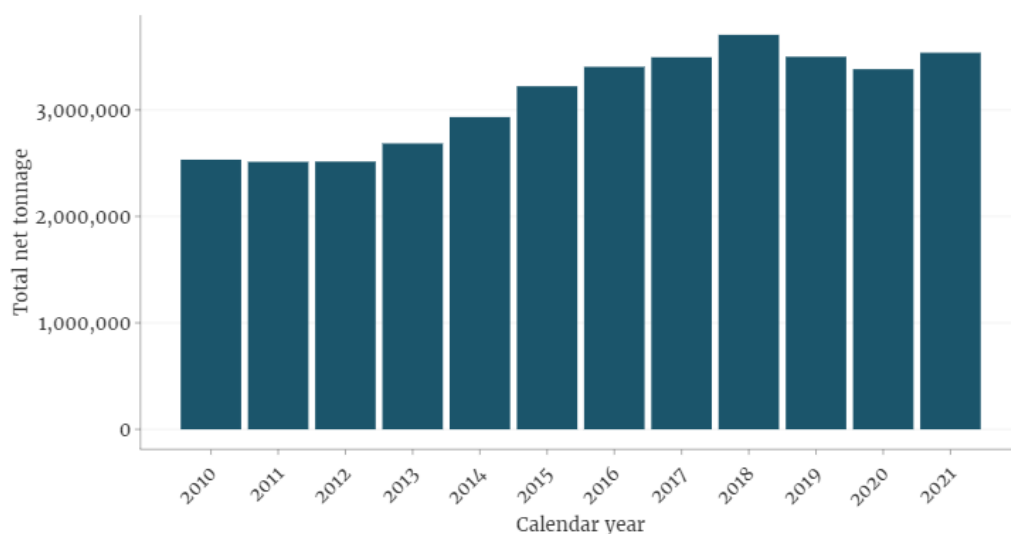
Waste sent to Class 1 landfills (landfills that accept household waste) increased by 47 per cent from 2.5 million tonnes in 2010 to 3.7 million tonnes in 2018.¹¹⁶ While waste to Class 1 landfills decreased slightly in 2019 and 2020, with the decrease in 2020 likely largely due to COVID-19, longer-term trends suggest the rate of waste disposal is increasing for many sites around the country (figure 2.13). In 2021 there were 3.5 million tonnes of waste sent to landfill.

¹¹⁴ Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

¹¹⁵ This estimate includes waste disposed of to Classes 1, 2, 3 and 4 landfills, clean fills, and farm dumps. It also includes the materials recycled here in New Zealand and those sent offshore for recycling.

¹¹⁶ Ministry for the Environment. 2021. *Estimates of waste generated in Aotearoa New Zealand*. Retrieved from environment.govt.nz/facts-and-science/waste/estimates-of-waste-generated.

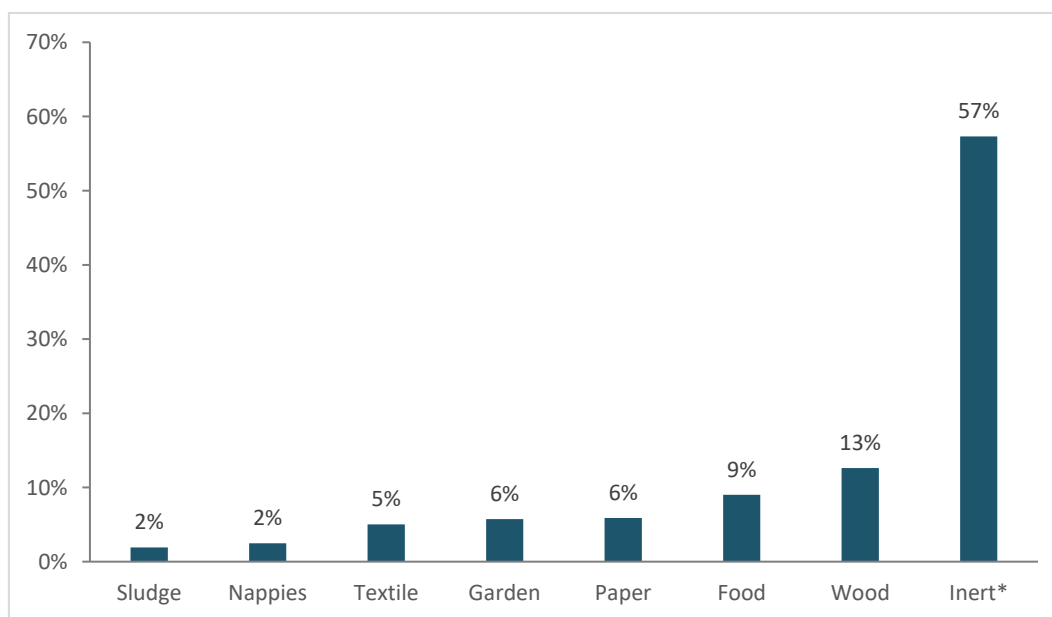
Figure 2.13: Total tonnage of waste to Class 1 landfills, 2010–21



Source: Ministry for the Environment. *Estimates of Waste generated in Aotearoa New Zealand*. Retrieved from www.environment.govt.nz/facts-and-science/waste/estimates-of-waste-generated.

Solid waste in New Zealand either is disposed of at landfills or is recycled. No incineration of municipal waste occurs, and incineration is only used on a very small scale for hazardous and clinical waste. The majority of the solid waste disposed of at municipal landfill consists of inert waste (57 per cent) and wood waste (13 per cent) (figure 2.14).

Figure 2.14: Estimate of New Zealand’s waste composition, 2018–20



Note: * Waste that neither produces greenhouse gases nor decomposes.

Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Estimates based on survey conducted in 2012.

The Waste Minimisation Act 2008 introduced a levy on all waste disposed of in municipal landfills. The funding from this levy helps local government, communities and businesses to reduce waste. The Act also provides for requirements for reporting, clarification of the roles and responsibilities of territorial authorities, and accreditation for product stewardship schemes.

Wastewater from almost every town in New Zealand with a population over 1000 is collected and treated in community wastewater treatment plants. The country has approximately 318 wastewater treatment plants.¹¹⁷ Most of the treatment processes are aerobic, but a significant number of plants use partially anaerobic processes such as oxidation ponds or septic tanks. Small communities and rural dwellings are generally served by simple septic tanks followed by ground soakage trenches.¹¹⁸

In 2020 the waste sector contributed 4.1 per cent of New Zealand's gross greenhouse gas emissions. Between 1990 and 2020, emissions from the waste sector declined by 17.1 per cent. This was the only gross emissions sector to have a decrease in emissions between 1990 and 2020.

Annual emissions increased between 1990 and 2002 because of the ongoing growth in population and economic activity. However, since 2005 annual emissions have steadily declined. This is mainly due to ongoing improvements in managing solid waste disposal at municipal landfills, particularly in landfill gas recovery. This decline is despite ongoing population growth and the resulting increases in the amount of municipal waste generated. Emissions in the waste sector were from solid waste disposal (80.7 per cent), wastewater (11.5 per cent), incineration (5.7 per cent) and composting (2.1 per cent).

2.13 Tokelau

This *National Communication* includes reporting on Tokelau's response to the challenges of climate change. Tokelau has been a dependent territory of Aotearoa New Zealand since 1926, and is considered "part of New Zealand" for certain purposes under the Tokelau Act 1948 (NZ). The extension of New Zealand's ratification of the UNFCCC and the Paris Agreement to Tokelau was announced on 13 November 2017. The Government will continue to work with Tokelau to meet reporting obligations under the UNFCCC and the Paris Agreement. Tokelau has produced a climate change strategy, which this report sets out in annex E. The Government is working closely with Tokelau's national legislative and executive body to help achieve its vision for the future under the strategy.

2.13.1 National circumstances

In formal terms, Tokelau is administered by New Zealand, but in practice it is substantially self-governing, with strong links to New Zealand. Tokelau's national legislative and executive body, the General Fono, governs Tokelau's national matters. An Administrator, appointed by the New Zealand Government, is charged with the administration of the executive government of Tokelau and Tokelau's EEZ. The New Zealand Government is responsible for Tokelau's international relations. Nevertheless, Tokelau engages autonomously on climate change and Pacific fisheries matters where possible. New Zealand statute law does not apply to Tokelau unless it is expressly extended to Tokelau and agreed to by Tokelau.

¹¹⁷ GHG. 2020. *The New Zealand Wastewater Sector*, page 26. Report prepared for the Ministry for the Environment. Retrieved from environment.govt.nz/assets/Publications/Files/wastewater-sector-report.pdf.

¹¹⁸ GHG. 2020. *The New Zealand Wastewater Sector*. Report prepared for the Ministry for the Environment. Retrieved from environment.govt.nz/assets/Publications/Files/wastewater-sector-report.pdf.

Tokelau's population is spread over three small coral atolls (Atafu, Fakaofu and Nukunonu), which lie some 500 kilometres to the north of Samoa. The population of Tokelau is 1647 (2019), of whom 55.9 per cent are aged under 30 years. Tokelau has a common language and the three atolls share similar social structures, but each atoll has unique historical influences. Tokelauans are New Zealand citizens. In addition to the citizens living in Tokelau, approximately 8600 Tokelauans live in New Zealand.

Tokelau's two principal sources of revenue are economic assistance from New Zealand and fisheries revenue (the latter amounting to NZ\$61.4 million from 2018/19–2020/21). New Zealand provides general budget support (\$12.5 million per annum) to assist the delivery of essential services, consistent with its constitutional and United Nations Charter obligations.

General budget support is complemented by support for wellbeing and human development outcomes through investments in health, education, language revitalisation and justice reform as well as major investments in information and communications technology connectivity and planning for projects to enhance Tokelau's climate change resilience. New Zealand's total development assistance to Tokelau for the period 2019/20–2021/22 was NZ\$81.3million.

Tokelau's low-lying atolls are extremely vulnerable to the impacts of climate change and related hazards. The principal hazard induced by climate change that Tokelau faces is inundation of coastal waters during severe weather events. Storms have become more frequent and severe over time, and sea-level rise presents an additional risk to Tokelau's low-lying atolls. New Zealand also supports a range of climate-related projects in Tokelau. During the reporting period, this support related to climate change has included:

- funding for a Coastal Risk Mitigation Activity to build Tokelau's resilience to the impacts of climate change (NZ\$1 million). Through this activity, suppliers have worked with Tokelau to prepare a coastal hazard study and implementation plan, and to produce detailed designs for the repair of critical infrastructure and the construction of emergency shelters
- approval of funding (NZ\$4.1 million) to upgrade the main bridge in Nukunonu so that it is resilient to the impacts of coastal inundation
- funding for an activity to better understand climate mobility issues facing Pacific Island countries
- supporting Tokelau (through the Climate and Oceans Support Program in the Pacific) to make better use of climate and meteorological data in decision-making to increase resilience
- funding the development of a Water Scarcity Investment Plan with the Pacific Community (SPC)
- funding (through the Water Scarcity Investment Plan) the delivery and connection of 30 new water tanks and plumbing supplies, noting that 18 further tanks are awaiting a separate delivery of concrete.

2.13.2 Tokelau's climate change strategy

Living with Change: An Integrated National Strategy for Enhancing the Resilience of Tokelau to Climate Change and Related Hazards, 2017–30 (LivC)¹¹⁹ and its companion the *LivC Implementation Plan, 2017–22*¹²⁰ are Tokelau's response to the challenges posed by climate

¹¹⁹ Retrieved from www.tokelau.org.nz/site/tokelau/files/ClimateChange/LivCStrategy_web-2.pdf.

¹²⁰ Retrieved from www.tokelau.org.nz/site/tokelau/files/ClimateChange/LivCImplementPlan_web-2.pdf.

change and related hazards officially launched in April 2017. The strategy conveys Tokelau’s vision of the future, the issues that must be addressed, the specific outcomes Tokelau aims to achieve, and the actions that must be taken to manage the impacts of climate change. As the administering power for Tokelau, New Zealand is responsible for assisting Tokelau’s Government to meet the needs of the people of Tokelau. The New Zealand Government is working closely with Tokelau to help it achieve its LivC vision where possible.

The strategy identifies three inter-related climate-resilient pathways:

- mitigation – decarbonisation development
- adaptation – strengthened risk reduction and adaptation to enhance resilience in the face of climate change and disasters
- human development – capacity building, education, training, public awareness and outreach.

The first phase of the LivC Implementation Plan, 1 July 2017 to 30 June 2019 was transitional whereby stakeholders became familiar with LivC concepts and key deliverables, developed the necessary governance and institutional frameworks, increased national and villages’ capabilities, and established key partnerships. The second phase, 1 July 2019 to 20 June 2022 was the consolidation phase. During this phase, stakeholders continued to build LivC governance and institutional arrangements, as well as selected actions in Annex 2 of the LivC Plan to progress successfully to implementable projects.

Out of the eight initiatives in the LivC Implementation plan, six have been successfully turned into projects, summarised in table 1.

Table 2.2: Climate change and related hazards projects been funded by New Zealand and Tokelau

Climate Resilience Investment Pathway (CRIP) #		
CRIP #	Outputs	Outcomes
CRIP 2-1: Reducing the risks of inundation in Tokelau.	<ul style="list-style-type: none"> • Coastal hazard risk reduction plans for each village. • Preliminary and detailed designed for coastal infrastructure and measures. • Construction and quality assurance services out-source where necessary to implement the plan. 	<ul style="list-style-type: none"> • Effective coastal protection for public safety and community infrastructure. • Strengthening integration of climate change and disaster risk into capital development planning and decision making. • Increased awareness and knowledge of coastal management and risk reduction.
CRIP 2-2: Tokelau restoration of climate, weather, water and ocean services.	<ul style="list-style-type: none"> • Technical assistance with weather monitoring equipment (partnership with NEMA and MetService NZ). • Weather, climate, water, ocean and related environmental conditions monitoring and infrastructure plans for each village and a national plan identifying human resources and contracted services needed to support villages and implement their plans. 	<ul style="list-style-type: none"> • Effective climate, weather, water and related environmental conditions monitoring programme for public safety and community infrastructure. • Strengthening integration of weather, climate change and disaster risk into capital development plans to protect lives and property. • Increased awareness and knowledge of weather, climate, water, ocean and related environmental hazards.

Climate Resilience Investment Pathway (CRIP) #		
CRIP #	Outputs	Outcomes
CRIP 3-1: Tokelau Climate Change, resilience, readiness and emergency services' office.	<ul style="list-style-type: none"> Expert Assistance. Report outlining options for a new Tokelau Climate change, Resilient, Readiness & Emergency Services' Office (TCR2O) and/or similar arrangement. Identification of human and financial resources and contracted services needed to establish Tokelau's new TCR2O and/or similar institution. 	<ul style="list-style-type: none"> A fully functional national institution (Office/department) tasked with managing Tokelau's climate change and related hazards' programmes. Strengthening integration of climate change and disaster risk into government and villages' development planning and decision making and human resource development plans to reduce the accumulation of existing risks and prevent creation of additional risks.
CRIP 3-2: Increase resilience to climate change and ocean acidification	<ul style="list-style-type: none"> Identification and implementation of practical Adaptation Actions. Ecosystem and Social resilience assessment and mapping (ESRAM) study completed Research and Monitoring Programmes established. Capacity Building and Awareness raising at the villages' level completed. 	<ul style="list-style-type: none"> Increased awareness and knowledge of local communities from each of the three villages about climate change and ocean acidification. Improved understanding of resilience and capacity that can be integrated into climate change strategies. Improved ability to reduce risks and improve planning with knowledge of more effective methods for resource allocation.

LivC was formulated with the understanding that Tokelau and development partners would support its financing and implementation. New Zealand is the key partner supporting Tokelau's climate change and related programmes.

Strengthening Tokelau's climate change resilience is a national priority under Tokelau's new National Strategic Plan 2021–26.

3 Greenhouse gas inventory

Key points

- Aotearoa New Zealand's gross greenhouse gas emissions in 2020 were 78,778 kilotonnes of carbon dioxide equivalent (kt CO₂-e), comprising 44 per cent carbon dioxide, 44 per cent methane, 11 per cent nitrous oxide and 2 per cent fluorinated gases.
- The two largest contributors to New Zealand's emissions profile in 2020 were the agriculture sector (at 50 per cent of gross emissions) and the energy sector (at 40 per cent).
- Gross emissions decreased by 3 per cent between 2019 and 2020. The main reason for this is the COVID-19 pandemic restrictions.
- Since 1990, New Zealand's gross emissions have increased by 21 per cent. The emission sources that contributed the most to this increase are:
 - enteric fermentation from an increase in the dairy cattle population (methane)
 - fuel use in road transport due to traffic growth (carbon dioxide)
 - fertiliser use on agricultural soils (nitrous oxide)
 - fuel use in manufacturing industries and construction due to economic growth (carbon dioxide)
 - industrial and household refrigeration and air-conditioning systems from increased use of hydrofluorocarbon-based refrigerants (fluorinated gases) that replaced ozone depleting substances.
- The land use, land-use change and forestry (LULUCF) sector offset 30 per cent of New Zealand's gross emissions in 2020.
- New Zealand's net emissions in 2020 were 55,465 kt CO₂-e. Net emissions consist of gross emissions combined with the emissions and removals of the LULUCF sector.
- New Zealand's net emissions have increased by 26 per cent since 1990, due to the underlying increase in gross emissions.

3.1 Introduction

Aotearoa New Zealand supplies a transparent, accurate and regular national greenhouse gas inventory report, which forms one of the building blocks for effective climate change mitigation. As a developed country Party (Annex I Party) to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, New Zealand is obliged to prepare, publish and update *New Zealand's Greenhouse Gas Inventory* of anthropogenic greenhouse gas emissions and removals on an annual basis. New Zealand must also build and maintain the national system for estimating emissions and removals of greenhouse gases.

The latest edition of *New Zealand's Greenhouse Gas Inventory (2022 Inventory)*¹²¹ was submitted to the UNFCCC in April 2022. The 2022 Inventory includes information on emissions and

¹²¹ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Retrieved from environment.govt.nz/facts-and-science/climate-change/measuring-greenhouse-gas-emissions/about-new-zealands-greenhouse-gas-inventory (12 September 2022). The 2022 Inventory refers to the entire UNFCCC submission, which includes the National Inventory Report, the common reporting format database and the standard electronic format tables.

removals of greenhouse gases for the complete time series from 1990–2020.¹²² Inventory reporting under the UNFCCC considers five sectors: energy, industrial processes and product use (IPPU), agriculture, waste and LULUCF. For Tokelau, a non-self-governing territory of New Zealand, emissions and removals are also reported separately by sector as ‘Other.’

Greenhouse gas emissions and removals reported in this chapter were prepared in accordance with UNFCCC reporting guidelines. Under the UNFCCC guidelines, the emissions and removals from the entire LULUCF sector are estimated and reported in the inventory. For accounting purposes under the Kyoto Protocol, only the emissions and removals from afforestation, reforestation, deforestation and forest management activities are included (as required under Articles 3.3 and 3.4 of the Kyoto Protocol). Therefore, the reporting of land use, land-use change and forestry (LULUCF) activities under the Kyoto Protocol differs from that under the UNFCCC.

For the period 2013–20, New Zealand’s target is to reduce emissions to 5.0 per cent below 1990 levels by 2020. New Zealand has taken its target under the UNFCCC. New Zealand remains a Party to the Kyoto Protocol and has applied the Kyoto Protocol framework of rules to ensure actions taken to meet the target are transparent and have integrity. To measure progress towards New Zealand’s target, annual gross emissions from the 2022 Inventory, as the final submission for the period, are summed for the 2013–20 period. This represents the quantity of gross emissions for which New Zealand is responsible.

For the target period, New Zealand’s gross emissions sum to 639,600.7 kilotonnes of carbon dioxide equivalent (kt CO₂-e). The contribution towards New Zealand’s target from LULUCF activities under the Kyoto Protocol is a net removal of 123,281.1 kt CO₂-e (for more information, see chapter 2, section 2.3, and chapter 11 of the 2022 Inventory). In addition, New Zealand can access sufficient Kyoto units (carry-over from the first commitment period) for the purpose of meeting the target if required, pending the outcome of the expert review of the 2022 Inventory. Refer to New Zealand’s latest net position for further details.¹²³

This chapter provides summary information on the latest human-induced greenhouse gas emission trends in New Zealand. It also includes information on the national inventory system. Annex A includes numerical data on inventory trends and annex B contains additional details on New Zealand’s inventory system. For additional information on the national inventory system and the country’s emissions and removals, see the 2022 Inventory.

3.2 National trends in greenhouse gas emissions and removals

3.2.1 Emissions in 2020

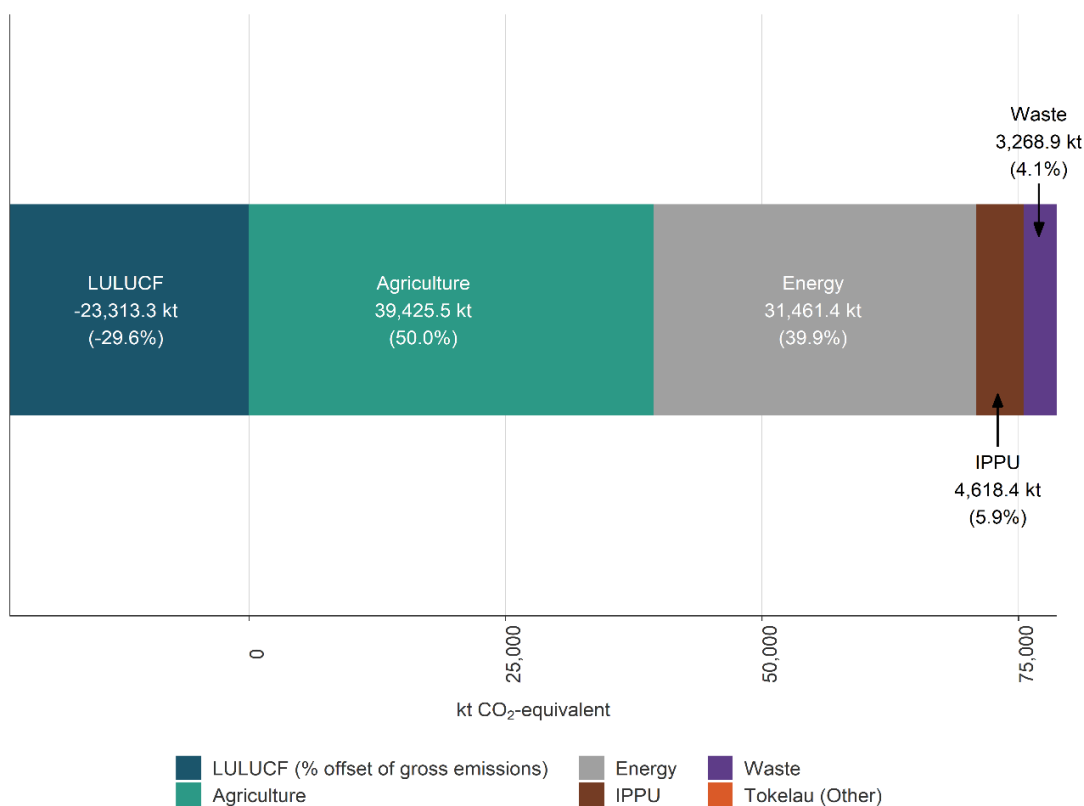
In 2020, Aotearoa New Zealand’s gross greenhouse gas emissions (excluding emissions and removals from the LULUCF sector) were 78,778.4 kt CO₂-e. The sectors contributing the most to the country’s emissions profile were agriculture at 50.0 per cent and energy at 39.9 per cent. Minor emission contributions came from the IPPU sector at 5.9 per cent and waste sector

¹²² To allow time for data collection and processing, there is always a gap of 15 months between the end of the most recent calendar year in the time series and the submission of the inventory.

¹²³ For the 2020 net position report, see the Ministry for the Environment’s website: environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/emissions-reduction-targets/latest-update-on-new-zealands-2020-net-position (accessed 14 September 2022).

at 4.1 per cent. Emissions from Tokelau were negligible at only 0.005 per cent. In 2020, the LULUCF sector offset 29.6 per cent of gross emissions (figure 3.1). Net emissions in 2020, at 55,465.1 kt CO₂-e, were therefore lower than gross emissions (table 3.1).

Figure 3.1: New Zealand’s greenhouse gas emissions by sector, 2020



Note: IPPU = industrial processes and product use; kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry. The percentages may not add up to 100 per cent due to rounding. The LULUCF sector, which is not part of gross emissions, is included here as a negative value. The Tokelau sector is barely visible due to its small contribution (4.18 kt CO₂-e or 0.005 per cent of New Zealand’s gross greenhouse gas emissions).

Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

3.2.2 Changes in gross emissions between 1990 and 2020

Between 1990 and 2020, New Zealand’s gross greenhouse gas emissions increased by 20.8 per cent (table 3.1 and figures 3.2 and 3.3). The average annual growth in emissions was 0.6 per cent. The emissions categories that contributed the most to the increase in gross emissions were enteric fermentation from dairy cattle (methane, CH₄),¹²⁴ road transportation (CO₂), agricultural soils (nitrous oxide, N₂O), manufacturing industries and construction (CO₂) – especially the categories of chemicals, food processing, beverages and tobacco – and fluorinated gases (F-gases) used as substitutes for ozone depleting substances (ODS). Figure 3.4 shows the trends by sector across the entire time series from 1990–2020.

¹²⁴ Enteric fermentation is a digestive process by which micro-organisms break down carbohydrates into simple molecules for absorption into the bloodstream of an animal.

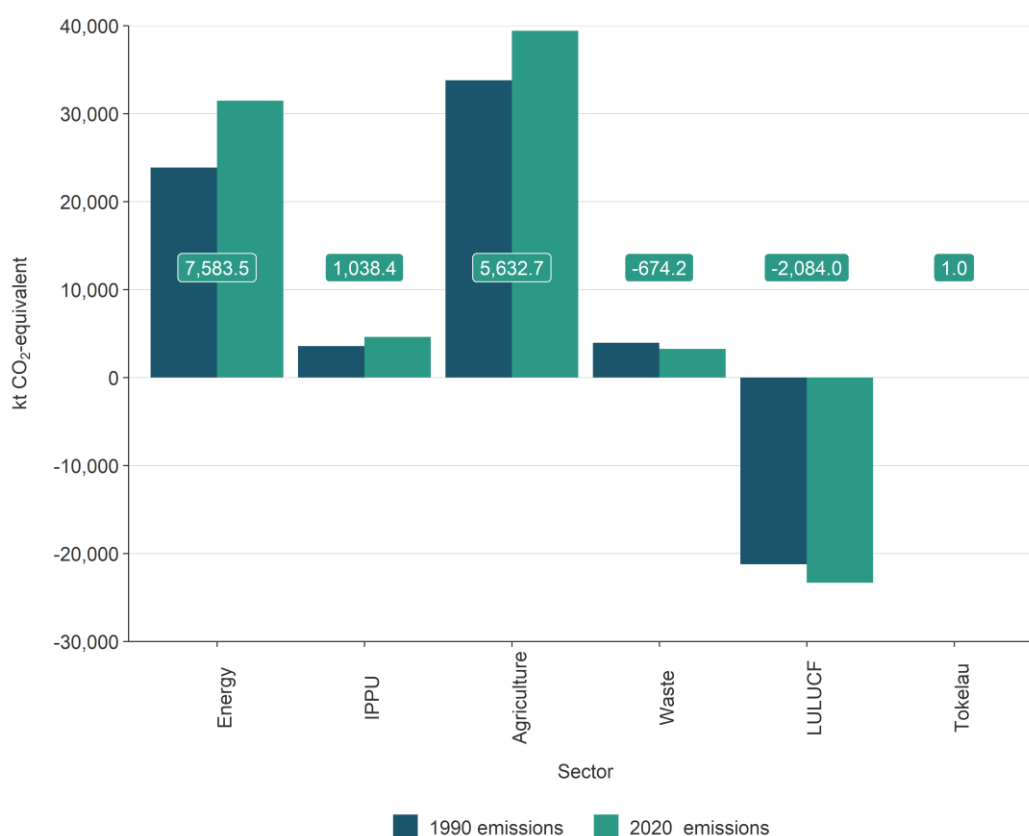
Table 3.1: New Zealand's emissions by sector, 1990 and 2020

Sector	kt CO ₂ -equivalent		Change from 1990 (kt CO ₂ -equivalent)	Change from 1990 (%)
	1990	2020		
Energy	23,877.9	31,461.4	7,583.5	31.8
Industrial processes and product use	3,579.9	4,618.4	1,038.4	29.0
Agriculture	33,792.9	39,425.5	5,632.7	16.7
Waste	3,943.1	3,268.9	-674.2	-17.1
Tokelau	3.2	4.2	1.0	31.9
Gross (excluding LULUCF)	65,197.0	78,778.4	13,581.4	20.8
LULUCF	-21,229.2	-23,313.3	-2,084.0	-9.8
Net (including LULUCF)	43,967.8	55,465.1	11,497.3	26.1

Note: kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry. Net emissions from the LULUCF sector are reported as a negative number because the sector removes more CO₂ from the atmosphere than it emits (see chapter 6 of the 2022 Inventory). Columns may not total due to rounding. Percentages presented are calculated from unrounded values. For Tokelau contributions by sector, see section 3.2.8.

Source: Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

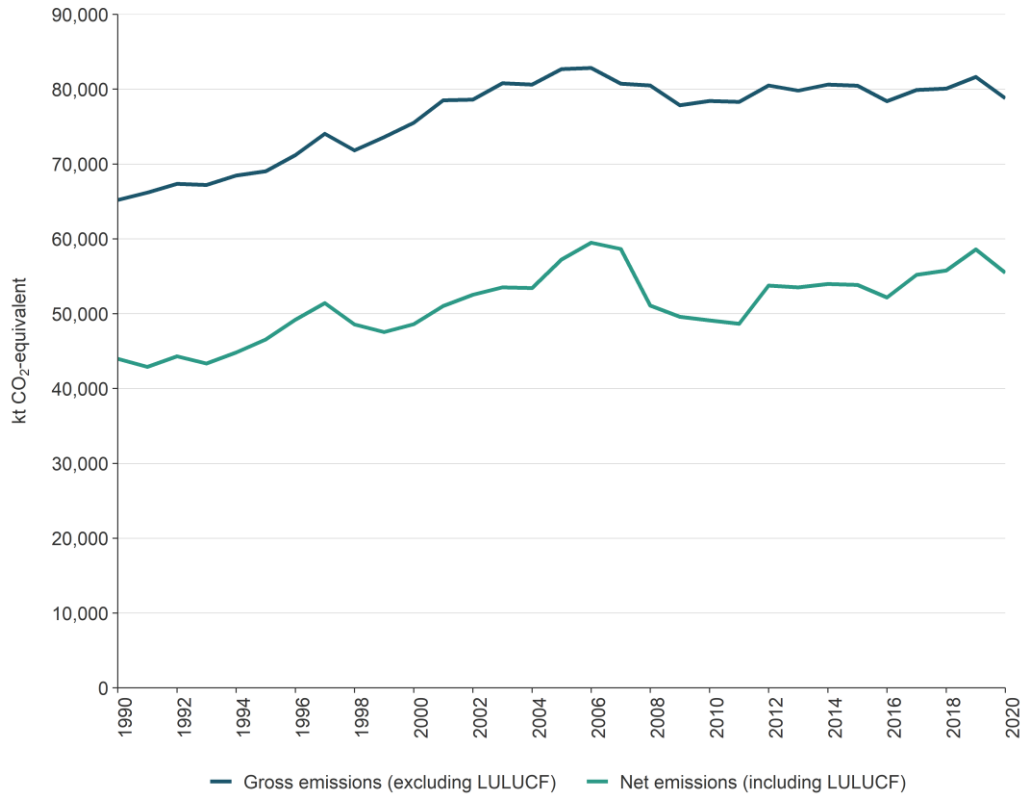
Figure 3.2: Change in New Zealand's emissions by sector, 1990 and 2020



Note: IPPU = industrial processes and product use; kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry. Tokelau is not visible due to its very low greenhouse gas emissions.

Source: Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

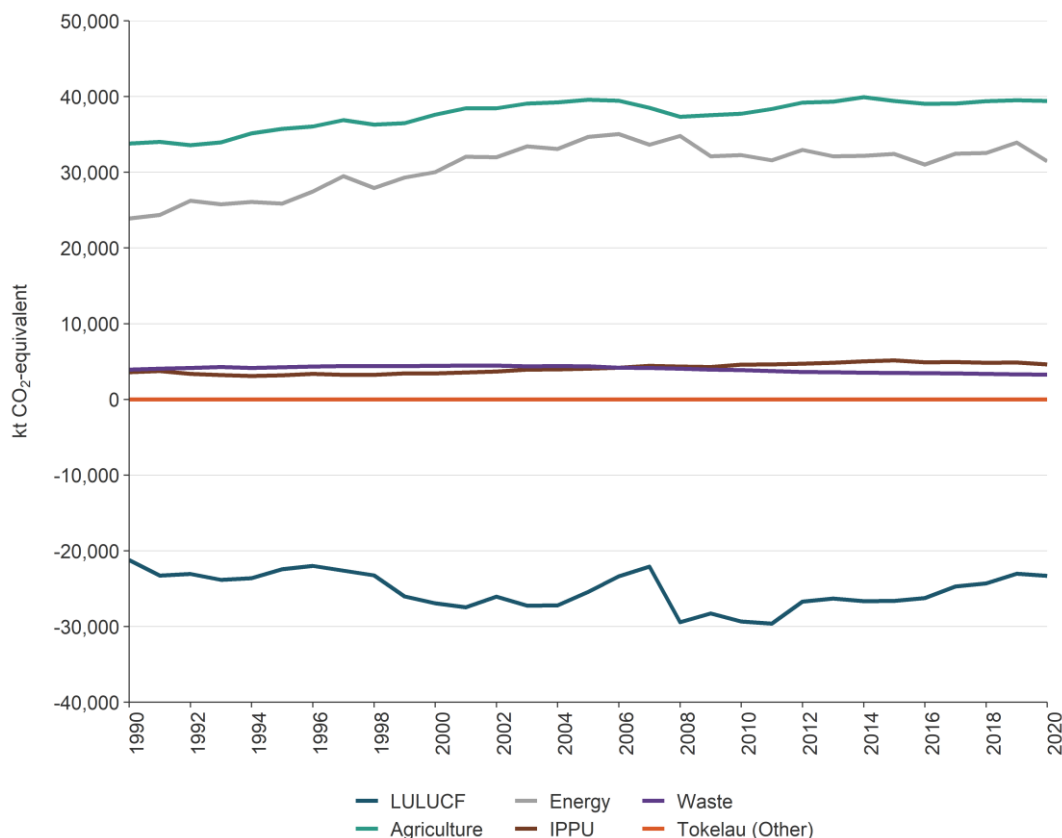
Figure 3.3: New Zealand’s gross and net emissions (under the UNFCCC), 1990–2020



Note: kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry; UNFCCC = United Nations Framework Convention on Climate Change.

Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

Figure 3.4: Trends in New Zealand’s greenhouse gas emissions by sector, 1990–2020



Note: IPPU = industrial processes and product use; kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry. Net removals from the LULUCF sector are reported under the UNFCCC guidelines (see chapter 6 of 2022 Inventory).

Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

3.2.3 Changes in net emissions between 1990 and 2020

For reporting purposes, the difference between gross and net emissions is whether or not the LULUCF sector is included. Gross emissions exclude the LULUCF sector, while net emissions include the LULUCF sector. As figure 3.3 demonstrates, New Zealand’s net emissions are always lower than gross emissions. This is because the LULUCF sector acts as a net carbon sink across the time series. The main reason is that managed forest makes a significant contribution to the inventory.

Between 1990 and 2020, our country’s net greenhouse gas emissions increased by 26.1 per cent (table 3.1 and figure 3.3). The categories that contributed the most to the increase in net emissions were land converted to forest land (declining CO₂ sink), enteric fermentation from dairy cattle (CH₄), road transportation (CO₂) and agricultural soils (N₂O). Despite the considerable variability that occurred from year to year over this period, overall the amount of CO₂ the LULUCF sector has removed from the atmosphere has increased since 1990.¹²⁵ In 2020, net removals in the LULUCF sector increased by 9.8 per cent compared with 1990 levels.

¹²⁵ The amount of CO₂-e the LULUCF sector removes is the difference between removals and any emissions in this sector from, for example, harvesting and deforestation.

3.2.4 Energy sector

The energy sector produces two types of emissions: combustion emissions and fugitive emissions. Combustion emissions that result from fossil fuel being burned are reported under the following categories:

- energy industries, covering public electricity and heat production, petroleum refining, and manufacture of solid fuels and other energy
- manufacturing industries and construction, covering iron and steel, other non-ferrous metals, chemicals, pulp, paper and print, food processing, beverages and tobacco, non-metallic minerals and other uses (manufacturing of machinery, mining (excluding fuels) and quarrying, construction, textile and leather)
- transport, covering domestic transportation such as civil aviation, road transportation, railways, domestic marine transport and pipeline transport
- other sectors, covering commercial/industrial, residential and agriculture/forestry/fishing.

Fugitive emissions resulting from production, processing, transmission, storage and use of fossil fuels and non-productive combustion are reported under the following categories:

- solid fuels, covering by-products of coal mining operations
- oil and natural gas and other emissions from energy production, covering production and processing of natural gases, and geothermal operations.

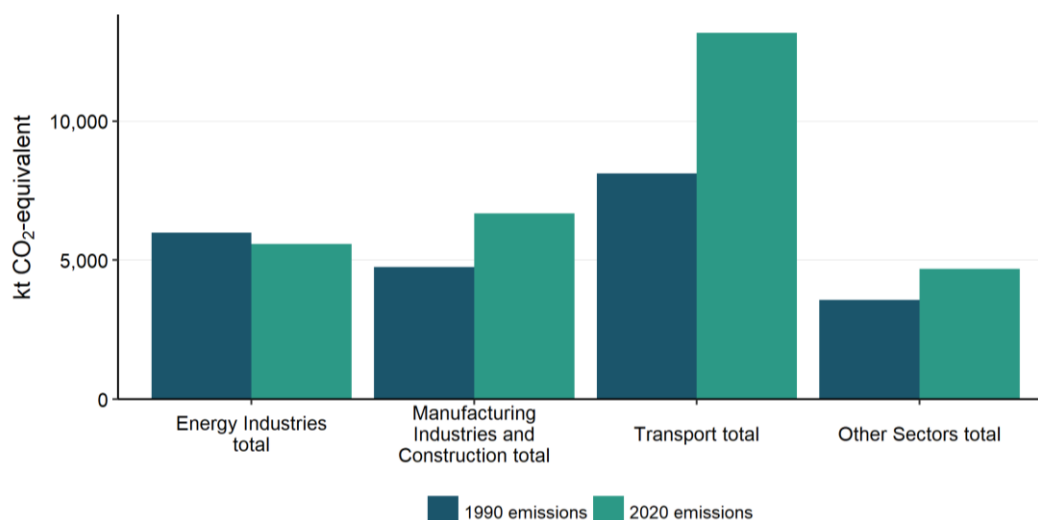
In 2020, emissions from the energy sector contributed 31,461.4 kt CO₂-e (table 3.1), of which fugitive emissions accounted for 4.3 per cent. Emissions from the energy sector are dominated by CO₂ at 97.1 per cent, with smaller contributions from CH₄ (2.2 per cent) and N₂O (0.7 per cent). The major categories contributing to emissions in the sector are road transportation, contributing 38.2 per cent, and manufacturing industries and construction, contributing 21.2 per cent.

Figure 3.5 summarises change in emissions from fuel combustion in the energy sector between 1990 and 2020. Over this period, emissions from the energy sector have increased by 31.8 per cent. This is mainly driven by increases in three categories: road transportation increased by 76.1 per cent; food processing, beverages and tobacco increased by 83.0 per cent; and public energy and heat production increased by 32.3 per cent.

Recent global events such as the COVID-19 pandemic restrictions have impacted on the supply of and demand for energy in New Zealand. Between 2019 and 2020, emissions decreased by 7.2 per cent in the energy sector because of suppressed activity in road transportation and domestic aviation during periods of restriction. These decreases were partially offset by an increase in emissions from public electricity and heat production. This increase occurred because hydro inflows reduced over the year, with the result that the share of electricity from renewable sources dropped from 83 per cent in 2019 to 81 per cent in 2020.

Emissions from the energy sector peaked in 2006, after which a flat to decreasing trend has been observed (figure 3.4). The trend reflects a steady growth in energy production from renewable sources, dominated by hydro-electric generation and with smaller contributions from geothermal and wind generation. In 2020, fossil fuel thermal plants supplied only 18.8 per cent of New Zealand's total electricity supply, which is well below the global average. While renewable sources provide a strong power generation base, renewable hydro-electric generation remains sensitive to rainfall fluctuations in key catchment areas feeding hydro-electric schemes.

Figure 3.5: Change in New Zealand’s emissions from fuel combustion categories, 1990 and 2020



Note: kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent.

Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

3.2.5 Industrial processes and product use sector

The IPPU sector covers non-energy emissions from industrial processes, and emissions of a range of greenhouse gases with uses such as refrigeration and medical applications. New Zealand has a small number of industrial processing plants emitting non-energy related greenhouse gases. The IPPU sector reports CO₂, CH₄ and N₂O emissions from eight industrial processes:

- calcination of limestone in cement production
- calcination of limestone in burnt and slaked lime production
- production of ammonia, which is further processed into urea
- production of methanol
- production of hydrogen in oil refining and for making hydrogen peroxide
- production of steel, from iron sand and from scrap steel
- oxidation of anodes in aluminium smelting
- use of soda ash and limestone in glass making.

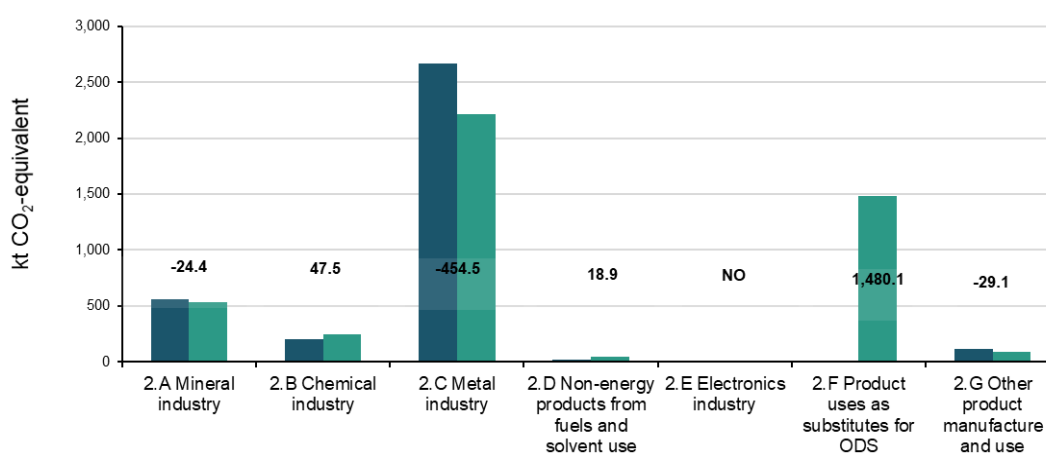
Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are used in many products such as refrigeration and air-conditioning equipment. PFCs are also emitted from anode effects in aluminium smelting. Some recovered HFCs are exported for destruction. Sulphur hexafluoride (SF₆) is used in the electricity distribution sector and for small-scale medical and scientific applications. All F-gases are imported into New Zealand, with no domestic production.

In 2020, emissions from the IPPU sector contributed 4,618.4 kt CO₂-e (table 3.1). Emissions from the IPPU sector are dominated by CO₂ at 62.0 per cent and F-gases at 34.0 per cent, with smaller contributions from CH₄ and N₂O. The major categories contributing to emissions in the sector are metal industry at 48.0 per cent and product uses as substitutes for ODS (mainly HFCs used for refrigeration and air conditioning) at 32.0 per cent. Most emissions in the metal industry occur in iron and steel production and aluminium production. Most non-CO₂ emissions occur in the product uses as substitutes for ODS category.

Between 1990 and 2020, emissions from the IPPU sector increased by 29.0 per cent. This is driven by increases in product uses as substitutes for ODS after HFCs were introduced to replace ODS in refrigeration and air-conditioning units. To a lesser degree, increased production of metals, lime and cement have also contributed to increased emissions within the sector. In the same period, substantial reductions in emissions of PFCs have occurred due to improved management of anode effects in aluminium smelting, and reductions in emissions from N₂O used for medical applications. Figure 3.6 summarises change in emissions from the IPPU sector between 1990 and 2020.

Between 2019 and 2020, emissions decreased by 5.0 per cent in the IPPU sector. This change occurred because of a significant decrease in the metal industry category and lesser decreases in other categories. The COVID-19 pandemic restrictions explain the lower emissions, as they led to plant shutdowns and decreased production.

Figure 3.6: Change in New Zealand’s emissions from the IPPU sector, 1990 and 2020



Note: IPPU = industrial processes and product use; kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; ODS = ozone depleting substances. Emissions from the electronics industry are not occurring (NO).

Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

3.2.6 Agriculture sector

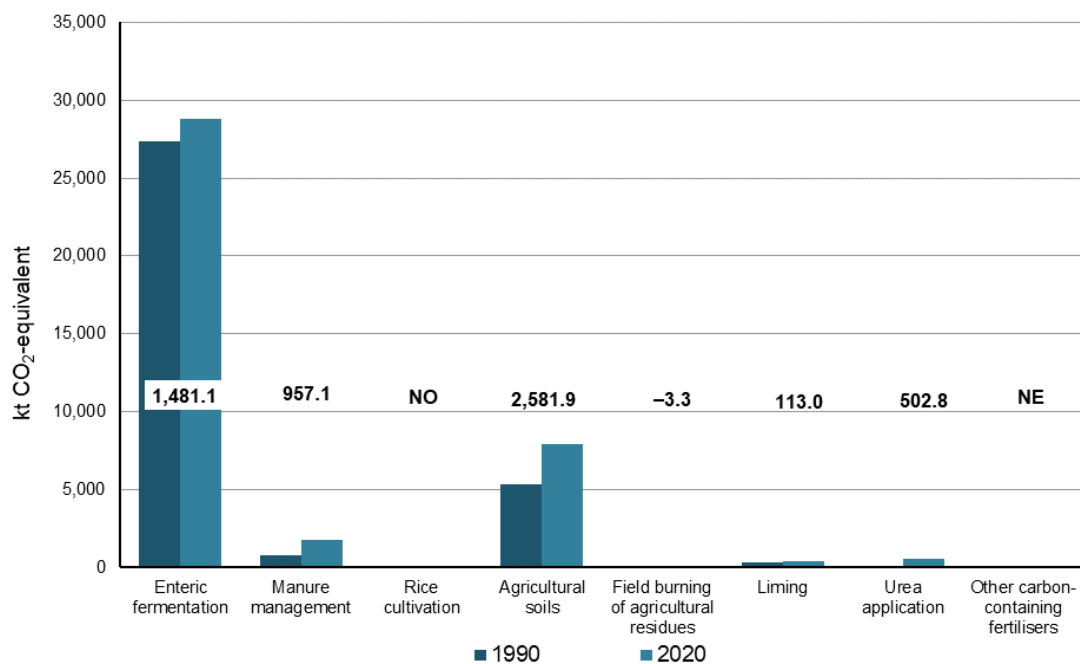
Practices in the New Zealand agriculture sector differ from those in most other developed countries. In this country, farms typically use year-round outdoor pastoral grazing systems. For this reason, the agriculture sector is more sensitive to climatic events than countries where grain-fed systems and indoor feedlots are common. Trends in the agriculture sector are driven by the population of ruminant livestock (dairy cattle, beef cattle, sheep and deer). Since 1990, the number of dairy cattle in our country has increased, while the number of sheep and beef cattle has decreased. Consequently, the land area of sheep, beef and deer grazing has decreased by 35.7 per cent and the area of dairy farming has increased by 67.4 per cent.

In 2020, emissions from the agriculture sector contributed 39,425.5 kt CO₂-e (table 3.1). The major sources of emissions were enteric fermentation, contributing 73.1 per cent of the sector’s emissions, and agricultural soils, contributing 20.0 per cent. Methane emissions from enteric fermentation made up 36.6 per cent of gross emissions, and N₂O emissions from agricultural soils made up 10.0 per cent. Between 2019 and 2020, total agricultural emissions decreased by 0.2 per cent. This change occurred because the sheep population decreased, as did the use of lime and urea fertiliser. Emissions from other sources, such as inorganic fertiliser and beef and dairy cattle, rose but these increases were not enough to offset the overall decrease in agricultural emissions.

Between 1990 and 2020, emissions from the agriculture sector increased by 16.7 per cent. This has largely been driven by an increase in the population of dairy cattle, which has led to increases in emissions across several agricultural reporting categories. The population has expanded because farming dairy cattle has provided better financial returns over the period. Figure 3.7 summarises change in emissions from the agriculture sector between 1990 and 2020.

Agriculture emissions peaked in 2014 (figure 3.4), which corresponded with the peak in total cattle numbers. Agriculture emissions have since been declining, partly because profitability of dairy exports relative to other primary sector exports has fallen since 2015.

Figure 3.7: Change in New Zealand’s emissions from the agriculture sector, 1990 and 2020



Note: kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry. Rice cultivation does not occur (NO) in New Zealand. Emissions from other carbon-containing fertilisers are not estimated (NE).

Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

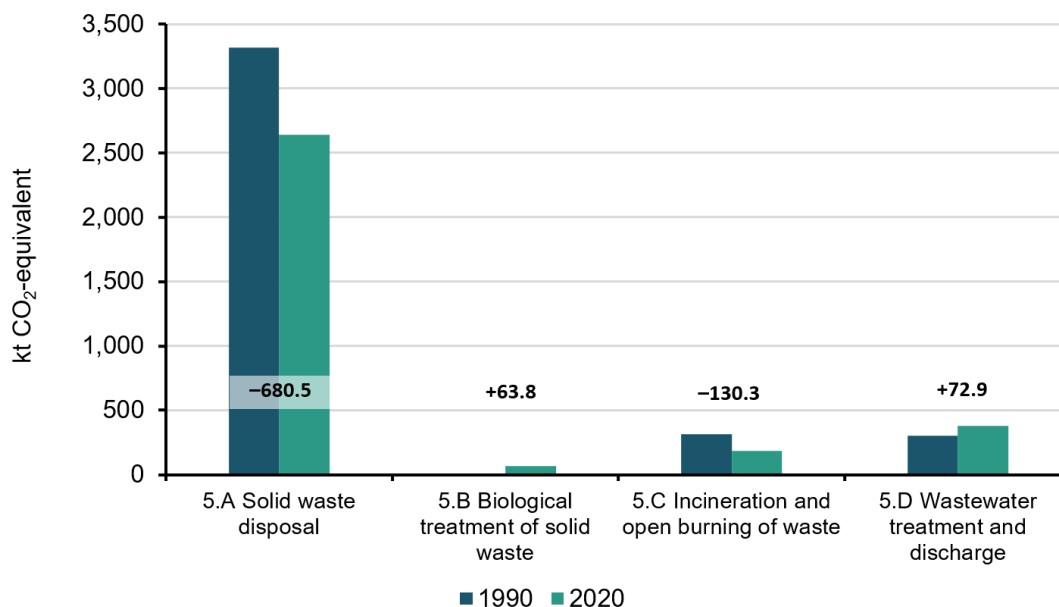
3.2.7 Waste sector

Greenhouse gas emissions from the waste sector result from the processing and disposal of solid waste, biological treatment of solid waste, incineration and open burning of waste, and wastewater treatment and discharge. In New Zealand, most emissions from the waste sector are CH₄ (92.1 per cent), followed by N₂O (5.1 per cent) and CO₂ (2.7 per cent).

In 2020, emissions from the waste sector contributed 3,268.9 kt CO₂-e (table 3.1). The largest source of waste sector emissions in 2020 was solid waste disposal at 80.7 per cent, followed by wastewater treatment and discharge at 11.5 per cent. Between 2019 and 2020, emissions from the waste sector decreased by 1.3 per cent. This was largely because of decreases in CH₄ emissions from solid waste disposal, due to changes in the composition of waste disposed in municipal landfills.

Between 1990 and 2020, total emissions from the waste sector decreased by 17.1 per cent. Annual emissions peaked in 2002 and have generally declined since then, even though the growth in population and economic activity has resulted in overall higher volumes of waste since 1990. The reason for the downward trend in emissions in the waste sector since 2005 (figure 3.4) is that the management of solid waste disposal at municipal landfills has continued to improve. Figure 3.8 summarises change in emissions from the waste sector between 1990 and 2020.

Figure 3.8: Change in New Zealand’s emissions from the waste sector, 1990 and 2020



Note: kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent.

Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

3.2.8 Tokelau (other) sector

Tokelau is a non-self-governing territory of New Zealand made up of three small coral atolls. It has a subsistence economy, in which sharing of resources plays a significant role. The combination of the small land area, small population and absence of industry means Tokelau has an extremely minimal impact on the environment and contributes only a minor amount of greenhouse gas emissions. Emissions in Tokelau are limited to:

- CO₂ from boat engines and land vehicles
- CO₂ from back-up power generators
- F-gases from the use of refrigerants
- CH₄ and N₂O from livestock (pig and poultry)
- CH₄, CO₂ and N₂O from waste.

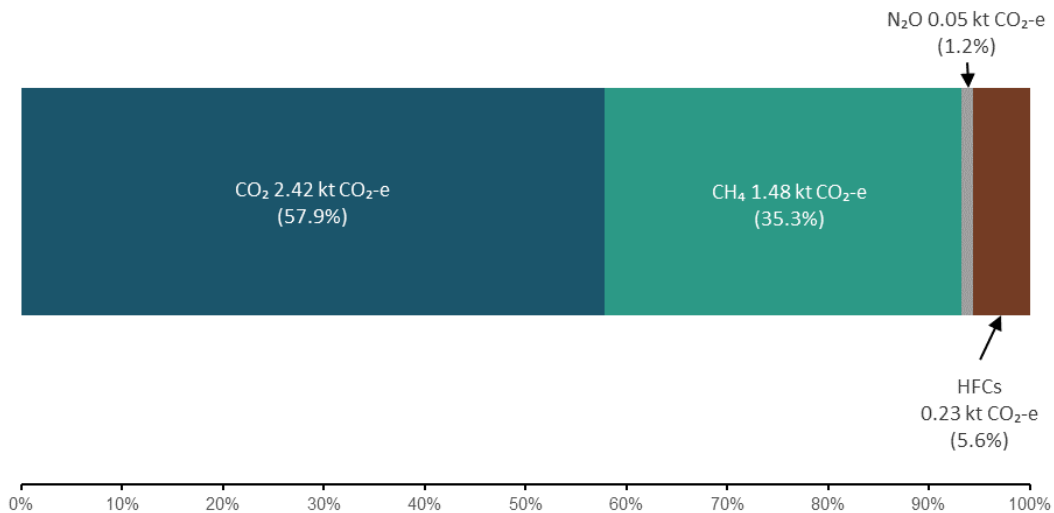
In 2020, emissions from Tokelau contributed 4.2 kt CO₂-e (table 3.1). Carbon dioxide dominated emissions from Tokelau, contributing 57.9 per cent of total emissions, followed by CH₄ at 35.3 per cent, HFCs at 5.6 per cent and N₂O at 1.2 per cent (figure 3.9). The major source of emissions in Tokelau is the energy sector, which contributed 57.5 per cent of emissions, followed by the agriculture sector at 19.7 per cent, waste sector at 16.6 per cent and IPPU sector at 6.1 per cent in 2020 (figure 3.10).

The largest source of emissions in Tokelau is domestic navigation.

Between 1990 and 2020, emissions from Tokelau increased by 31.9 per cent. This is driven by an increase in domestic navigation, which occurred after Tokelau gained ownership and use of passenger and cargo vessels, and an increase in electricity generation due to the introduction of air conditioning after 2006.

Between 2019 and 2020, total emissions from Tokelau decreased by 2.8 per cent. The reason for this change was that domestic navigation reduced because shipping in Tokelau decreased in response to restrictions related to the COVID-19 pandemic.

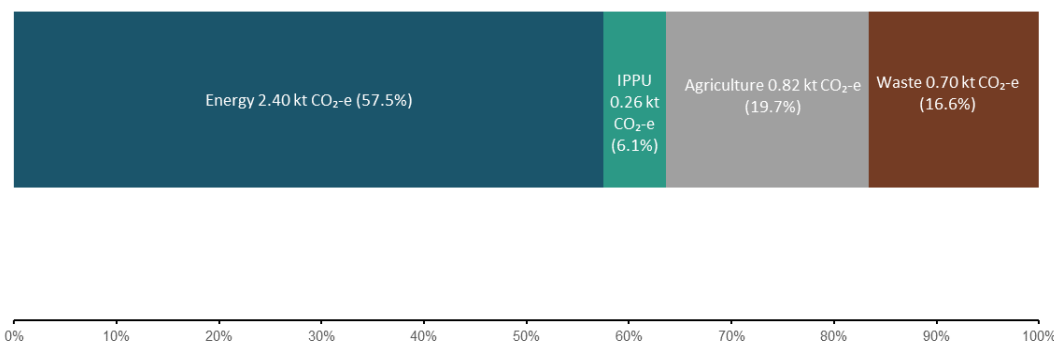
Figure 3.9: Tokelau’s greenhouse gas emissions by gas, 2020



Note: CH₄ = methane; CO₂ = carbon dioxide; HFCs = hydrofluorocarbons; kt CO₂-e = kilotonnes of carbon dioxide equivalent; N₂O = nitrous oxide.

Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

Figure 3.50: Tokelau’s greenhouse gas emissions by sector, 2020



Note: IPPU = industrial processes and product use; kt CO₂-e = kilotonnes of carbon dioxide equivalent.

Source: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

3.2.9 Land use, land-use change and forestry sector

Plantation forestry forms a core part of the New Zealand economy and has a considerable influence on the LULUCF sector emissions profile. As a result of its intensive forest management combined with the temperate climate, fertile soils and high rainfall, our country has one of the highest rates of plantation forest growth among developed countries.

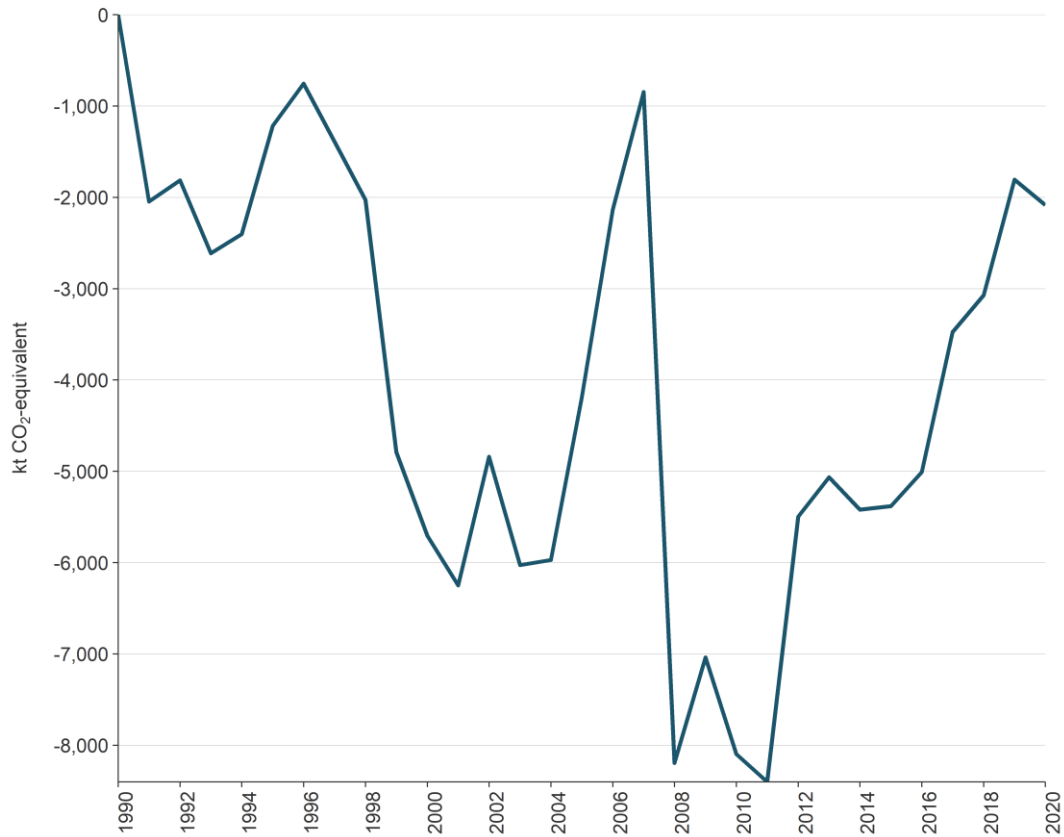
In New Zealand, the LULUCF sector is a net carbon sink. In 2020, net emissions from the LULUCF sector (as reported under the UNFCCC)¹²⁶ were $-23,313.3$ kt CO₂-e (table 3.1). This total comprises removals of $-23,666.2$ kt CO₂-e of CO₂, and small emissions of CH₄ at 81.7 kt CO₂-e and N₂O at 271.3 kt CO₂-e (resulting in the net removals figure of $-23,313.3$ kt CO₂-e as noted above). The greatest contribution to both emissions and removals came from the category of forest land remaining forest land. A large amount of CO₂ is sequestered as trees grow, while large emissions come from sustainable harvesting of plantation forests.

Net emissions from the LULUCF sector have fluctuated over the time series as the rate of harvesting, afforestation and deforestation changes. (See figure 3.11, which plots the absolute net change in emissions across the time series to demonstrate how much emissions caused by these activities vary from year to year.) Between 1990 and 2020, net removals from the LULUCF sector have increased by 9.8 per cent. This is largely the result of increased production of harvested wood products, which have compensated for the emissions from the increase in forest harvesting (figure 3.12).

Between 2019 and 2020, net removals from the LULUCF sector increased by 1.2 per cent. The largest change in absolute terms was in the harvested wood products category, which had an increase in emissions of 24.4 per cent. This change resulted from disruptions in processing and logistics while COVID-19 pandemic restrictions applied. The second greatest change occurred in the grassland category, where emissions decreased by 41.2 per cent between the two years. The reason was that deforestation of planted forest reduced, resulting in fewer conversions from forest land to grassland.

¹²⁶ Under the UNFCCC, the greenhouse gas inventory reports emissions and removals from the entire LULUCF sector. Under the Kyoto Protocol, the subset of these emissions due to afforestation, reforestation, deforestation and forest management activities is reported (commonly referred to as Articles 3.3 and 3.4 activities) and used for target accounting. Therefore, the emissions totals and trends under UNFCCC and the Kyoto Protocol reporting are different.

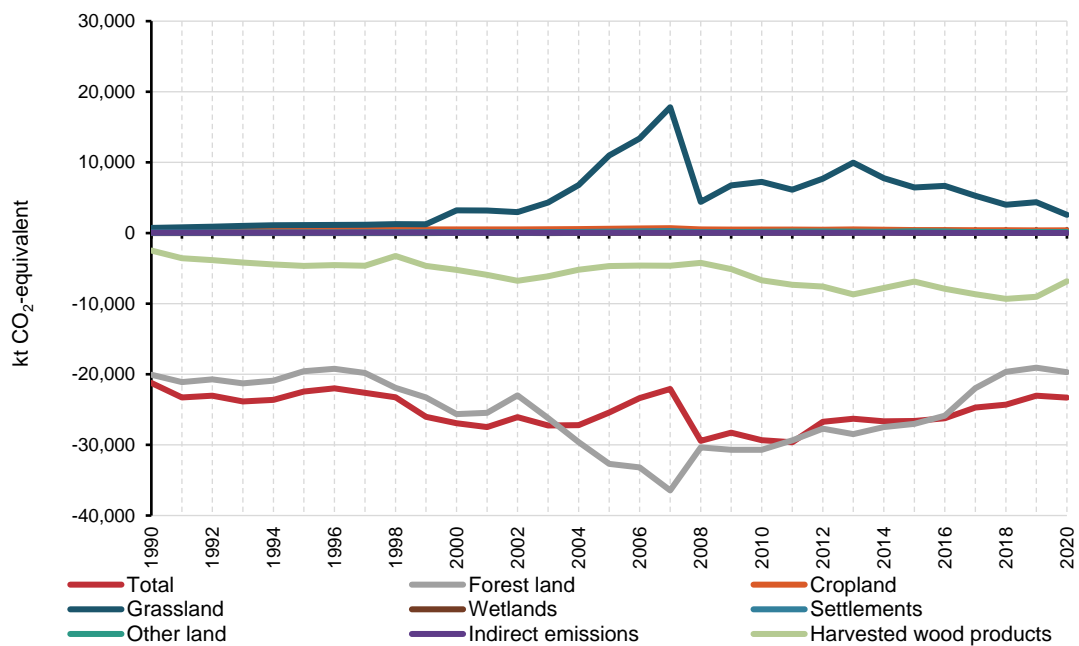
Figure 3.11: Absolute change in net emissions from the LULUCF sector, 1990–2020



Note: kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

Source: Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

Figure 3.62: New Zealand's annual emissions from the LULUCF sector, 1990–2020



Note: kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

Source: Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

3.2.10 Articles 3.3 and 3.4 activities under the Kyoto Protocol

For Annex 1 Parties that have taken a target to reduce greenhouse gas emissions under the Kyoto Protocol, accounting and reporting of afforestation, reforestation and deforestation activities (Article 3.3) and forest management (Article 3.4) is mandatory during the second commitment period (2013–20). This is a change from the first commitment period, when reporting on forest management was voluntary. Even though New Zealand did not take a target under the Kyoto Protocol for the second commitment period, it applies Kyoto Protocol LULUCF accounting to its target under the UNFCCC for the period 2013–20. Our country reports on the mandatory activities under Articles 3.3 and 3.4 by monitoring trends in land use. To do so, land use maps and forestry statistics are used to detect and report the emissions from afforestation, reforestation, deforestation and forest management activities. New Zealand did not elect to report on any voluntary activities during the 2013–20 period. In 2020, activities covered 10,188,427 hectares, which represents 37.8 per cent of the country's total land area.

In 2020, net emissions reported under Articles 3.3 and 3.4 of the Kyoto Protocol were –29,476.1 kt CO₂-e. This consists of –14,764.7 kt CO₂-e for afforestation and reforestation activities, 1,320.5 kt CO₂-e for deforestation activities and –16,031.9 kt CO₂-e for forest management activities. Estimates under the UNFCCC and the Kyoto Protocol differ because of their different approaches in accounting for pre-1990 forest in the LULUCF sector: it appears under forest management in Kyoto Protocol reporting, and as forest land remaining forest land in LULUCF reporting. Our government has interpreted forest management to include the whole area classified as pre-1990 natural forest and pre-1990 planted forest. Because reporting of emissions occurs against a business-as-usual reference level, New Zealand only accounts for emissions and removals that differ from the forest management reference level.

Our government elected to account for LULUCF activities at the end of the accounting period rather than annually, in line with its accounting approach for the Kyoto Protocol first commitment period. The accounting quantity for the 2013–20 period is –123,281.1 kt CO₂-e. This is the sum of emissions and removals from afforestation, reforestation and deforestation (Article 3.3) and net emissions from forest management (Article 3.4). (See chapter 2, section 2.3, and chapter 11 of the 2022 Inventory for details.)

3.3 Emissions and removals by gas

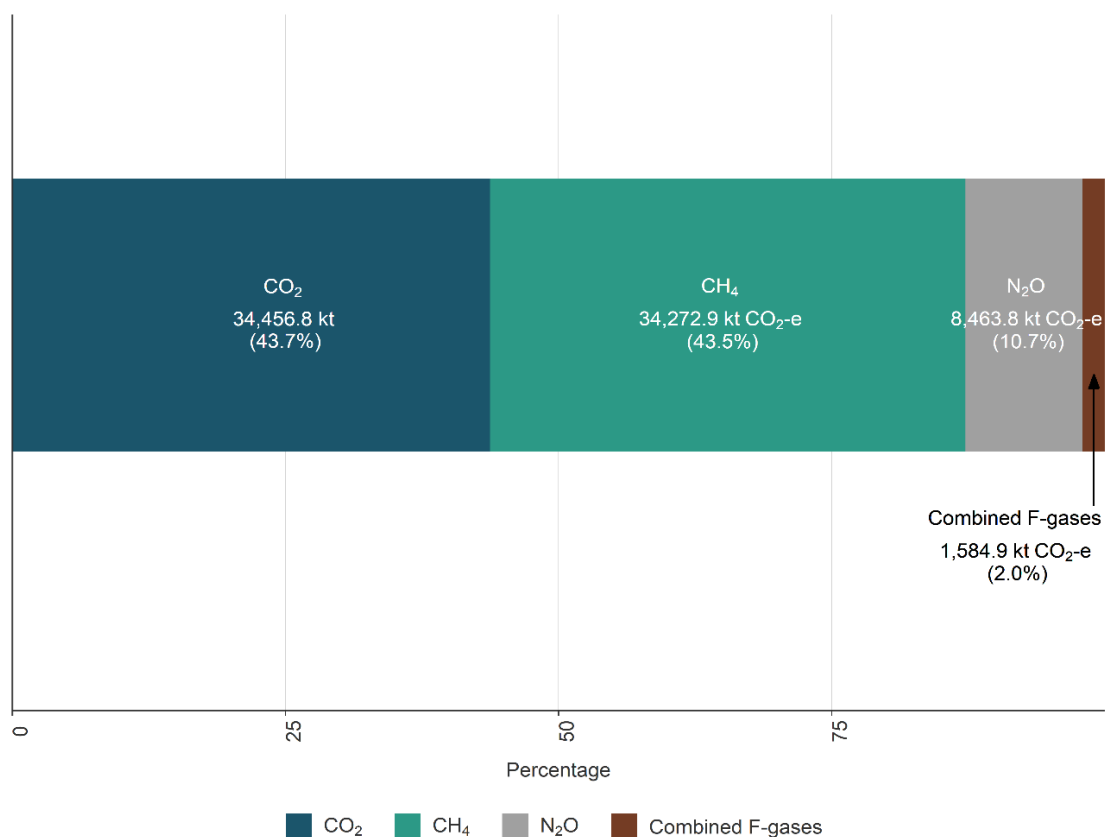
3.3.1 Overview

Inventory reporting under the UNFCCC covers the following direct greenhouse gases: CO₂, CH₄, N₂O, HFCs, PFCs, SF₆ and nitrogen trifluoride.¹²⁷ Figure 3.13 shows New Zealand's emissions profile by gas in 2020. Table 3.2 and figure 3.14 show the change in all direct greenhouse gases between 1990 and 2020.

In accordance with UNFCCC reporting guidelines, indirect greenhouse gases are included in inventory reporting but not in the national emissions total. These indirect greenhouse gases include carbon monoxide, sulphur dioxide, oxides of nitrogen and non-methane volatile organic compounds.

¹²⁷ Because nitrogen trifluoride emissions do not occur in New Zealand, no nitrogen trifluoride data are included in the greenhouse gas inventory report.

Figure 3.13: New Zealand's gross greenhouse gas emissions by gas, 2020



Note: CH₄ = methane; CO₂ = carbon dioxide; F-gases = fluorinated gases; kt CO₂-e = kilotonnes of carbon dioxide equivalent; N₂O = nitrous oxide. The percentages may not add up to 100 per cent due to rounding.

Source: Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

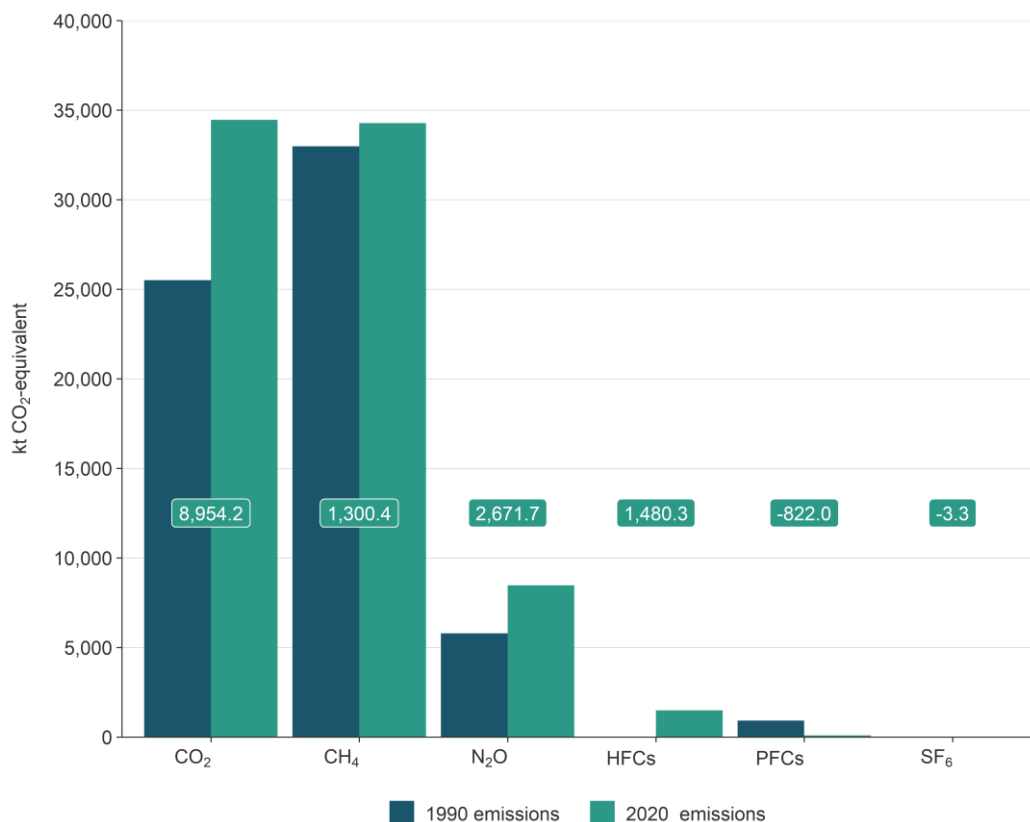
Table 3.2: New Zealand's emissions of greenhouse gases by gas, 1990 and 2020

Direct greenhouse gas emissions	kt CO ₂ -equivalent		Change from 1990 (kt CO ₂ -equivalent)	Change from 1990 (%)
	1990	2020		
CO ₂	25,502.5	34,456.8	8,954.2	35.1
CH ₄	32,972.5	34,272.9	1,300.4	3.9
N ₂ O	5,792.0	8,463.8	2,671.7	46.1
HFCs	NO	1,480.3	1,480.3	NA
PFCs	909.9	87.9	-822.0	-90.3
SF ₆	20.0	16.7	-3.3	-16.5
Gross, all gases	65,197.0	78,778.4	13,581.4	20.8

Note: CH₄ = methane; CO₂ = carbon dioxide; HFCs = hydrofluorocarbons; kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; N₂O = nitrous oxide; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride. Gross emissions exclude net removals from the LULUCF sector. The percentage change for HFCs is not applicable (NA) as emissions were not occurring (NO) in 1990. Columns may not total due to rounding. Percentages presented are calculated from unrounded values.

Source: Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

Figure 3.14: New Zealand's gross emissions by gas, 1990 and 2020



Note: CH₄ = methane; CO₂ = carbon dioxide; HFCs = hydrofluorocarbons; kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; N₂O = nitrous oxide; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride.

Source: Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

3.3.2 Carbon dioxide

Carbon dioxide is the primary greenhouse gas emitted from human activities in New Zealand. Human activities are altering the carbon cycle, both by adding more CO₂ to the atmosphere and by influencing the ability of natural sinks to remove CO₂ from the atmosphere. The main human activity that emits CO₂ is the combustion of fossil fuels for energy and transportation. Some industrial processes, waste processing and land-use changes also emit CO₂. Between 1990 and 2020, gross CO₂ emissions increased by 35.1 per cent (table 3.2).

Carbon dioxide emissions contributed the largest proportion of our country's gross greenhouse gas emissions in 2020 at 34,456.8 kt CO₂-e (43.7 per cent of gross emissions). The main contributor to total CO₂ emissions was the energy sector, which contributed 88.7 per cent of gross CO₂ emissions. Of this total, transport (38.0 per cent) and manufacturing industries and construction (19.1 per cent) contributed the most to CO₂ emissions.

3.3.3 Methane

The lifetime of CH₄ in the atmosphere is much shorter than CO₂, but CH₄ is more efficient at trapping radiation. Natural processes in soil and chemical reactions help remove CH₄ from the atmosphere. In New Zealand, CH₄ is the second-most prevalent greenhouse gas emitted from human activities. Most CH₄ comes from ruminant livestock farming, with further contributions from coal mining activities, natural oil and gas systems, and waste disposal activities. Between 1990 and 2020, gross CH₄ emissions increased by 3.9 per cent (table 3.2).

Methane contributed 34,272.9 kt CO₂-e in 2020 (43.5 per cent of gross emissions). The main contributor to total CH₄ emissions was the agriculture sector, at 88.9 per cent of our country's gross CH₄ emissions. Of this total contribution, 84.1 per cent came from enteric fermentation in ruminant livestock. Methane is also the largest component of New Zealand's waste sector emissions, contributing 3,011.9 kt CO₂-e (8.8 per cent of gross CH₄ emissions).

3.3.4 Nitrous oxide

Nitrous oxide is naturally present in the atmosphere as part of Earth's nitrogen cycle and has a variety of natural sources. However, human activities such as agriculture, fossil fuel combustion, wastewater management and industrial processes are increasing the amount of N₂O in the atmosphere. Nitrous oxide is a potent greenhouse gas. It stays in the atmosphere for longer than CH₄ but for shorter periods than CO₂, before being destroyed through chemical reactions. Between 1990 and 2020, gross N₂O emissions increased by 46.1 per cent (table 3.2).

Nitrous oxide contributed 8,463.8 kt CO₂-e in 2020 (10.7 per cent of gross emissions). The main contributor to total N₂O emissions is the agriculture sector, at 94.5 per cent of New Zealand's gross N₂O emissions. Of this contribution, 93.1 per cent of gross N₂O came from agricultural soils (from fertiliser use and the deposition of animal dung and urine) and the remainder from manure management.

3.3.5 Hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride

HFCs, PFCs and SF₆ are often referred to together as F-gases. They are human-made chemicals mostly used in refrigeration and air conditioning, as well as in foams, aerosols, fire protection and solvents. Fluorinated gases can escape into the atmosphere during maintenance, through leaks from faulty or outdated equipment, or from some metal refining processes. These gases have long atmospheric lifetimes (decades for HFCs and millennia for PFCs and SF₆) and are potent greenhouse gases. Changes in the emissions of these gases between 1990 and 2020 have been relatively large (table 3.2).

In total, F-gases contributed 2.0 per cent of gross emissions in 2020. The IPPU sector is the only source of F-gases in New Zealand. Taken together, the emissions of HFCs, PFCs and SF₆ were 1,584.9 kt CO₂-e in 2020. Emissions of F-gases are dominated by HFCs (93.4 per cent of all F-gases). PFCs contributed 5.5 per cent and SF₆ contributed 1.1 per cent to total emissions of F-gases.

4 Policies and measures

Key developments since the *Seventh National Communication*

Targets

Aotearoa New Zealand is on track to meet its 2020 international greenhouse gas emissions target, based on the 2022 submission of its national Greenhouse Gas Inventory. This will be formally confirmed following the international expert review process.

New Zealand's first nationally determined contribution (NDC1) under the Paris Agreement was updated in 2021 to be compatible with global efforts to limit global warming to 1.5°C above pre-industrial levels. We have increased our ambition to reduce greenhouse gas emissions to 50 per cent below gross 2005 levels by 2030.

Policies and measures

In 2019, New Zealand enacted a legislative framework to reduce domestic emissions, increase removals and contribute to global efforts to limit temperature rise to 1.5°C, and assess risk and increase resilience. Key elements of this framework include:

- establishing He Pou a Rangi – Climate Change Commission to provide independent expert advice to the Government on climate change matters
- legislating long-term domestic emissions reduction targets for 2050
- implementing a system of emissions budgets that step progressively towards the 2050 targets; the first three emissions budgets were set in May 2022
- requiring the preparation and publication of emissions reduction plans that contain the policies and strategies for achieving emissions budgets; the first emissions reduction plan was published in May 2022
- requiring six-yearly national climate change risk assessments; the first risk assessment was published in August 2020
- requiring the preparation and publication of national adaptation plans that respond to the risk assessments; the first national adaptation plan was published in August 2022.

New Zealand established the He Waka Eke Noa – Primary Sector Climate Action Partnership to develop a system for measuring, managing and reducing agricultural greenhouse gas emissions, including an emissions pricing system. This partnership includes the Government, the primary sector and iwi and Māori.¹²⁸

The Government has legislated to bring agricultural emissions within an emissions pricing system by 2025, either through the New Zealand Emissions Trading Scheme or through an alternative system. This will mean that all domestic emissions in New Zealand are subject to emissions pricing.

New Zealand established the Carbon Neutral Government Programme to accelerate the reduction of emissions within the public sector.

The New Zealand Emissions Trading Scheme was reformed to implement an annually updated emissions cap, introduce an auctioning platform to sell units into the market, begin phasing-down free allocation, simplify some forestry provisions and improve its administration and transparency.

New Zealand passed legislation making climate-related disclosures mandatory for approximately 200 large financial market participants. These organisations include large publicly listed companies, insurers, banks, credit unions, building societies and investment managers.

¹²⁸ 'Iwi' – tribe, large group descended from a common ancestor.

4.1 Introduction

Aotearoa New Zealand is committed to achieving a low-emissions and climate-resilient economy. To achieve this, New Zealand has established a framework that drives climate change policy across Government.¹²⁹

The framework focuses on:

- leadership both domestically and internationally
- a productive, sustainable and climate-resilient economy
- a just and inclusive society.

The framework supports New Zealand's commitments under the Paris Agreement, which includes provisions on mitigation, adaptation and climate finance.

Under the Paris Agreement, New Zealand has set its first Nationally Determined Contribution (NDC1) headline target of reducing net emissions by 50 per cent below 2005 gross emissions by 2030. This target represents the highest possible ambition at this time for contributing to the global effort of limiting temperature rise to 1.5°C above pre-industrial levels. New Zealand's second NDC is due in 2025 to cover the period 2031–35.

Equally as important, New Zealand has adopted domestic emissions reduction targets for 2050 in its primary legislation – the Climate Change Response Act 2002. The 2050 targets will be met through a series of interim targets, known as emissions budgets.

For the first time, the Government has set domestic emissions budgets out to 2035, placing limits on the greenhouse gas (GHG) emissions that New Zealand can produce for each budget period.

New Zealand's first emissions reduction plan, published in May 2022, sets out how the first emissions budget will be met. The plan sets out a coherent and ambitious package of both strategic and sector-specific policies and measures needed to deliver the necessary emissions reductions to meet the first emissions budget, while putting New Zealand on track to achieve long-term targets.

The framework also supports New Zealand to prepare for and adapt to the impacts of climate change, with the first national adaptation plan for 2022–28 published in August 2022. The plan sets out both the Government's long-term adaptation strategy and Government-led strategies, policies and proposals that will help New Zealand adapt to the changing climate and its effects. See chapter 6 for further detail.

Guided by the framework, the Government's programme of work will continue to develop and implement policies that contribute to the global effort to limit temperature increase; and to allow New Zealand to prepare for and adapt to the effects of climate change.

¹²⁹ Minister for Climate Change. 2018. Framework for climate change policy and key upcoming decisions. Proposal to Cabinet Environment, Energy and Climate Committee. Retrieved from environment.govt.nz/assets/Publications/framework-for-climate-change-policy-and-key-upcoming-decisions.pdf (8 November 2022).

4.1.1 Key targets

New Zealand has set both domestic and international emissions reduction targets to drive its contribution to global efforts under the Paris Agreement to limit the global temperature rise to 1.5°C above pre-industrial levels.

Domestic targets

In 2019, the Climate Change Response Act 2002 (CCRA) was amended to include new domestic emissions reduction 2050 targets.¹³⁰ These legislated targets require:

- all GHGs, other than biogenic methane, to reach net zero by 2050
- a minimum 10 per cent reduction in biogenic methane emissions by 2030, and a 24 to 47 per cent reduction by 2050 (compared with 2017 levels).

International targets

2030 NDC target (2021–30)

Under the Paris Agreement, New Zealand has set a headline target for NDC1 to reduce net greenhouse gas emissions to 50 per cent below gross 2005 levels by 2030. The NDC1 target is economy-wide, covering all sectors and all greenhouse gases.¹³¹

2020 target (2013–20)

New Zealand set a target to reduce gross GHG emissions to 5 per cent below 1990 levels over the period 1 January 2013 to 31 December 2020.

This target is under the United Nations Framework Convention on Climate Change (UNFCCC) while applying the Kyoto Protocol framework of rules. This means we can meet this target through a combination of reducing our emissions, forestry activities and offshore mitigation.

We are on track to meet this target based on the 2022 submission of *New Zealand's Greenhouse Gas Inventory*. This will be formally confirmed following the international expert review process.

2012 target (2008–12)

In 2015 New Zealand met the previous target, under the first Kyoto Protocol commitment period, of reducing greenhouse gas emissions to 1990 levels between 2008 and 2012. New Zealand's 'True-up Report' to UNFCCC^{132, 133} provides detail on how the target was met.

New Zealand has pledged to take action in line with the undertakings of other countries and is committed by the Paris Agreement to increasing ambition following future periodic stocktakes undertaken as part of the Agreement. New Zealand will continue to regularly

¹³⁰ www.legislation.govt.nz/act/public/2002/0040/latest/whole.html#LMS282014.

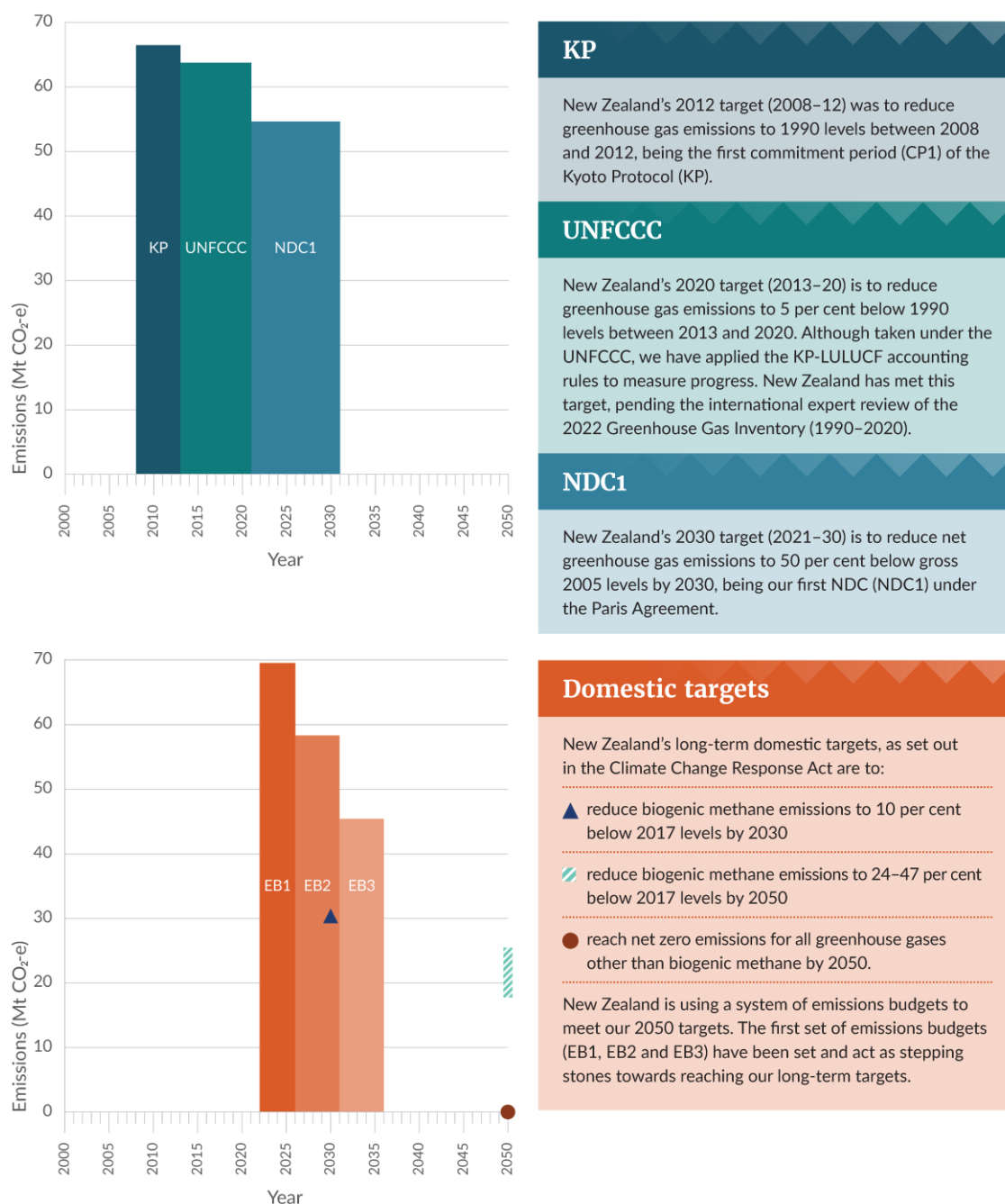
¹³¹ unfccc.int/sites/default/files/NDC/2022-06/New%20Zealand%20NDC%20November%202021.pdf.

¹³² environment.govt.nz/publications/report-upon-expiration-of-the-additional-period-for-fulfilling-commitments-by-new-zealand/.

¹³³ Ministry for the Environment. 2015. Report upon expiration of the additional period for fulfilling commitments by New Zealand. Retrieved from unfccc.int/files/kyoto_protocol/reporting/true-up_period_reports_under_the_kyoto_protocol/application/pdf/true-up_period_report_by_new_zealand_2015.pdf (8 November 2022).

review its contributions to international mitigation action, taking into account the latest science, development of new technologies, progress by other countries and the commitments New Zealand has made. In 2021, New Zealand updated its first NDC to be more consistent with the global efforts to limit global warming to 1.5°C above pre-industrial levels. New Zealand will report on the implementation and achievement of its NDC1 through the Paris Agreement’s Enhanced Transparency Framework.

Figure 4.1: New Zealand’s international and domestic emissions reductions targets



Note: Budget periods cover the years 2022–25 for EB1, 2026–30 for EB2 and 2031–35 for EB3. Target and budget periods end at 31 December. Biogenic methane is defined as the methane produced by the agriculture and waste sectors. Calculations use the IPCC’s Fourth Assessment Report (AR4).

4.2 Policy context for climate change actions

This section provides an overview of the climate change policy context for Aotearoa New Zealand. It sets out the relevant domestic legislation and outlines the country's key strategies to reduce emissions and increase removals.

4.2.1 Domestic legislation

Climate Change Response Act 2002

The Climate Change Response Act 2002 (CCRA) is New Zealand's primary climate change legislation. It provides the legal framework to enable New Zealand to meet its obligations under the UNFCCC, the Paris Agreement and the Kyoto Protocol. It also includes the framework for the New Zealand Emissions Trading Scheme (NZ ETS).

In 2019, amendments to the CCRA introduced the Zero Carbon Framework. Under this framework, New Zealand can develop and implement climate change policies that:

- contribute to global efforts under the Paris Agreement to limit the global average temperature increase to 1.5°C above pre-industrial levels and
- allow New Zealand to prepare for, and adapt to, the impacts of climate change.¹³⁴

The 2019 amendments:

- established He Pou a Rangi – Climate Change Commission (the Commission)¹³⁵ to:
 - provide independent advice to the Government on climate change mitigation and adaptation
 - monitor and review the Government's progress towards meeting the emissions budgets and 2050 targets, as well as the implementation of emissions reduction and national adaptation plans
- set new domestic emissions reduction targets for 2050
- established a system of emissions budgets to step New Zealand towards these 2050 targets
- require the development of an emissions reduction plan for each budget period that sets out the policies and strategies for achieving the emissions budget
- require the Commission to prepare a national climate change risk assessment every six years¹³⁶
- require the Government to develop a national adaptation plan that responds to the Commission's risk assessment.

¹³⁴ Chapter 6 provides further detail on the adaptation components of the CCRA.

¹³⁵ The Climate Change Commission was established in December 2019.

¹³⁶ The Government prepared the first national climate change risks assessment. Progress reports and subsequent risk assessment are to be prepared by the Climate Change Commission.

Comprehensive review of the Resource Management Act 1991

The Resource Management Act 1991 (RMA) is the primary legislation governing the use of New Zealand's land, water and air resources, and is also administered by the Ministry for the Environment. The RMA currently requires anyone exercising and functioning powers under it to have regard to the effects of climate change.

The current provisions in the RMA do not enable the consideration of the climate change effects of greenhouse gas emissions. On 30 November 2022, the Resource Management Amendment Act 2020 will require local authorities to consider the climate change effects of greenhouse gases.

The resource management system is being reformed and will be replaced with three new acts: the Natural and Built Environments Act, the Spatial Planning Act and the Climate Adaptation Act. The Climate Adaptation Act will address complex issues associated with managed retreat, and funding and financing climate adaptation. The Natural and Built Environments Bill and Spatial Planning Bill are expected to be introduced to Parliament later in 2022. The Climate Adaptation Bill is likely to follow at the end of 2023.

4.2.2 Key strategies to reduce emissions and increase removals

Emissions budgets and Aotearoa New Zealand's first emissions reduction plan

Aotearoa New Zealand's first three emissions budgets

Aotearoa New Zealand's contribution to the global effort to limit temperature rise to 1.5°C above pre-industrial levels underpins and drives New Zealand's long-term targets, which in turn will be achieved through a series of interim targets – known as emissions budgets.

An emissions budget is a total quantity of greenhouse gas emissions that is permitted during a five-year period, or four years in the case of the first emissions budget (2022–25). Emissions budgets will get smaller over time and will help New Zealand progressively step towards the 2050 targets. An emissions reduction plan will be prepared for each emissions budget period and will set out the policies and strategies needed to achieve the upcoming emissions budgets and, ultimately, the 2050 targets.

On 31 May 2021, the Commission delivered advice to the Government in its report *Ināia tonu nei: A low emissions future for Aotearoa*. The Commission's report provided recommendations on the first three emissions budgets, policy direction for the first emissions reduction plan, New Zealand's 2030 NDC and reductions required for biogenic methane.

As required by the CCRA, the Minister of Climate Change set New Zealand's first three emissions budgets for 2022–25, 2026–30 and 2031–35 in May 2022 (table 4.1).

Table 4.1: Aotearoa New Zealand’s first three emissions budgets (Mt CO₂-e)

	First emissions budget (2022–25)	Second emissions budget (2026–30)	Third emissions budget (2031–35)
All gases, net (AR5)	290	305	240
Annual average	72.5	61.0	48.0

Note: Emissions in million tonnes of carbon dioxide equivalent (Mt CO₂-e) are based on the global warming potential (GWP)100 metric values from the Intergovernmental Panel on Climate Change’s (IPCC) *Fifth Assessment Report* (AR5).

Sector sub-targets

For the first three emissions budgets, the Government has set sector sub-targets to track progress across key sectors over each emissions budget period. Unlike emissions budgets, these sub-targets are not legislated.

The Climate Change Chief Executives Board (the Board) is responsible for monitoring and reporting on overall progress towards the emissions budgets, including sector sub-targets. This will involve advising on how to adjust policy settings to manage variances within – and between – sector sub-targets to support meeting the overall emissions budgets.

Aotearoa New Zealand’s first emissions reduction plan

In May 2022, the Government published New Zealand's first emissions reduction plan (mapped below), setting out the policies and strategies for how New Zealand will meet its first emissions budget and ultimately the 2050 targets.

These policies and strategies form a coherent, strategic package with a mutually supportive and balanced mix of emissions pricing, well-targeted regulations, tailored sectoral policies, direct investment (public and private), innovation and mechanisms to meet our climate targets, while supporting an equitable transition to a low-emissions economy.

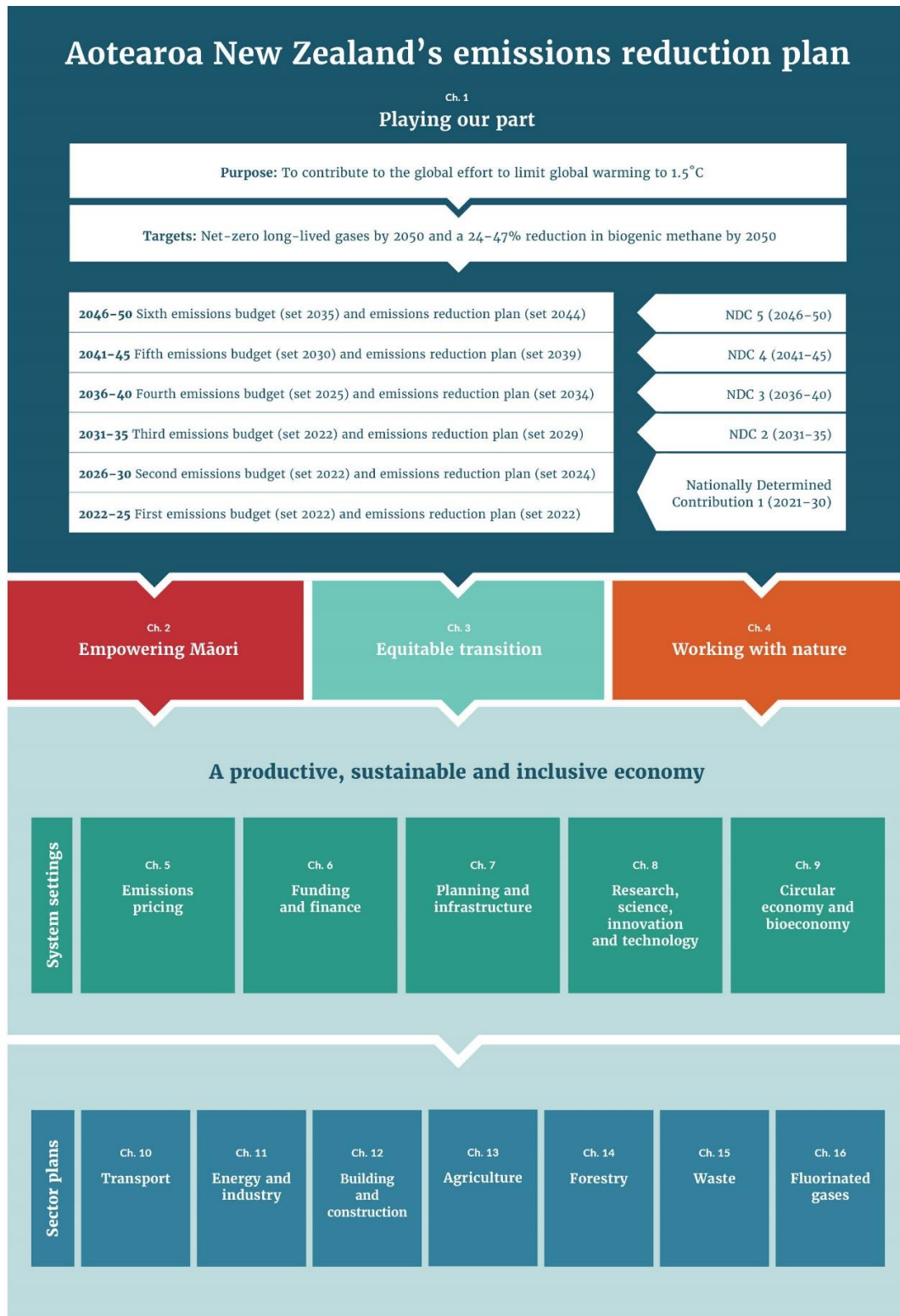
Future emissions reduction plans will continue to build on these policies and strategies, and the mix of policy tools will change over time, responding to changing circumstances. The next emissions reduction plan for the 2026–30 period is to be published by the end of 2024.

Figure 4.2 gives an overview of New Zealand’s first emissions reduction plan. It sets out several of the plan’s guiding principles, its systems approach and sector plans.

See the [emissions reduction plan](#) for more information.¹³⁷

¹³⁷ Ministry for the Environment. 2022. *Te hau mārohi ki anamata: Towards a productive, sustainable and inclusive economy – Aotearoa New Zealand’s First Emissions Reduction Plan*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/emissions-reduction-plan.

Figure 4.2: Aotearoa New Zealand’s emissions reductions strategy



Empowering Māori

An approach to climate policy that empowers Māori is a guiding principle in the emissions reduction plan. Climate change, and our response to it, has the potential to affect all aspects of Māori life. Tangata whenua (people of the land) are especially vulnerable to the effects of climate change and there are particular risks and opportunities for the Māori economy in the transition.

Māori are kaitiaki (guardians) of their whenua (land), leaders in their communities, decision-makers about resources and infrastructure, land owners and business owners. Māori will help lead the transition in each of these roles. Mātauranga Māori (Māori knowledge systems and world views) will help us learn and better inform our decision-making.

An equitable transition for Māori, led by Māori, will require new funding approaches and strengthened Crown–Māori relationships and capability to work together as partners through our climate response.

Key actions in the emissions reduction plan

Establish a platform for Māori climate action that will:

- embed partnership and representation – to uphold Te Tiriti of Waitangi principles, processes and mechanisms will be resourced and designed alongside Māori to help tangata whenua to actively participate in the climate response
- support Māori-led strategy and alignment – to elevate te ao Māori (the Māori world) within the climate response, Māori will be supported to define, measure and implement a Māori climate strategy and action plan
- activate kaupapa Māori (Māori approach or customary practice), tangata Māori (Māori people) solutions – to enable community action, kaupapa Māori, tangata Māori actions and solutions for the climate emergency will be funded.

Equitable transition

Achieving an equitable transition to a low-emissions economy is another guiding principle in the emissions reduction plan.

Under the Paris Agreement, the Government has agreed to “take into account the imperatives of a just transition of the workforce and the creation of decent work and quality jobs...”. The Government also signed the ‘Supporting the Conditions for a Just Transition Internationally’¹³⁸ declaration at the 26th United Nations Climate Change Conference of the Parties.

The CCRA requires the emissions reduction plan to include a strategy to mitigate the impacts that reducing emissions and increasing removals will have on employees and employers, regions, iwi and Māori, and wider communities, including the funding for any mitigation action.

The Government’s strategy to mitigate the impacts for these groups is built around the following objectives.

¹³⁸ UN Climate Change Conference UK 2021. 2021. Supporting the Conditions for a Just Transition Internationally. Retrieved from: ukcop26.org/supporting-the-conditions-for-a-just-transition-internationally/ (24 November 2022).

Objectives

Seize the opportunities of the transition, including new business and job opportunities.

Support proactive transition planning with industries, workers, iwi and Māori, regions, small and medium businesses, and communities.

Enable an affordable and inclusive transition, particularly for those least able to respond.

Build the evidence base and tools to monitor and assess impacts to enable timely and well-evidenced policy responses.

Encourage informed public participation, to support an active, engaged and informed public willing to advocate for and take up actions consistent with a low-emissions society.

Refer to section 4.4 for the actions to achieve these five objectives.

Working with nature

The emissions reduction plan is an opportunity to use nature-based solutions to tackle the climate emergency and to design our response to the climate crisis in a way that protects, enhances and restores nature where possible.

Through engagement with tangata whenua, the Government has heard the call for a kaupapa Māori approach to climate change. A kaupapa Māori approach requires a holistic view, in which our efforts to reduce emissions and promote climate resilience support wider outcomes for te taiao (the environment) and people at the same time.

In New Zealand and around the world, biodiversity is rapidly declining and has reached a crisis point.

Key actions in the emissions reduction plan

- Prioritise nature-based solutions in our planning and regulatory system.
- Establish an integrated work programme that delivers climate, biodiversity and wider environmental outcomes.
- Report on biodiversity as part of emissions reduction plan reporting.
- Encourage global efforts to use nature-based solutions.

*Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy 2020*¹³⁹ sets out the national vision for biodiversity for the next 30 years. The Biodiversity Strategy recognises that, for our native wildlife to thrive, we need to address the climate and biodiversity crises at the same time.

A systems approach

The emissions reduction plan details how we will ensure our system settings also foster low-emissions development and support New Zealand's transition to a low-emissions economy. Table 4.2 provides a short overview of the key actions we are taking on across the whole economy.

¹³⁹ Department of Conservation. 2020. *Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy 2020: Summary*. Wellington: Department of Conservation. Retrieved from www.doc.govt.nz/nature/biodiversity/aotearoa-new-zealand-biodiversity-strategy/te-mana-o-te-taiao-summary/ (9 November 2011).

Table 4.2: System settings – key actions

Settings	Key actions
Emissions pricing	<ul style="list-style-type: none"> Implement emissions pricing for agriculture Align the New Zealand Emissions Trading Scheme unit and price controls with climate goals Adjust the New Zealand Emissions Trading Scheme to drive a balance of gross and net emissions reductions
Funding and finance	<ul style="list-style-type: none"> Establish the Climate Emergency Response Fund (with initial down payment of NZ\$4.5 billion) Support climate objectives by issuing Sovereign Green Bonds Improve transparency and management of climate risks through mandatory climate reporting
Planning and infrastructure	<ul style="list-style-type: none"> Reform the resource management system to promote lower emissions and climate resilience Enable low-emissions and resilient housing and urban development Address funding and financing challenges for infrastructure to support low-emissions urban environments
Research, science, innovation and technology	<ul style="list-style-type: none"> Develop a portfolio of climate innovation platforms Support the development, assessment and deployment of low-emissions technology Scale up and reorient existing initiatives towards accelerating our transition to a low-emissions economy
Circular economy and bioeconomy	<ul style="list-style-type: none"> Accelerate the supply and uptake of bioenergy Support businesses moving to circular practices Develop a circular economy and bioeconomy strategy

Note: In a circular economy, we design out waste and pollution, keep resources in use for as long as possible, then recover and regenerate products and materials at the end of their life cycle.

Sector plans

Every sector will need to play a role in reducing emissions. The emissions reduction plan includes sector plans, detailing the policies and strategies that will reduce emissions and increase removals. Key policies and strategies from the emissions reduction plan are reflected in section 4.3.

Meeting the first emissions budget requires New Zealand to make sustained cuts in gross emissions, as well as storing carbon through forestry. In the first emissions budget period, it is likely that the most significant emissions reductions will be in the transport, energy and industry sectors.

Productivity Commission

The New Zealand Productivity Commission – Te Kōmihana Whai Hua o Aotearoa is an independent Crown entity that provides advice to the Government on improving New Zealand’s productivity.

In 2018, the Productivity Commission released the *Low-emissions Economy*¹⁴⁰ report, which included 173 findings and 77 recommendations. Among the recommended changes, it emphasised three particular changes that must happen for New Zealand to achieve its low-emissions goals, while continuing to grow incomes and wellbeing:

- transition from fossil fuels to electricity and other low-emissions fuels across the economy
- substantial afforestation
- changes to the structure and methods of agricultural production.

The report found that it is necessary to act quickly and that delaying the transition will make it more costly. In 2019, the Government released its climate action plan¹⁴¹ in response to the Productivity Commission’s report.

The emissions reduction plan builds on the *Low-emissions Economy* report and the climate action plan 2019.

Aotearoa New Zealand’s first national adaptation plan

In August 2022, Aotearoa New Zealand released its first national adaptation plan 2022–28 in response to the risks identified in the National Climate Change Risk Assessment 2020.

The emissions reduction plan and the national adaptation plan are both key strategies and are interlinked. For further details on adaptation, refer to chapter 6.

See the [national adaptation plan](#) for more information.

4.3 Policies and measures, and their effects

This section outlines Aotearoa New Zealand’s key policies and measures to reduce emissions and increase removals. It begins by setting out cross-cutting policies and measures before describing those that are sector specific.

In preparing this chapter, priority has been given to policies and measures – or combinations of policies and measures – that have the most significant impact on greenhouse gas emissions and removals, or that support an equitable transition, are innovative or are easy for other parties to replicate.

Many of the sector-specific policies and initiatives set out in this section have been drawn from New Zealand’s first emissions reduction plan.

¹⁴⁰ Productivity Commission. 2018. *Low-emissions Economy*. Wellington: Productivity Commission. Retrieved from productivity.govt.nz/assets/Documents/4e01d69a83/Productivity-Commission_Low-5emissions-economy_Final-Report.pdf.

¹⁴¹ Ministry for the Environment. 2019. *Transitioning to a Low-emissions Future: The Government response to the Productivity Commission’s Low Emissions Economy report*. Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate-change/transitioning-low-emissions-future-government-response-productivity.

4.3.1 Cross-cutting policies and measures

New Zealand Emissions Trading Scheme

The NZ ETS has been New Zealand's primary emissions pricing tool since its inception in 2008. It requires upstream entities, such as fuel suppliers and emitters with process emissions, to surrender emissions units (New Zealand Units or NZUs) to the government for their activities. It also rewards entities that remove carbon from the atmosphere, which for New Zealand is predominantly through forestry. Entities that embed or export greenhouse gases where those emissions had been priced by the NZ ETS as if they would occur in New Zealand are also entitled to emissions units.

Each NZU represents one tonne of carbon dioxide equivalent and is provided to the NZ ETS market through three channels: government auctions, units earned by entities performing removal activities, and free units to eligible industries (industrial allocation). Once units have been allocated to the market, they can be traded on the secondary market with the price being set by supply and demand at a point in time.

The NZ ETS is a form of 'cap-and-trade' scheme. Its power comes from both pricing emissions and removals and covering emissions with a 'cap' – or limit – on the tonnes of net emissions that can be emitted annually. Over time this cap will decrease in alignment with emission budgets, reducing the supply of NZUs available for auctioning. The reducing cap on net emissions shapes future economic development by encouraging alignment of investment decisions with a low-carbon economy and influencing technology choices towards low-emissions alternatives.

The NZ ETS creates a price signal on domestic emissions within the stationary energy, liquid fossil fuel, industrial process, synthetic greenhouse gas, waste, and forestry sectors.¹⁴² Emissions from the agriculture sector (approximately 50 per cent of New Zealand's emissions)¹⁴³ are outside the NZ ETS. Additionally, two-thirds of waste,¹⁴⁴ one-third of synthetic greenhouse gases,¹⁴⁵ and other small sources of gross emissions are excluded from the NZ ETS to reduce administrative costs or to address measurement uncertainties.

NZ ETS settings for forestry have been designed to align with international target accounting rules. Emissions and removals depend on the forest type and if the forest existed before or after 1990. Exotic forests established prior to 31 December 1989 (known as pre-1990 forests) cannot earn NZ ETS emissions units from forest growth, but units are required to be surrendered if the forest is deforested. Forests, exotic or indigenous, established from 1 January 1990 (known as post-1989 forests) have the option of entering the NZ ETS and can earn units for emissions removals from the forest's growth. Emissions units are required to be surrendered if the forest is deforested, and depending on the accounting methodology used, emissions units may need to be surrendered if the forest is harvested. Approximately 55 per cent of the post-1989 forest estate is in the NZ ETS.

¹⁴² NZ ETS coverage is defined slightly differently from IPCC sectors.

¹⁴³ The agricultural sector has reporting requirements in the NZ ETS but no surrender obligations. Work is ongoing to price emissions in the agricultural sector and decisions are yet to be made as to what form this will take.

¹⁴⁴ Only waste emissions from managed landfills are within the NZ ETS. Emissions from unmanaged sites, or wastewater treatment plants are not within the scheme.

¹⁴⁵ These are instead covered by a levy if they are contained in imported goods (eg, refrigerated truck, air conditioning unit).

International linking

Prior to May 2015, some types of international emissions units issued under the Kyoto Protocol could be imported and surrendered to cover NZ ETS obligations. The NZ ETS closed to international markets and became a domestic-only scheme in 2015 once the true-up for the first commitment period under the Kyoto Protocol was completed.

In 2021 New Zealand increased its NDC (NDC1) to a 50 per cent reduction of net emissions below New Zealand's gross 2005 levels by 2030. To meet NDC1, domestic action will be prioritised; however, offshore mitigation will still be needed. New Zealand is exploring a range of options to source offshore mitigation with environmental integrity, and that prioritises partnering with countries in the Asia-Pacific region in ways that promote sustainable development outcomes and resilience. New Zealand is also exploring linking the NZ ETS to international markets with environmental integrity.

Recent changes to the NZ ETS

In 2020 the NZ ETS was amended¹⁴⁶ to include an auctioning platform, the removal of the Fixed Price Option (FPO)¹⁴⁷, the inclusion of a flexible cap on NZ ETS net emissions, a phase-out of industrial allocation, the introduction of averaging accounting for forestry, and other technical changes including improvements to market transparency.

The Government is considering the recommendations¹⁴⁸ of the Climate Change Commission to amend the NZ ETS to strengthen the incentives for gross emissions reductions and manage the amount of exotic forestry driven by the scheme. It has agreed in principle to those recommendations subject to ongoing policy analysis. There are also many other areas of active work ongoing, including reforming industrial allocation, market governance, and permanent forestry.

NZ ETS implementation costs

The approximate cost of implementing and administering the NZ ETS since 2008 is NZ\$110.9 million. The budgeted NZ ETS implementation and administration costs borne by Government, as budgeted for the 2021/22 financial year, were approximately NZ\$6.5 million.¹⁴⁹ This only includes costs incurred by the Ministry for the Environment and the Environmental Protection Authority – Te Mana Rauhi Taiao.

¹⁴⁶ Through the Climate Change Response (Emissions Trading Reform) Amendment Act 2020.

¹⁴⁷ Previously NZ ETS participants could meet their surrender obligations through a fixed price of NZ\$25 for emissions occurring prior to and including the 2019 calendar year, or NZ\$35 for 2020 calendar year emissions.

¹⁴⁸ Recommendations 11.1 and 25.2a.

¹⁴⁹ Vote Environment 2021/22. Retrieved from www.treasury.govt.nz/sites/default/files/2021-05/est21-v3-envir.pdf (accessed 9 November 2022).

Key actions in the emissions reduction plan

- Align NZ ETS settings with emissions budgets.
- Adjust the NZ ETS to drive an appropriate balance of gross and net emissions reductions.
- Develop an overarching market governance framework.
- Align emissions leakage policies with current and future climate response.
- Develop a voluntary carbon market framework.
- Price agricultural emissions informed by recommendations from He Waka Eke Noa – Primary Sector Climate Action Partnership

Dedicated funding and finance initiatives

The Government has a responsibility to use its funds wisely. The public and private sectors need to work together to provide the funding and financing that will be necessary to reduce our emissions. This approach to funding and financing will complement other measures to drive emissions reductions, such as regulation.

Climate Emergency Response Fund

In Budget 2022 the Government established its Climate Emergency Response Fund (CERF), a Budget funding mechanism to support the Government's climate spending. The CERF was established using the cash proceeds from New Zealand's Emissions Trading Scheme over the period from 2022/23 to 2025/26 as a down payment. The CERF was initially established at NZ\$4.5 billion and to date has provided NZ\$3.7 billion for climate-related spending initiatives. The Minister of Finance has signalled an intention to continue using ETS cash proceeds to support climate investment, and to provide additional funding for high-value initiatives.

New Zealand's Sovereign Green Bond Programme

New Zealand's Sovereign Green Bond Programme launched in 2022, providing the opportunity to invest in projects that contribute to climate and environmental objectives. Green Bonds provide financing to advance climate change and environmental priorities like the transition to clean transport and support for biodiversity. The bonds are a way to recognise green public sector projects already planned or under way that meet internationally recognised standards for eligibility, selection and reporting.

Green Bonds do not mean taking on new debt over and above the Government's existing borrowing; they will be issued as part of the overall forecast core Crown borrowing programme. Money raised from the bonds will be used to support projects that help reach the Government's pledge to reduce net greenhouse gas emissions by 50 per cent by 2030 and reach its net zero carbon target by 2050. New Zealand Debt Management at the Treasury is leading work on the Green Bond Programme. Subject to market conditions, the inaugural issuance is expected in late 2022.

New Zealand Green Investment Finance Ltd

New Zealand Green Investment Finance (NZGIF) is a Crown-owned investment vehicle established in April 2019, and was operational from September of that year. Established with an initial investment capital of NZ\$100 million from the Government, it was recapitalised to NZ\$400 million in Budget 2021. NZGIF has a mandate to invest in commercial opportunities

that accelerate the reduction in domestic greenhouse gas emissions and provide a commercial return on the investment. It will seek to crowd in industry, investment houses and other sources of private finance to develop large-scale projects in areas such as transport, industrial process heat, waste, plastics, the built environment and agriculture.

Climate-related disclosures

New Zealand became the first country in the world to require annual public disclosure of climate-related risks and opportunities when it passed the Financial Sector (Climate-related Disclosures and Other Matters) Amendment Act in 2021. This legislation, which applies to large publicly listed companies, insurers, banks, credit unions, building societies and investment managers, ensures that the effects of climate change are routinely considered in business, investment, lending and insurance decisions.

State Sector Decarbonisation Fund

In December 2019, the New Zealand Government launched the State Sector Decarbonisation Fund (SSDF) to help reduce the estimated 490,000 tonnes of carbon dioxide equivalent (CO₂-e) annually emitted across the state sector. The NZ\$219.5 million fund is administered by the Energy Efficiency and Conservation Authority (EECA). EECA works with the state sector to provide expert advice and technical support, and to facilitate low-emissions energy investments.

The SSDF supports the Carbon Neutral Government Programme (CNGP) and aims to help numerous organisations within the public sector to be carbon neutral from 2025. SSDF investment focuses on replacing fossil-fuelled boilers across the state sector and particularly in hospitals and tertiary institutions with low-emissions alternatives, such as biomass boilers and heat pumps. EECA also works with the Ministry of Education to replace coal boilers in schools. With the support from the SSDF, it was announced that all coal boilers across New Zealand schools will be replaced with low-emissions alternatives by 2025. Other priorities are to support the replacement of vehicle fleets with electric vehicles, install energy-efficient chillers and install LED lighting.

As of August 2022, NZ\$137.4 million of capital funding has been allocated across 10 tranches, supporting 86 decarbonisation projects across the state sector. It is estimated that this will reduce the state sector's carbon emissions by around 43,292 tonnes per annum.

Public sector leadership

While government agencies are only responsible for 2 per cent of New Zealand's energy-related emissions, the transition to a low-emissions economy calls for the Government to demonstrate the action required to accelerate the transition and influence New Zealanders to do the same.

Carbon Neutral Government Programme

The Carbon Neutral Government Programme (CNGP) has been set up to accelerate the reduction of emissions within the public sector. The programme's aim is to make a number of organisations within the public sector carbon neutral from 2025. It was launched in December 2020. The CNGP is a cross-government programme led by the Ministry for the Environment (MfE) in partnership with EECA and the Ministry of Business, Innovation and Employment (MBIE).

CNGP organisations should:

- measure, verify and report their emissions annually
- set gross emissions reduction targets and longer-term reduction plans
- introduce a plan to reduce their organisation's emissions
- offset any remaining gross emissions from 2025.

Emissions measurement and reporting by CNGP participants is being implemented in a phased manner.

By December 2022, all departments, departmental agencies and non-public service departments will report on their emissions and publish reduction plans, including gross emissions reduction targets, from the 2021/22 financial year.

By December 2023, all Crown agents are to report emissions, and publish reduction plans from the 2022/23 financial year. Further, the Reserve Bank of New Zealand, offices of Parliament, state-owned enterprises and tertiary institutions (including the New Zealand Institute of Skills and Technology) are encouraged to report their emissions and publish reduction plans from the 2022/23 financial year.

Emissions reduction targets will be reviewed in 2025, 2028 and 2030 to ensure they are ambitious and practicable. Guidance, tools, training and support are provided to CNGP organisations.

The initial priorities for emissions reductions are to:

- phase out coal-fired boilers from the public sector, with a focus on removing the largest by the end of 2025
- optimise the size of agencies'¹⁵⁰ light vehicle¹⁵¹ fleets and purchase battery electric vehicles, or plug-in hybrid electric vehicles if a full electric vehicle is not appropriate, unless there are operational requirements or other circumstances that prevent them from doing so
- requiring the use of the National Australian Built Environment Rating System New Zealand (NABERSNZ), to promote energy efficient government office accommodation, by agencies¹⁵² that occupy large office spaces (over 2,000m²)¹⁵³
- requiring agencies¹⁵⁴ to use an approved sustainable building rating system, when building a new non-residential government owned building with an estimated capital value of \$9 million and over.

¹⁵⁰ This requirement applies to agencies that must follow the Government Procurement Rules.

¹⁵¹ Light vehicles are defined as those that weigh 3,500 kilograms or less.

¹⁵² This requirement applies to those agencies that are subject to the Government Property System Leadership mandate.

¹⁵³ Agencies entering a new lease or renewing an existing lease should target the building achieving a minimum of a 4 star NABERSNZ rating. Agencies planning a new build project need the building to achieve a minimum 5 star NABERSNZ rating.

¹⁵⁴ This requirement applies to agencies that must follow the Government Procurement Rules.

The State Sector Decarbonisation Fund and/or the Government Investment in Decarbonising Industry (GIDI) Fund managed by EECA can be available to organisations seeking financial support for decarbonisation projects.

The CNGP is collaborating closely with the Building for Climate Change programme and New Zealand Government Procurement (both within MBIE). Through the CNGP, the Government and wider public sector are collectively showing leadership in reducing and offsetting emissions from their activities.

Sustainable government procurement

The Procurement System Lead is responsible for leading and coordinating best-practice procurement across government. New Zealand Government Procurement, a branch within MBIE, supports the Procurement System Lead to undertake this role. Government spends approximately NZ\$51.5 billion through procurement each year; providing an opportunity to achieve positive social, economic, cultural and environmental outcomes through its procurement activities.

The New Zealand Government is committed to designing waste out of the system. Rule 20 of the Government Procurement Rules sets an expectation that agencies:

- procure low-emissions and low-waste goods, services and works
- encourage innovation to significantly reduce emissions and waste impacts from goods and services.

As major procurers of building and construction projects, government agencies have significant influence. The Procurement System Lead has published a procurement guide to reducing carbon emissions in building and construction, which:

- provides practical guidance to support government agencies to lead the way in reducing carbon emissions generated by the construction of new government buildings
- sets an expectation that agencies should choose the lowest carbon option that meets the project requirements.

Climate implications of policy assessment

From November 2019, it became mandatory for central government agencies to do a greenhouse gas emissions analysis on certain policy proposals. The requirement will enable New Zealand to measure, monitor and report on Cabinet decisions that will impact New Zealand's greenhouse gas emissions.

Climate innovation platforms

To accelerate emissions reductions, the Government is working towards establishing climate innovation platforms to coordinate action on key challenges and take opportunities in our shift to a low-emissions future. The platforms will improve the competitiveness of existing sectors, grow new ones and reduce emissions simultaneously. The approach is intended to be established and built upon by late 2023.

Climate innovation platforms will be:

- outcomes focused – they will be designed around a specific goal
- international-facing – they will look for innovation and investment both at home and from across the world

- designed to help New Zealand absorb climate innovation at pace – with a mandate stretching across different agencies and sectors to identify and remove barriers to testing and widespread use of innovations
- flexible and open to change as the global environment changes.

This all-of-government approach will use a wide range of tools and approaches, including proactive policy, regulatory settings and innovation tools, to ensure that ideas from New Zealand and around the world can be implemented quickly. The nature of individual platforms and exact mix of government support (including but not limited to research and development support, international partnerships, training and skills development, and sector regulatory and policy changes) will depend on the particular challenge the platform is addressing.

The Government will take a portfolio approach – in which a range of initiatives are pursued at the same time, and support is boosted for the most promising ones – to adapt to changing priorities and levels of uncertainty as New Zealand progresses to a low-emissions future. The portfolio will engage across all areas of the economy to develop future-focused platforms, including working closely with the private sector to ensure the platforms have optimum impact.

4.3.2 Energy

In 2020, the energy sector was responsible for 23 per cent of New Zealand’s total gross emissions.¹⁵⁵

New Zealand’s energy system is highly renewable by international standards. Just over 40 per cent of our total primary energy supply¹⁵⁶ and nearly 28 per cent of our total final energy consumption¹⁵⁷ comes from renewable energy sources.

The Government’s 2050 vision for energy and industry is for New Zealand to have a highly renewable, sustainable and efficient energy system supporting a low-emissions economy.

- Energy will be accessible and affordable and will support the wellbeing of all New Zealanders.
- Energy supply will be secure, reliable and resilient, including in the face of global shocks.
- Energy systems will support economic development and an equitable transition to a low-emissions economy.

To achieve this future, New Zealand needs to move away from fossil fuels and shift towards increased renewable electricity generation, and the development and use of other low-emissions fuels. A well-planned transition can help reduce energy costs for businesses and New Zealanders, increase energy independence and create high-wage jobs in areas such as hydrogen, bioenergy and electrification. It can also be an opportunity to improve our productivity as we adopt clean technologies and improve energy efficiency.

¹⁵⁵ Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020/ (10 November 2022).

¹⁵⁶ Total primary energy supply is the amount of energy available for use in New Zealand, accounting for imports and exports.

¹⁵⁷ Total final energy consumption is the total energy consumed by end users, such as households and industry. It excludes energy that the energy sector uses itself, energy transformation and distribution losses.

In order to achieve this vision, the emissions reduction plan sets out actions across five interdependent focus areas. These actions complement the NZ ETS. They are designed to address barriers in responding to the emissions price and minimise impacts on households, businesses, communities and Māori, while unlocking health and other benefits.

Key actions in the emissions reduction plan

Set a strategy and targets to guide us to 2050 by:

- setting a target for 50 per cent of total final energy consumption to come from renewable sources by 2035
- developing an energy strategy to address strategic challenges in the energy sector and signal pathways away from fossil fuels.

Reduce emissions and energy use in industry by:

- supporting industry to improve energy efficiency, reduce costs and switch from fossil fuels to low-emissions alternatives through the GIDI Fund and EECA's business programmes
- banning new low- and medium-temperature coal boilers and phasing out existing ones by 2037 through a national direction for industrial greenhouse gas emissions.

Reduce our reliance on fossil fuels and exposure to volatile global fuel markets, and support the switch to low-emissions fuels by:

- setting a pathway to reduce reliance on fossil gas through a Gas Transition Plan
- increasing access to low-emissions fuels, including developing a Hydrogen Roadmap.

Ensure the electricity system is ready to meet future needs by:

- investigating options for electricity storage in dry years through the New Zealand Battery Project and investigating the need for electricity market measures to support the transition to a highly renewable electricity system
- developing regulatory settings to enable investment in offshore renewables, energy and innovation
- reducing barriers to developing and efficiently using electricity infrastructure, including transmission and distribution networks
- supporting renewable and affordable energy in communities through the Māori and Public Housing Renewable Energy Fund¹⁵⁸ and the Community Energy Fund.

Use energy efficiently, lower costs and manage demand for energy by:

- improving business and consumer energy efficiency through programmes such as Equipment Energy Efficiency (E3),¹⁵⁹ Gen Less¹⁶⁰ and Support for Energy Education in Communities¹⁶¹
- helping low-income New Zealanders have warmer, drier homes through Warmer Kiwi Homes.¹⁶²

¹⁵⁸ www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/low-emissions-economy/energy-efficiency-in-new-zealand/maori-and-public-housing-renewable-energy-fund

¹⁵⁹ www.eeca.govt.nz/regulations/equipment-energy-efficiency/about-the-e3-programme

¹⁶⁰ genless.govt.nz/

¹⁶¹ www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-hardship/support-for-energy-education-in-communities-programme

¹⁶² www.eeca.govt.nz/co-funding/insulation-and-heater-grants/warmer-kiwi-homes-programme

Strategic approaches to manage the phase-out of fossil fuels

Aotearoa New Zealand Energy Strategy

The Government is developing an Aotearoa New Zealand Energy Strategy to support the transition to a low-carbon economy, address strategic challenges in the energy sector and signal pathways away from fossil fuels.

The strategy will reflect the Government's vision for the energy and industry sectors that, by 2050, New Zealand has a highly renewable, sustainable and efficient energy system that is accessible and affordable, secure and reliable, and supports the wellbeing of New Zealanders.

The Energy Strategy will help set the pathways to navigate our way through the energy trilemma¹⁶³ and to provide certainty for the sector, industry and consumers. It will set the direction for New Zealand's pathway away from fossil fuels, towards greater levels of renewable electricity and other low-emissions alternatives.

Scoping work is under way. MBIE will collaborate and engage with Treaty partners and work with energy system stakeholders to develop it by the end of 2024.

Gas Transition Plan

The Government will develop a gas transition path by the end of 2023. This will set out a transition pathway for the fossil gas industry, explore opportunities for renewable gases and contribute to an equitable transition as we reduce our reliance on fossil gas. The Gas Transition Plan will be an input to the Energy Strategy.

New Zealand Energy Efficiency and Conservation Strategy 2017–2022

The current New Zealand Energy Efficiency and Conservation Strategy (NZECS) 2017–2022 sets the overarching policy direction for government support and intervention for promoting energy efficiency, energy conservation and the use of renewable sources of energy.

In December 2021 the Minister of Energy and Resources decided that a new five-year energy efficiency and conservation strategy should be developed to replace the existing strategy.

This new strategy will better align with the Government's climate change and energy system priorities. It is intended that the new NZECS will complement, and integrate with, the broader Energy Strategy.

Hydrogen Roadmap

The Government will develop a Hydrogen Roadmap for New Zealand by 2023. This roadmap will build on the *Vision for Hydrogen in New Zealand*, published in September 2019, to set a strategy guiding investment in hydrogen, and maximising economic benefits and emissions reductions.

The Government is also reviewing and evaluating current hydrogen regulatory settings to ensure they are fit-for-purpose for new hydrogen technologies and novel applications of hydrogen, and consistent with international best-practice standards.

¹⁶³ Energy security, energy equity and environmental sustainability.

Programmes regulating energy efficiency

Equipment Energy Efficiency programme

As noted in previous National Communications, New Zealand and Australia have a trans-Tasman Equipment Energy Efficiency (E3) programme, which develops standards and measures for energy efficiency in both countries. The E3 programme aims to increase the energy efficiency of new appliances and equipment sold in Australia and New Zealand, thereby reducing energy consumption and associated greenhouse gas emissions.

Inefficient appliances are kept out of the country through administering and developing Minimum Energy Performance Standards (MEPS) and Mandatory Energy Performance Labelling (MEPL) requirements, also allowing consumers to make more informed purchasing decisions. The Energy Efficiency (Energy Using Products) Regulations 2002 are used to implement the MEPS and MEPL requirements in New Zealand with ongoing development of MEPS and MEPL for a range of commonly used residential, commercial and industrial electrical products.

Minimum energy performance standards

Under the MEPS regulations, new products entering the market must meet or exceed minimum energy performance criteria before they can be sold in New Zealand. This currently applies to 17 product classes.¹⁶⁴

The regulations are updated periodically as technology changes, new test methods are developed, or as new products are added to the programme. The 2021 update included amending the MEPS for refrigerated cabinets, air conditioners and heat pumps.

Mandatory energy performance labelling

Product labelling regulations require an Energy Rating Label to be displayed to consumers at the point of sale in retail outlets. Currently seven product classes have MEPL requirements.¹⁶⁵ The Energy Rating Label shows how much electricity the appliance will use in one year (based on test conditions and usage assumptions) and provides a star rating that allows comparison between products of a similar size.

E3 Prioritisation Plan

The E3 Prioritisation Plan for 2021–22 has been developed to ensure activities that provide the greatest benefit are actioned first. The plan helps to reduce emissions, utilise opportunities to save energy and lower energy costs for households and businesses as early as possible. The plan shortlists 34 products and projects and identifies 26 of these as ‘top priority’ and 8 as ‘medium-term’ priority.

¹⁶⁴ Air conditioners and heat pumps; ballasts for fluorescent lamps; chillers; close control air conditioners; compact fluorescent lamps; computers and laptops; distribution transformers; electric storage water heaters; external power supplies; gas water heaters; household refrigerating appliances; linear fluorescent lamps; computer monitors; refrigerated cabinets; set top boxes; televisions; three-phase electric motors.

¹⁶⁵ Air conditioners and heat pumps; clothes dryers; washers; dishwashers; household refrigerating appliances; computer monitors; televisions.

Publicly Available Specifications

EECA has worked with Standards New Zealand since 2020 to develop five Publicly Available Specifications (PAS). These cover residential and commercial electric vehicle chargers, high-temperature heat pumps, biomass boilers and fossil fuel boilers.

The PAS have been well received by industry and are also used to detail minimum specification requirements for EECA funding programmes such as the GIDI Fund.

PAS for smart homes were published in September 2022, introducing the concept of residential demand response and demand flexibility systems to New Zealand households. Residential demand response and demand flexibility will help to reduce peak electricity generation and help consumers to optimise electricity use to reduce outgoings.

Reduce emissions and energy use in industry

Energy use by businesses (excluding transport) accounts for about 50 per cent of New Zealand's total energy use, and more than 40 per cent of New Zealand's energy-related emissions.¹⁶⁶

EECA works with New Zealand's businesses and large energy users to find long-term solutions that improve energy efficiency and decarbonise operations by switching to renewable forms of energy. These business decarbonisation programmes aim to help businesses meet emissions reduction targets, benefit from improved energy productivity and use low-emissions innovations and insights. Priorities include:

- improving support to businesses through better use of data and insights
- investigating new opportunities to support business sectors, and funding new technology opportunities
- fast-tracking investment into, and implementation of, projects that reduce business emissions through a co-investment approach
- exploring new funding mechanisms to accelerate decarbonisation.

Government Investment in Decarbonising Industry Fund

In 2020, the Government launched the Government Investment in Decarbonising Industry Fund. The GIDI Fund is a partnership between the Government and business administered by EECA to accelerate the decarbonisation of industrial process heat. This is achieved through assisting private sector businesses with the upfront capital costs of energy efficiency initiatives as well as switching from fossil fuels to renewables to accelerate their decarbonisation goals.

The first iteration of the GIDI Fund was an NZ\$69 million fund, which supported 53 projects with a combined estimated lifetime carbon abatement of 7.4 million tonnes, and which will all be fully commissioned by April 2024.

This initial demand for the GIDI Fund highlighted New Zealand businesses are committed to decarbonising and how working in partnership can effectively accelerate our country's decarbonisation goals.

¹⁶⁶ EECA. Productive and low emissions business. Retrieved from www.eeca.govt.nz/strategic-focus-areas/productive-and-low-emissions-business/ (10 November 2022).

In 2022 the New Zealand Government expanded the GIDI Fund and allocated approximately NZ\$650 million over four years to directly support, enable and accelerate decarbonisation across the business sector. This will include:

- continued support for medium to large process heat decarbonisation projects
- additional support for branching into medium to small emitters, including for efficient equipment replacement, and decarbonisation of commercial space and water heating
- working directly with New Zealand's very largest emitters on their decarbonisation pathways and entering into bespoke arrangements for the fund to support them through the available funding
- investing more into necessary renewable fuel supply infrastructure (eg, enabling electricity or biomass infrastructure) where it will enable decarbonisation projects.

Energy Transition Accelerator programme

The Energy Transition Accelerator (ETA) is an EECA programme available to large energy-using businesses and public sector organisations committed to reducing their carbon emissions.

Under this programme, EECA works with large energy users to help them develop a tailored and practical long-term decarbonisation roadmap for transitioning. This shows large energy users what the technically and economically feasible opportunities are, including innovative technologies, energy-efficiency initiatives and fuel switching opportunities. Significant emissions reduction opportunities have been identified and are beginning to be realised.

Technology demonstration programme

The Technology demonstration programme helps businesses test new or underutilised energy-saving technologies and process improvement opportunities that could also benefit the wider sector. This project supports both first and early adopters of new technologies to help accelerate market uptake of energy-efficient, low-carbon technologies. EECA provides co-investment for project costs and shares the lessons learned with the business sector.

The funding contributes to the cost of demonstrating proven technology or an innovative process improvement opportunity that has yet to be widely adopted in New Zealand. The project must improve energy efficiency and/or reduce carbon emissions. EECA pays up to 40 per cent of project costs, generally limited to NZ\$100,000. For projects that result in energy and carbon savings through process heat technology or processes, funding can be up to NZ\$250,000 or higher in exceptional circumstances.

For example, high-temperature heat pump technologies that were supported by the Technology demonstration programme were adopted to replace fossil fuels in the food processing sector and also as a heat source for large buildings. Additionally, a demonstration biomass pellet conversion was adopted in Government-funded business decarbonisation projects.

Sector Decarbonisation Programme

EECA's Sector Decarbonisation Programme collaborates with sector associations and technical experts to connect New Zealand businesses with world-class innovation and best-practice guidance to decarbonise at a sector level. The programme also provides new businesses with best-practice knowledge when they enter the sector.

The pilot Sector Decarbonisation Programme focused on the indoor cropping sector, with the aim to help create sector-wide decarbonisation pathways for businesses in this sector.

Energy-efficient communities

Gen Less

Following the conclusion of EECA's successful Energy Spot campaign, EECA shifted its communications approach in 2019 in response to growing government priorities and public attention on climate change.

Gen Less was subsequently launched in October 2019 to help educate people and businesses about their energy choices and support the Government's wider move towards a net zero carbon New Zealand by 2050.

The Gen Less platform is run by EECA. The Gen Less website,¹⁶⁷ social media channels and direct mailing lists provide information about climate change and how to reduce energy-related emissions at individual, household and business levels.

Gen Less is based on extensive research into New Zealanders' beliefs, attitudes and knowledge about climate change. It is advertised across television, radio, digital and outdoor billboard sites. The 'umbrella' campaigns seek to capture New Zealanders' attention by positioning climate change as something everyone can and should tackle together, now, while driving people to the website and other channels where they can get information relevant to their circumstances.

There have been a number of 'sub-campaigns', targeting businesses, particularly small to medium enterprises, and transport behaviours, encouraging mode shift and the uptake of electric vehicles (see chapter 9 for more detail).

Support for Energy Education in Communities Programme

The Support for Energy Education in Communities (SEEC) Programme¹⁶⁸ is part of a suite of Government initiatives to lift people out of energy hardship. The programme is part of an NZ\$17 million four-year package from the Government's COVID-19 Response and Recovery Fund, announced in August 2020 to reduce energy hardship and strengthen the consumer voice.

The SEEC Programme includes funding to build and expand the network of services to support people experiencing energy hardship achieve warmer, more energy-efficient homes and lower their energy bills.

Funding is available to eligible community-level groups, organisations or businesses, and will be primarily allocated through a regular open process. The first funding round opened in December 2020. The funding is to contribute to the provision of personalised, specialist advice and education to households in energy hardship, and purchasing low-cost, energy-saving equipment and devices.

The SEEC Programme complements other initiatives across government, the community and private sector that focus on making homes warmer and more energy efficient. The SEEC Programme consists of the SEEC Fund and the associated SEEC Equipment and Devices Fund.

¹⁶⁷ www.genless.govt.nz.

¹⁶⁸ www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-hardship/support-for-energy-education-in-communities-programme.

Further programmes to improve the energy system

Māori and Public Housing Renewable Energy Fund

This fund trials community-scale renewable technologies on Māori and public housing. These include technologies such as modern geothermal, solar panels and batteries. The most recent round made funding available for larger, more complex, renewable energy technologies, such as small-scale hydro, wind energy generation and projects integrating remote distribution and retail solutions.

In May 2022, the Government announced NZ\$16 million over four years to support small-scale community renewable energy projects. This builds on and expands the successful Māori and Public Housing Renewable Energy Fund and aims to support low-income communities or communities with insecure access to energy.

New Zealand Battery Project

The New Zealand Battery Project is investigating solutions to the 'dry year problem' when hydro catchments are low and fossil fuels are used to generate electricity to cover the shortfall. The New Zealand Battery Project will provide comprehensive advice on the technical, environmental and commercial feasibility of pumped hydro and other potential energy storage projects to mitigate the dry year problem.

The project's first phase includes evaluating the viability of pumped hydro schemes of various sizes at Lake Onslow, as well as at other possible locations around the country. The project is also considering the viability of three other technologies: flexible geothermal, hydrogen and biofuels.

The New Zealand Battery Project will help to achieve the Government's target of 50 per cent of total final energy consumption coming from renewable sources and the aspirational target of 100 per cent renewable electricity generation by 2030.

4.3.3 Building and construction

In 2018, nearly 9.4 per cent of domestic emissions were building-related. These emissions are largely accounted for in the energy and industry, transport and waste sectors and include:

- operational emissions – from the energy and other resources used when operating a building
- embodied carbon – emissions from the manufacture, transport, use and disposal of the materials and products used in a building across its life, from construction and maintenance to deconstruction.

MBIE's Building for Climate Change programme¹⁶⁹ is leading a range of legislative, regulatory and technical actions across Government and industry to reduce the building and construction sector's emissions and support warmer, drier and healthier homes and buildings. Given the number of new buildings designed and constructed in New Zealand each year, these requirements have the potential to contribute to significant levels of emissions reductions over time.

¹⁶⁹ MBIE. Emissions reduction. Retrieved from www.building.govt.nz/getting-started/building-for-climate-change/emissions-reduction/ (11 November 2022).

As buildings are long-lived and have a significant impact on the economy and New Zealanders' wellbeing, this work is important to get right. As we reduce our emissions and build New Zealand's circular economy and bioeconomy, we can expect healthier homes, less reliance on global supply chains for construction materials and more sustainable living.

The Government has made significant investments to lift buildings' energy efficiency, improve their quality and drive down energy costs:

- EECA has delivered more than 90,000 insulation and heating retrofits for low-income homeowners under the Warmer Kiwi Homes programme since July 2018. The programme helps ensure low-income homeowners have warmer, drier, healthier and more energy-efficient homes.
- In 2021, MBIE progressed changes to Building Code compliance pathways that increased the minimum requirements for insulation in new homes and buildings. These changes will deliver warmer, drier, healthier and energy-efficient homes that cost significantly less to heat.
- In Budget 2022 Government allocated NZ\$40 million for commercial space and water heating decarbonisation through the GIDI Fund.

More opportunities are being realised as shown in the box below.

Key actions in the emissions reduction plan

- Reduce the embodied carbon of construction materials by supporting innovation and regulating to promote the use of low-emissions building design and materials.
- Accelerate the shift to low-emissions buildings by promoting good examples, providing incentives and supporting the use of low-emissions practices.
- Improve building energy efficiency by amending the Building Code and measuring energy performance to ensure buildings are designed, and retrofitted, to use less energy for heating and cooling.
- Establish foundations for future emissions reduction by improving emissions data for buildings and materials, building relationships with Māori, and progressing behaviour change and workforce transition programmes.

Improving energy efficiency and reducing embodied carbon

Building on frameworks released in 2020¹⁷⁰ and recent increases to minimum insulation requirements, the Building for Climate Change programme is developing proposals to introduce operational efficiency and embodied carbon reporting requirements for new buildings. It is also proposed that over time, buildings may need to meet caps on embodied carbon and emissions from energy usage. It is anticipated people will be able to choose how they meet these caps rather than specifying the design or systems to be used (or not used) for heating, construction, deconstruction and so on. Public consultation on proposed options is expected to take place in 2023.

¹⁷⁰ Ibid.

Requirements for waste minimisation plans to be developed as a prerequisite for receiving a building consent are also being explored. These could support people to design waste out of their buildings, reduce waste going to landfill, and contribute to the development of end-markets for reused or recycled building materials.

Energy performance ratings

New Zealand does not have a comprehensive compulsory building certification system in contrast to many other countries. A number of voluntary systems are in place, such as Homestar,¹⁷¹ Green Star,¹⁷² NABERSNZ¹⁷³ and Passive House.¹⁷⁴ These have limited but increasing uptake across the sector.

The Building for Climate Change programme is exploring the introduction of mandatory ratings for certain building types, which could require new and existing buildings to hold and display a current energy performance rating. Building energy ratings can incentivise building owners to invest in improvements to their buildings' energy usage, as a higher rating potentially provides reward in the market. Building rating schemes can also contribute to effectively reducing buildings' energy use and costs. Commercial buildings use 21 per cent of New Zealand's electricity, costing business NZ\$800 million every year. On average, building energy performance could be improved by 20–25 per cent.¹⁷⁵ The proposed energy performance ratings could initially apply to commercial, public, industrial and large-scale residential buildings, with application to residential buildings to be explored in the future.

National Australian Built Environment Rating System – New Zealand

NABERSNZ is an existing voluntary building rating system that can help owners and tenants to reduce energy use and costs and reduce greenhouse gas emissions. The NABERSNZ tool is designed to rate and improve the energy efficiency of New Zealand's office buildings. A NABERSNZ Certified Rating gives a star rating, from 0 to 6, that shows a building's energy performance compared with others. This helps building owners and tenants to understand, compare and improve energy performance.

There are three kinds of ratings. A 'base build' rating measures the energy performance of a building's core services including lifts, stairwell lighting, common toilets, air conditioning and ventilation. A 'tenancy' rating measures just the floors/areas occupied exclusively by the tenant, including energy use such as computers, lighting, data centres and staff kitchens. A 'whole building' rating combines base building and tenancy.

Government leading the way

The Government owns, manages or procures a large number of buildings, including public and defence housing, schools, hospitals and office buildings. The Government is using its purchasing power to drive the market towards low-emissions alternatives and to support workforce transition. Initiatives include:

¹⁷¹ www.nzgbc.org.nz/homestar.

¹⁷² www.nzgbc.org.nz/greenstar.

¹⁷³ www.nabersnz.govt.nz.

¹⁷⁴ passivehouse.nz.

¹⁷⁵ NABERSNZ. Background. Retrieved from www.nabersnz.govt.nz/about-nabersnz/background/ (11 November 2022).

- introducing sustainability requirements into government procurement, including procurement of new buildings
- requiring NABERSNZ energy efficiency ratings for government-owned and tenanted office buildings from 1 January 2022
- requiring Green Star ratings for new government-owned, non-residential buildings from 1 April 2022
- commitment by Kāinga Ora in 2020 that all of the new homes it constructs will be built to a Homestar 6 standard.

Insulation and heating grants programmes

The Warmup New Zealand (WUNZ) programme commenced in 2009 and was EECA's core heating and insulation retrofit programme helping to improve the health, productivity and energy efficiency of New Zealand homes. Upon its completion on 30 June 2018, the WUNZ programme had contributed to 324,000 insulation retrofits.

On 15 May 2018, the Government announced the Warmer Kiwi Homes (WKH) programme – EECA's new insulation and heating retrofit programme to deliver subsidised insulation and heating to low-income, owner-occupied households across New Zealand. Similar to the WUNZ programme, the WKH programme seeks to prevent unnecessary heat loss and increase the energy efficiency of low-income households while improving overall health outcomes for New Zealanders. Following the COVID-19 outbreak in April 2020, the Government increased its funding contribution from 67 per cent to 90 per cent and has since reduced this to 80 per cent.

The WKH programme has become one of EECA's most successful programmes to date. From July 2018 until 31 August 2022, EECA delivered 98,131 retrofits to households (67,772 insulation and 30,359 heating). In 2020, EECA commenced a formal evaluation of the WKH programme. The interim report published in January 2022¹⁷⁶ showed that 82 per cent of participants' homes are more comfortable, and the proportion of households restricting their heating fell from 80 per cent to 21 per cent after accessing the programme. The final evaluation results are expected in December 2022.

4.3.4 Transport

Transport is one of Aotearoa New Zealand's largest sources of greenhouse gases and was responsible for 17 per cent of New Zealand's total gross emissions in 2020.¹⁷⁷

This section outlines the Government's approach to reducing transport emissions. While the immediate focus is on action over the next three years, this approach lays the foundation for the next 30 years. Three focus areas guide the Government's approach to reducing transport emissions:

¹⁷⁶ Fyfe C, Grimes A, Minehan S, Taptiklis P. 2022. *Warmer Kiwis Study: Interim Report: An impact evaluation of the Warmer Kiwi Homes Programme*. Wellington: Motu Economic and Public Policy Research Trust. Retrieved from www.eeca.govt.nz/assets/EECA-Resources/Research-papers-guides/Warmer-Kiwis-Study-Interim-Report-2021.pdf (11 November 2022).

¹⁷⁷ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020/ (10 November 2022).

- reduce reliance on cars and support people to walk, cycle and use public transport
- rapidly adopt low-emissions vehicles, including by increasing access to ‘safe’ low- and zero-emissions vehicles
- begin work now to decarbonise heavy transport and freight.

The Government has set four transport targets to support these focus areas and help achieve the sector sub-target for transport.¹⁷⁸

- Target 1 – Reduce total kilometres¹⁷⁹ travelled by the light fleet by 20 per cent by 2035 through improved urban form and providing better travel options, particularly in our largest cities.
- Target 2 – Increase zero-emissions vehicles to 30 per cent of the light fleet by 2035.
- Target 3 – Reduce emissions from freight transport by 35 per cent by 2035¹⁸⁰.
- Target 4 – Reduce the emissions intensity of transport fuel by 10 per cent by 2035.

The targets indicate how much effort is required to reduce transport emissions across the system and will shape our policy and investment decisions to support the scale and pace of change required.¹⁸¹ Together, these targets equate to a 41 per cent reduction in transport emissions by 2035 from 2019 levels.¹⁸²

Achieving the transport targets depends on complementary policies, such as having a strong NZ ETS price to incentivise low-emissions fuels, and changing the way we plan our towns and cities to make it easier and safer for people to reduce car travel.

Many of the actions in the emissions reduction plan will also support an equitable transition, including by making clean and affordable transport options more accessible for low-income and transport-disadvantaged New Zealanders.

¹⁷⁸ Sector-sub targets are based on the Climate Change Commission’s demonstration path that is benchmarked to New Zealand’s Greenhouse Gas Inventory 1990–2019, as opposed to the 1990–2020 Inventory.

¹⁷⁹ Kilometres refers to vehicle kilometres travelled (VKT).

¹⁸⁰ This target for freight transport includes emissions from trucks, rail and ships. It excludes light vehicles and aviation.

¹⁸¹ The targets are closely interrelated. The projected impact of achieving each target is conditional on achieving one or more of the others. Target 1 reflects a change compared with the Te Manatū Waka – Ministry of Transport’s baseline projection for 2035. Target 2 is against the 2035 fleet projection, given the effects of achieving Target 1 on the size of the fleet. Target 3 is compared with the level of emissions from freight transport in 2019. Target 4 is conditional on undertaking activities as part of achieving Targets 1 to 3 that would bring about lower projected liquid fossil fuel use in 2035.

¹⁸² This 41 per cent is calculated not from the latest 1990–2020 inventory, but instead using: Ministry for the Environment. 2021. *New Zealand’s Greenhouse Gas Inventory 1990–2019*. Wellington: Ministry for the Environment.

Key actions in the emissions reduction plan

Reduce reliance on cars and support people to walk, cycle and use public transport including by:

- improving the reach, frequency and quality of public transport and making it more affordable for low-income New Zealanders
- increasing support for walking and cycling, including initiatives to increase the use of e-bikes
- ensuring safer streets and well-planned urban areas.

Rapidly adopt low-emissions vehicles including by:

- continuing to incentivise the uptake of low- and zero-emissions vehicles through the Clean Vehicle Discount scheme and consider the future of the Road User Charges exemption for light electric vehicles beyond 2024
- increasing access to safe, low- and zero-emissions vehicles for low-income households by supporting social leasing schemes and trialling an equity-oriented vehicle scrap-and-replace scheme
- improving the electric vehicle charging infrastructure across New Zealand to ensure that all New Zealanders can charge when they need to.

Begin work now to decarbonise heavy transport and freight including by:

- developing a national Freight and Supply Chain Strategy with industry. It will set out system-wide actions that need to happen across the sector to achieve our decarbonisation, resilience, productivity and wellbeing outcomes
- providing funding to support the freight sector to purchase zero- and low-emissions trucks
- requiring only zero-emissions public transport buses to be purchased by 2025
- supporting the uptake of low-carbon liquid fuels by implementing a sustainable aviation fuel mandate and a sustainable biofuels obligation.

Reducing reliance on vehicles and supporting people to walk, cycle and use public transport

Investment in walking and cycling

As part of Budget 2022, the Government committed NZ\$350 million from the Climate Emergency Response Fund (CERF) to support the uptake of active modes and public transport. This Transport Choices package will be developed and implemented by mid-2024, with investment to be targeted in four key areas:

- progressing strategic cycle networks
- creating walkable neighbourhoods
- safe, green and healthy school travel
- making public transport more reliable and easier to use.

Reducing vehicle kilometres travelled

Achieving the national vehicle kilometres travelled (VKT) reduction target will require a combination of good urban form, better transport options and effective demand management.

The emissions reduction plan calls for planning and investment programmes to frame this approach, with a focus on our major urban areas where the potential for change is greatest.

Waka Kotahi NZ Transport Agency (Waka Kotahi) will publish a national VKT reduction plan by mid-2023. This will update the national mode shift plan published by Waka Kotahi in September 2019, *Keeping Cities Moving*.¹⁸³ Among other things, this plan will include direction, guidance and tools to support VKT reduction in urban, rural and provincial places over time.

Waka Kotahi will also partner with councils and others to develop urban VKT reduction programmes in Aotearoa's largest urban areas. These programmes will build on mode shift plans developed for Aotearoa's six fastest-growing cities in 2020/21 and are due to be in place by the end of 2024.

Te Manatū Waka – Ministry of Transport is developing proposed sub-national VKT reduction targets by the end of 2022. These will help frame urban VKT reduction programmes. These targets will set out the contribution that major urban areas will make in delivering on the national VKT reduction target of a 20 per cent reduction in VKT by light vehicles by 2035.

The NZ\$350 million CERF funding, allocated for the Transport Choices package, will also build momentum, capability and public support for VKT reduction through targeted investments that support mode shift and that reduce people's reliance on cars (see above for the four key investment areas for the Transport Choices package).

*Public transport bus decarbonisation*¹⁸⁴

The Government is committed to ongoing investment in public transport, including the decarbonisation of public transport buses. The 2021–24 National Land Transport Programme proposes spend of NZ\$1.33 billion on public transport services and NZ\$1.699 billion on public transport infrastructure over the three-year period.¹⁸⁵

Public transport buses bought from 2025 are required to be zero-emission vehicles.¹⁸⁶

The Government has also recently completed a review of the policy framework for planning and contracting public transport, known as the Public Transport Operating Model (PTOM). Following the review, the Government is replacing PTOM with the Sustainable Public Transport Framework (SPTF), which will prioritise fair and equitable treatment of employees, mode-shift and improved environment and health outcomes. The SPTF reforms include:

- enabling in-house delivery of public transport services by public transport authorities
- requiring services to be procured, contracted and/or delivered in such a way that ensures transparency around aspects of operation and service delivery

¹⁸³ www.nzta.govt.nz/walking-cycling-and-public-transport/keeping-cities-moving/

¹⁸⁴ Public transport initiatives in the emissions reduction plan fall into two focus areas: reduce reliance on cars and support people to walk, cycle and use public transport; and begin work now to decarbonise heavy transport and freight.

¹⁸⁵ The National Land Transport Programme (NLTP) is a three-year programme that sets out how Waka Kotahi, working with its partners, plans to invest the National Land Transport Fund in transport infrastructure and services. Activities in the NLTP must reflect the priorities in the Government Policy Statement on Land Transport. www.nzta.govt.nz/planning-and-investment/national-land-transport-programme/

¹⁸⁶ Waka Kotahi. Requirements for urban buses in New Zealand (the 'RUB'). Retrieved from www.nzta.govt.nz/resources/requirements-for-urban-buses/ (12 November 2022).

- enabling different asset ownership arrangements to remove barriers to decarbonisation
- enabling public transport authorities to deliver innovative services, such as on-demand public transport services.

The Government has also committed additional funding through Budget 2022 to further support key public transport outcomes, including:

- NZ\$61 million over four years to fund improved wages and conditions for bus drivers
- NZ\$137 million over 12 years to support public transport authorities to invest in bus decarbonisation initiatives
- approximately NZ\$25 million a year to implement and operate Community Connect – a 50 per cent concession on public transport for Community Services Card holders.

Rapidly adopting low-emission vehicles

Since 2016 the Government has been implementing a suite of initiatives to encourage electric vehicle uptake.¹⁸⁷ New Zealand’s competitive advantage in renewable electricity generation enables electric vehicle opportunities to be encouraged. The initiatives aim to tackle and remove barriers that may prevent households and businesses from choosing electric vehicles. The initiatives that have been implemented are described below.

Road User Charge exemptions

The removal of road user charges was introduced as an incentive to encourage electric vehicle uptake in both the light and heavy fleets.

A Road User Charges exemption on light electric vehicles commenced in 2012 and will run until 31 March 2024. A new Road User Charges exemption for heavy electric vehicles was introduced in 2017 and will run until 31 December 2025.¹⁸⁸

Clean Vehicle Discount Scheme

The Clean Vehicle Discount encourages buyer demand for low-emission vehicles by providing rebates for zero- and low-emission light vehicles, and requiring a fee be paid for high-emission vehicles, registered in New Zealand for the first time.¹⁸⁹

The Clean Vehicle Discount is based on carbon dioxide (CO₂) emissions. The rebate part of this policy for those buying zero- and low-emission vehicles was introduced in July 2021. The second part, comprising fees for those purchasing higher-emitting vehicles, was introduced on 1 April 2022. Significant increases in the share of electric vehicle and hybrid vehicle sales, as well as the variety of available vehicle models, have occurred as a consequence.

¹⁸⁷ Te Manatū Waka – Ministry of Transport. Te Kaupapa Waka Hiko: Electric Vehicles Programme. Retrieved from www.transport.govt.nz/area-of-interest/environment-and-climate-change/electric-vehicles-programme/ (12 November 2022).

¹⁸⁸ Anyone using New Zealand’s roads contributes towards their upkeep. Most road users pay levies in the prices of their fuel. Others, such as drivers of light diesel vehicles and diesel-powered heavy vehicles like trucks, pay imposed fees known as Road User Charges.

¹⁸⁹ www.nzta.govt.nz/vehicles/clean-car-programme/clean-car-discount/overview/.

Clean Vehicle Standard

The Clean Vehicle Standard was passed into legislation in February 2022.¹⁹⁰ It sets ambitious annual targets for the period 2023–27 that require light vehicle importers to progressively reduce the CO₂ emissions of the vehicles they import. It allows subsequent targets for 2028 and later years to be set by regulation. By 2027, the strength of the targets rival those in leading markets such as North America and the European Union.

Importers will be encouraged to bring cleaner cars into New Zealand by ensuring that, on average, the vehicles they import each year achieve the annual CO₂ targets. Importers face charges calculated per vehicle and per gram of CO₂ where targets are not met.

To meet the emissions reduction plan target of 30 per cent of our light vehicle fleet being zero emissions by 2050, and to contribute to achieving net zero carbon economy by 2050, progressively stricter annual CO₂ targets could be imposed on vehicle importers from 2028 until this eventually reaches 0 grams.

Low Emissions Transport Fund

Since 2016, EECA have been supporting the uptake of low-emission vehicles through the Low Emission Vehicle Contestable Fund (LEVCF). Key achievements included:

- funding the installation of 832 public charging stations
- supporting 647 new low-emission vehicles, from light vehicles to heavy freight vehicles
- funding a fleet optimisation pilot project to reduce fleet sizes and help prepare for electric vehicles
- supporting the delivery of New Zealand's first hydrogen fuel cell bus and 300 kilowatt hyper electric vehicle charger.

In 2021, the LEVCF was reconfigured into the Low Emissions Transport Fund (LETF) to better reflect the expanded scope for projects, which is supporting the demonstration and adoption of low-emissions transport technology, innovation and infrastructure to accelerate the decarbonisation of New Zealand's transport sector. The Government will increase the funding contribution from NZ\$6–7 million per year to NZ\$25 million per year by 2023/24.

Although the LETF launched less than a year ago, the fund has already supported some important projects to accelerate the adoption of low-emission transport. This includes:

- committing funding to 51 public charging stations to fill key gaps in the public charging network¹⁹¹
- New Zealand's first electric milk tanker
- a wireless charging ground-pad solution for electric buses
- the construction of a passenger bus with solar panels providing 5 to 10 per cent of its own power so that it has greater range and less maintenance than other electric buses.

¹⁹⁰ www.nzta.govt.nz/vehicles/clean-car-programme/clean-car-standard/overview/

¹⁹¹ Once these chargers are installed and operational, there will be a public charger every 75 kilometres along New Zealand's state highway network.

Electric vehicle charging infrastructure

A draft national electric vehicle charging infrastructure strategy (due at the end of 2022) will set out the Government's vision and policy objectives around electric vehicle charging. It will support the transition to and use of low-emissions transport by being accessible, affordable, convenient, secure and reliable for all users.

Vehicle Fuel Economy Labelling programme

The Vehicle Fuel Economy Labelling programme, which came into effect in April 2008, makes it compulsory for vehicle traders and online vendors to display information about the fuel economy of their vehicles. Its aim is to allow consumers to make a more informed choice when purchasing a vehicle and place an appropriate value on fuel economy.

In 2022, the label was updated to clearly display the CO₂ emissions of vehicles, and any rebate available or charge payable under the Clean Vehicle Discount Scheme. Star ratings for carbon emissions were recalibrated to be much stricter; vehicles must now produce much lower emissions to receive a high star rating.

Begin work now to decarbonise heavy transport and freight

Freight and Supply Chain Strategy

A Freight and Supply Chain Strategy is being developed in collaboration with iwi/Māori, local government and industry. It will set out system-wide actions that need to happen across the sector to achieve our decarbonisation, resilience, productivity, and wellbeing outcomes.

This includes exploring longer-term options for decarbonising freight modes and identifying quick wins, and exploring ways to encourage greater mode-shift to rail and coastal shipping. The Strategy will build on work being progressed in the first emissions budget period and set the pathway for what actions we should take in the second and third budget periods.

Zero-emissions trucks and buses

Heavy vehicles (trucks and buses) contribute a quarter of Aotearoa New Zealand's carbon emissions related to road use. The Government requires that only zero-emission public transport buses be purchased by 2025. The Government is now exploring policy options to encourage the uptake of zero-emission trucks.

Sustainable Biofuels Obligation

On 9 November 2022, the Government introduced the Sustainable Biofuel Obligation Bill to help overcome the cost and risk barriers to sustainable biofuels uptake. This bill introduces an obligation for any person or company that imports or refines more than 50,000 litres of liquid fossil fuels for transport in New Zealand, excluding aviation fuels, to reduce the greenhouse gas emissions intensity of those fuels by also supplying sustainable biofuels.

The Obligation will come into force on 1 April 2024.

The Obligation will require fuel wholesalers that purchase or import fuel for use in New Zealand to reduce the total emissions of the fuels they sell by a set percentage each year. Fuel suppliers will do this by blending biofuels into some, or potentially all, of the fuels they sell. Both domestically produced and imported biofuels can be used to meet the percentage reduction, subject to their meeting set sustainability criteria.

The Obligation will set a single target for petrol and diesel fuels. A separate mandate for sustainable aviation fuels (SAF) will also be considered.

Infrastructure and planning

As part of the Carbon Neutral Government Programme, Waka Kotahi is transitioning to lower-emissions transport infrastructure. It has committed to lowering the carbon footprint of construction projects and is on a structured pathway for measuring and reporting on progress against emissions reduction targets for non-corporate emissions. Waka Kotahi is also reducing its corporate emissions in line with an emissions reduction plan.

Waka Kotahi uses a Vehicle Emissions Prediction Model to predict enabled emissions from vehicles in the New Zealand fleet under typical road, traffic and operating conditions. It can be used to estimate enabled greenhouse gas emissions from road projects, and can be used to inform investment decisions. Waka Kotahi also uses a Vehicles Emissions Mapping Tool. This is a GIS (geographic information system) user interface that uses information from the Vehicle Emissions Prediction Model to visualise and map emissions related to the New Zealand road network. It provides context for planning and investment decision-making.

Emissions impact assessment is required for all Waka Kotahi investment decisions.

Cross-cutting measures to contribute to the delivery of a low-emissions transport system

Government Policy Statement on Land Transport 2021

The Government Policy Statement on Land Transport (GPS-LT), a land transport investment strategy, is the Government's main lever for delivering its transport priorities over a 10-year period. It includes strategic priorities which are focused on outcomes the Government would like to achieve from investment in transport. GPS-LT 2021/22–2030/31 includes climate change as a priority, with a focus on supporting a rapid transition to a low-carbon transport system.

The GPS-LT 2021 recognises that reducing emissions will contribute to a resilient transport sector and promotes the benefits of:

- inclusive access through supporting the development of public and active modes of transport in urban areas. Promoting higher-density, transit-oriented development where people live in closer proximity to where they work, learn and play will help reduce emissions by making public and active transport more accessible and appealing
- encouraging a healthy and safe population by reducing exposure to elevated concentrations of land transport-related air and noise pollution
- improved resilience and security by managing the impact of climate-related effects on critical infrastructure.

The GPS-LT 2021 is currently being reviewed, and a new GPS-LT 2024 is expected to be released for engagement in early 2023, with a final version intended to be issued in mid-2023. The GPS-LT 2024 will continue to support emissions reduction by building on the strategic direction of GPS-LT 2021 to move New Zealand towards a low-carbon transport system.

International aviation and shipping

In 2016, the Government agreed to participate in the Carbon Offsetting Reduction Scheme for International Aviation (CORSIA). It is one of four measures¹⁹² the international aviation sector is focused on to reduce its carbon footprint. Implementation of CORSIA is included in the Civil Aviation Bill, which is currently being progressed through the House and anticipated to be passed into law by the end of 2022. In the interim, a Memorandum of Understanding is in place between the State and airline operator that falls under CORSIA to ensure New Zealand meets its monitoring, reporting and offsetting obligations.

For international shipping, States, including New Zealand, work through the International Maritime Organization (IMO) to pursue emissions reductions from international shipping. The IMO adopted its Initial Strategy on the Reduction of GHG Emissions from Ships in 2018.¹⁹³ The Initial Strategy sets a target of reducing the total annual GHG emissions from international shipping by at least 50 per cent by 2050 compared to 2008. This strategy will be reviewed by 2023. New Zealand will be represented at the IMO negotiations in December 2022, which will include a focus on the revision of the Initial Strategy.

In 2022 New Zealand acceded to Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL), which seeks to address the impact of shipping emissions on human health and environments in and around port communities, as well as on climate change and ozone layer depletion. MARPOL Annex VI will be the main 'vehicle' to bring in globally consistent GHG emissions reduction measures negotiated at the IMO.

At the 2021 United Nations Climate Change Conference, Aotearoa New Zealand agreed to support the following.

- The Clydebank Declaration on Green Shipping Corridors supports work to decarbonise international shipping corridors through international coalitions between two or more States to partner to establish green corridors on shared maritime routes. This would be done in conjunction with the relevant ports and operators. New Zealand will need to work with like-minded countries (with participation from ports, operators and others along the value chain) to facilitate partnerships to establish green shipping corridors.
- The International Aviation Climate Ambition Coalition and associated Aviation Net Zero Declaration supports the goal of net zero international aviation emissions by 2050, implementing CORSIA and investigating a sustainable aviation fuel mandate.

4.3.5 Industry

In 2020, the industrial processes and product use sector was responsible for 6 per cent of New Zealand's total gross emissions.¹⁹⁴

¹⁹² Other measures are sustainable aviation fuels, aircraft technology and standards, and operational improvements (eg, improved ground operations and air traffic management).

¹⁹³ IMO. 2018. *Initial Strategy on Reduction of GHG Emissions from Ships*. Retrieved from www.imo.org/en/OurWork/Environment/Pages/GHG-Emissions.aspx (12 November 2022).

¹⁹⁴ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020/ (10 November 2022). This value excludes energy related emissions from industry, which are reported in the Energy sector of the inventory.

The Government is acting to decarbonise process heat and reduce industrial emissions. These actions, alongside actions to encourage greater energy efficiency, support electrification and increase low-emissions fuel use, will support industrial decarbonisation and provide clear investment signals for the future. Action 11.4.1 in the emissions reduction plan also refers to national direction to support decisions on greenhouse gas emissions from industrial process heat made under the Resource Management Act 1991. National direction is in development to provide a regulatory framework for reducing greenhouse gas emissions from the process heat sector. This is a complementary measure to other actions in the Government's programme to decarbonise industry.

Moving away from fluorinated gases (F-gases)¹⁹⁵ with high global warming potentials will also support our domestic transition to a low-emissions future and the global phase-down of F-gases. To achieve this transition, the Government will encourage and support New Zealanders to increasingly replace F-gases with alternatives that have lower global warming potentials (GWPs). A regulated product stewardship scheme will help reduce emissions from refrigerants through improving through-life and end-of-life management. Where alternative gases pose risks to health and safety, the Government will promote good industry practice through training schemes.

Key actions in the emissions reduction plan

- Develop an action plan for decarbonising industry by the end of 2024. The plan will sit within the energy strategy to align with the broader approach for decarbonising the energy sector, including ensuring competitive energy prices and security of supply.
- Develop training and accreditation for handling alternative refrigerants.
- Prohibit the import of equipment pre-charged with F-gases.
- Investigate prohibiting F-gases with high GWP.
- Introduce a mandatory product stewardship scheme for refrigerants.

Emissions Trading Scheme

Emissions produced as a result of industrial processes and product use are captured by the NZ ETS. Activities include the production of iron and steel, aluminium,¹⁹⁶ clinker and burnt lime, and glass.

Bulk importers of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) and users of sulphur hexafluoride above a threshold have obligations to surrender NZUs equivalent to the amount of HFCs and PFCs they import or the sulphur hexafluoride emitted through use. While there is currently no manufacture of HFCs and PFCs in New Zealand, should this occur in the future, manufacturers of these gases would also have obligations under the NZ ETS.¹⁹⁷

¹⁹⁵ Hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride are all types of F-gases and are defined as greenhouse gases in the CCRA.

¹⁹⁶ The aluminium smelting definition in the NZ ETS includes PFC emissions inherent to its manufacturing process.

¹⁹⁷ Exporters of HFCs and PFCs are eligible to receive NZUs, as long as they meet prescribed eligibility criteria.

Synthetic greenhouse gas levy

A levy is applied to imported goods and motor vehicles containing synthetic greenhouse gas (HFCs and PFCs). The levy applies to goods such as fridges, freezers, heat pumps, air conditioners, refrigerated trailers and air-conditioning units contained in motor vehicles. The levy is linked to the price of carbon in the NZ ETS and varies between items to reflect the amount of gas, the specified gas and its global warming potential.

Permitting scheme for imports and exports of bulk HFCs

The Kigali Amendment to the Montreal Protocol is facilitating a worldwide phase-down of the use of HFCs by requiring parties to limit their consumption (defined as import and production minus export) of HFCs. In line with its ratification of the Kigali Amendment, New Zealand has implemented a permitting scheme for imports and exports of bulk HFCs. This requires importers and exporters of bulk HFCs to obtain a permit for the HFCs they want to transport. Import permits are issued in limited numbers for each calendar year. The scheme has been active since 1 January 2020.

4.3.6 Agriculture

The agriculture sector contributes 50 per cent of Aotearoa New Zealand's gross emissions. Approximately 94 per cent of our nitrous oxide emissions and around 91 per cent of our biogenic methane emissions are from agriculture. There is increasing recognition that the sector needs to rapidly reduce emissions and adapt to resilient, sustainable production to play its part in the global climate change response. Pricing agricultural emissions, increasing research into new technologies and mitigations, and supporting farmers and growers to change practice are the key elements being progressed.

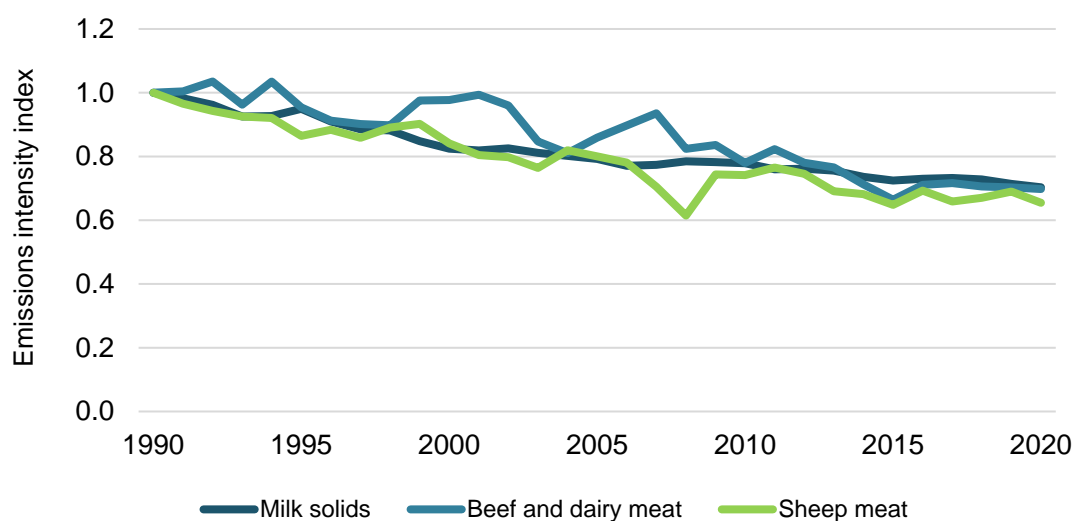
New Zealand has a target for biogenic methane of a 10 per cent reduction by 2030, and a 24 to 47 per cent reduction by 2050 (compared with 2017 levels).

The split gas target reflects the different impact of methane – which is a short-lived gas – compared to carbon dioxide and nitrous oxide, which are long-lived gases. The Intergovernmental Panel on Climate Change (IPCC) advises that rapid, steep methane reductions, alongside bringing global carbon dioxide emissions to net zero by 2050, are needed to limit global warming to 1.5°C.

A feature of Aotearoa New Zealand agriculture is that emissions per unit of product (known as emissions intensity) have been decreasing in recent decades, with the rate of reduction close to 1 per cent a year since 1990 (figure 4.3). This is a result of improvements such as plant and animal genetics, grassland management and animal health, and better-optimised fertiliser applications.

The Government recognises that agriculture must be at the forefront of climate action and has invested consistently in research and development to improve the measurement and mitigation of agricultural emissions (see chapter 8). The Government and industry have invested about NZ\$200 million over the last 10 years into agricultural emissions research, capability building and international leadership.

Figure 4.3: Trend in emissions intensity (kg CO₂-e per kg product) for major livestock categories indexed to 1990 emissions intensity, 1990–2020



Key actions in the emissions reduction plan

Five key focus areas for agriculture informed the actions included in the emissions reduction plan. The key actions in the first four focus areas are detailed below. The fifth focus area, to enable Māori-led solutions, is cross-cutting and embedded in actions and work with Māori across the other four focus areas.

Price agricultural emissions

- Introduce an agricultural emissions pricing mechanism by 2025.
- Support early adopters of low-emissions practices.

Accelerate mitigation technologies

- Establish a new Centre for Climate Action on Agricultural Emissions to drive a step change in mitigation practice and technology innovation and uptake on farms.

Support producers to make changes

- Fund tikanga-based (custom-based) programmes to support needs and aspirations of Māori.
- Introduce climate-focused extension and advisory services.

Transition to lower-emissions land uses and systems

- Develop food and fibre science and mātauranga Māori accelerators.

Pricing agricultural emissions by 2025

A key priority is to deliver advice on how to price agricultural emissions. Pricing agricultural emissions helps create an incentive for emitters to adopt cost-effective mitigations.

The Government has taken a unique approach in partnering with the agricultural and horticultural sector to develop a proposed system for pricing emissions by 2025. The Primary Sector Climate Action Partnership provided its final report to Government on 31 May, and the Government now has until December 2022 to report on how it intends to price emissions.

Final decisions will be made in early 2023. The Climate Change Commission has supported the process by assessing the sector's readiness to implement on-farm emissions pricing by 2025. The Commission has also provided advice on the case and options for providing financial assistance to the sector to manage the transitional impacts of introducing pricing.

The Partnership has explored alternative pricing approaches to agriculture entering the NZ ETS. The Partnership recommended a farm-level split gas levy to support incentivising emissions reductions at the farm level. The advice reflects New Zealand's split gas target with a different approach to methane, compared to carbon dioxide and nitrous oxide.

The agriculture sector is working towards a commitment that all farms will know their annual total of on-farm greenhouse gas emissions by 31 December 2022. This will support the introduction of farm level pricing in 2025.

Centre for Climate Action on Agricultural Emissions

A step change in investment, by both government and industry, is needed to accelerate delivery and widespread uptake of emissions reduction tools and technologies.

The Government has committed to a significant increase in investment of NZ\$338.7 million in the 2022 Budget to accelerate the development of adoptable greenhouse gas mitigations, including the establishment of a Centre for Climate Action on Agricultural Emissions to drive our efforts.¹⁹⁸

The Centre for Climate Action on Agricultural Emissions will include a new public-private joint venture with a focus on product development and commercialisation to get effective tools into the hands of farmers more quickly, and will deliver on three key outcomes:

- faster development, commercialisation and uptake of emissions mitigation technologies (which will enable gross emissions reduction)
- a strong system to support delivering mitigations over the long term
- strong leadership and alignment of biological emissions reduction efforts.

Discussions with the private sector on investment and participation in the joint venture are well advanced. The joint venture will be supported by an enhanced New Zealand Agricultural Greenhouse Gas Research Centre, with a focus on strengthening the underpinning biological emissions research and development system more broadly.

Global Research Alliance on Agricultural Greenhouse Gases

The Global Research Alliance on Agricultural Greenhouse Gases (GRA), initiated by New Zealand in late 2009, seeks to increase cooperation and investment to reduce the emissions intensity of agricultural production systems globally. New Zealand's leadership in establishing and hosting the GRA Secretariat and New Zealand's activities in support of the GRA (see chapters 7 and 9) aim to foster collaborative international research projects, global datasets, and standard measurement and mitigation techniques and protocols between countries.

¹⁹⁸ O'Connor D, Nash S, Whaitiri M. 2022. Partnership to reduce agricultural emissions. Retrieved from www.beehive.govt.nz/release/partnership-reduce-agricultural-emissions (13 November 2022).

New Zealand's activities have established global networks of scientists, creating capability development and training opportunities (particularly for scientists from developing countries) and identifying good-practice mitigation options for different production systems and climates. Through the GRA, New Zealand and Samoa are establishing an Indigenous Research Network. The Indigenous Research Network provides the opportunity for indigenous people in GRA member countries to be able to connect and share their traditional knowledge in both 'adaptation and mitigation' to address greenhouse gas emissions reductions. The Tāngata Whenua Alliance provides a New Zealand platform for iwi Māori to work with indigenous peoples in their GRA work programmes.

Sustainable Food and Fibre Futures

The Government established the Sustainable Food and Fibre Futures (SFF Futures) fund in 2018.¹⁹⁹ SFF Futures supports problem-solving and innovation in New Zealand's food and fibre sector by co-investing in initiatives that make a positive and lasting difference. It funds a range of projects, from small grassroots community projects to large-scale industry development; from new product development to new ways of tackling an environmental issue or improving animal health and welfare.

About NZ\$40 million of funding is available each year through SFF Futures. Projects undertaken require joint investment between the Government and private partner(s). Depending on whether the project is predominantly commercially oriented or community-driven or, in exceptional cases, has highly compelling public-good benefits, SFF Futures will contribute between 40 and 80 per cent of the total project costs.

As at 30 June 2022, SFF Futures has invested in 202 projects. Over the life of these projects, SFF Futures and private partners have committed a total of NZ\$442.9 million. Many projects provide sustainability and climate change benefits (of either reducing absolute emissions from the primary sector or reducing emissions per unit of product).

Example projects include: prototyping a spatial integrated farm plan for greenhouse gas reduction; the preliminary evaluation of potential feed-based commercial solutions to ruminant methane emissions; 'N-Vision', a programme to enable smarter nitrogen management; and 'Future Ready Farms', a project trialling and developing 12 farm nutrient technologies that will help reduce the food and fibre sector's environmental footprint.

SFF Futures superseded the Primary Growth Partnership (PGP) and the Sustainable Farming Fund (SFF). The Ministry for Primary Industries is continuing to support current PGP and SFF projects and programmes as part of the SFF Futures portfolio until their completion.

Sustainable Land Management and Climate Change Research Programme

In 2007, the Government set up the Sustainable Land Management and Climate Change (SLMACC) research programme²⁰⁰ as part of a wider plan of action to support the generation of new climate change knowledge across the agriculture and forestry sectors.

¹⁹⁹ Ministry for Primary Industries. Sustainable Food and Fibre Futures. Retrieved from www.mpi.govt.nz/funding-rural-support/sustainable-food-fibre-futures/ (13 November 2022).

²⁰⁰ Ministry for Primary Industries. Sustainable Land Management and Climate Change (SLMACC). Retrieved from www.mpi.govt.nz/funding-rural-support/farming-funds-and-programmes/slmacc/ (13 November 2022).

The research programme covered all aspects of climate change in the land-based sectors, including impacts and adaptation, reducing greenhouse gas emissions and increasing forest carbon sinks. Over 180 projects have been commissioned as at June 2022.

An independent review of the SLMACC research programme completed in 2018 found that the programme was creating high-quality research, engaging stakeholders and end users, and growing climate change science capability in New Zealand.

In 2020 the SLMACC research programme was changed to limit its focus to climate change adaptation (including in the forestry sector). This was largely due to the availability of other funding resources for climate change mitigation research, and the need to prioritise the limited funding available to the SLMACC research programme.

Also in 2020, NZ\$16 million in funding was allocated to a new four-year SLMACC Freshwater Mitigation programme. This fund supports field trials of existing farm technologies and practices that protect waterways and wetlands by reducing nutrient run-off and leaching, including nitrogen. The programme aims to produce scientific data that can be incorporated into decision support tools.

In addition to the research programmes included in the emissions reduction plan and those described above, domestic research has been supported through the government-funded New Zealand Agricultural Greenhouse Gas Research Centre, alongside other programmes, including the Pastoral Greenhouse Gas Research Consortium (PGgRc). For more information on the PGgRc, see chapter 8.

Regulations to manage freshwater introduced under the Essential Freshwater package

The National Policy Statement for Freshwater Management (NPS-FM) provides national policy direction to regional councils on freshwater management. These measures will impact emissions from agriculture through their influence on animal numbers.

Freshwater management in New Zealand is largely devolved to local authorities under the Resource Management Act 1991. Regional councils are responsible for managing water bodies in their region, including the flows and levels in any water body; control of the taking, use or damming, and diversion of water; the allocation of water; and the control of discharges.

In August 2020, the Essential Freshwater package was gazetted and includes several new regulatory instruments to stop the further degradation of New Zealand's freshwater resources, start making immediate improvements in freshwater ecosystems and water quality, and reverse past damage within a generation. The instruments introduced under the package include the:

- National Policy Statement for Freshwater Management 2020, designed to require regional councils to update regional plans which embed long term changes to manage freshwater
- National Environmental Standard for Freshwater, which regulates high-risk land use activities such as the application of synthetic nitrogen fertiliser in dairy farm systems
- Resource Management (Stock Exclusion) Regulations, which require farmers to exclude cattle, pigs and deer from rivers, lakes and wetlands.

Although the regulations were primarily designed to manage land use activities to see improvements in freshwater quality and ecosystem health, resulting changes in land use activity will also impact agricultural GHG emissions.

Under the NPS-FM, regional councils must have regard to the reasonably foreseeable impacts of climate change. As such, the NPS-FM encourages national consistency across regional councils in taking climate change impacts into account in freshwater planning. Communities and businesses require long-term stability in allocations and rules. Therefore, when rules are set, future changes in catchments and climate need to be considered.

The National Environmental Standard for Freshwater includes the synthetic nitrogen fertiliser cap regulation (the N-cap). The N-cap restricts the application of synthetic fertiliser to no more than 190 kilograms per hectare per year across the land used in pastoral systems. A farmer must obtain a resource consent in order to exceed the cap. When fully implemented, it is estimated that the N-cap regulations could reduce gross agricultural GHG emissions by approximately 0.5 per cent (equal to approximately 150 kilotonnes of carbon dioxide equivalent (kt CO₂-e) of nitrous oxide).

4.3.7 Land use, land-use change and forestry

Reducing gross emissions from the sectors that make up our economy is the Government's priority – but forestry has a part to play in offsetting the emissions of sectors that cannot easily reduce or remove their emissions. It also contributes to lowering gross emissions in other sectors through providing inputs to the bioeconomy. Forestry can provide flexibility in our path to a cost-effective, timely and equitable transition.

The role of forests in Aotearoa New Zealand has evolved over time and continues to do so. The past century has seen New Zealand's forestry sector transition from a dependence on indigenous tree species to a sustainable, plantation-based system. At the farm scale, tree and shrub plantings have become an increasingly important tool in land management, with both indigenous and exotic plantings being used increasingly in farm planning (for erosion control, animal welfare and watershed management).

Planted and natural forests (both tall and regenerating) cover approximately 37 per cent of New Zealand's land area.²⁰¹ The area of land in forests is expected to increase, with plantings being used increasingly to build value in marginal land and to meet national objectives for emissions reduction. New types of forests are emerging, including mānuka plantations for honey production, short-rotation exotic plantations to support the growth of the bioeconomy, exotic forests grown for carbon sequestration (and not intended for harvest) and forests actively managed to transition from exotic to indigenous species over time.

The pattern of afforestation is likely to be focused on lower-productivity agricultural land, areas where forestry can support erosion and water management, and more marginal (or difficult) parts of farm properties, particularly hill country properties. An issue that the Government is currently working through is the risk that high carbon prices will lead to increased levels of permanent exotic afforestation, which has the potential to displace other productive land uses, particularly sheep and beef farming and production forestry, impacting rural communities and economies.

In 2020 the Land Use and Carbon Analysis System (LUCAS) measured 2.13 million hectares of plantation forest and 7.84 million hectares of natural forest. New Zealand's large proportion of planted forest enables it to protect much of the natural forest resource from harvesting. Less

²⁰¹ FAO. 2020. *Global Forest Resources Assessment 2020 – Report – New Zealand*. Rome: Food and Agriculture Organization of the United Nations, p 14.

than 0.1 per cent of New Zealand's annual timber production is harvested from natural forests, which are managed under sustainable forest management plans and permits.²⁰² This system of management has been in place since 1993, following an amendment to the Forests Act 1949.

New Zealand's timber production is derived almost exclusively from exotic plantations. These production forests are managed on a sustainable cycle of planting, harvesting and replanting. Extensive planting of commercial forests occurred between 1992 and 2003, due to a relatively high rate of return for logs. A significant proportion of this planting was undertaken by farmers and utilised land less suitable for livestock production. These forests have contributed to offsetting emissions from other sectors of the economy.

Role of forests in emissions reduction

Forests can act as significant carbon sinks, by absorbing CO₂, as well as helping to achieve other positive environmental outcomes (such as reducing erosion). In 2020 the land use, land-use change and forestry (LULUCF) sector offset 30 per cent of New Zealand's gross emissions. Both the native forests and the plantation estate of New Zealand are significant carbon stores. New Zealand's natural (tall) forest and regenerating forest together are estimated to hold about 1.8 billion tonnes of carbon in their biomass.²⁰³

Promoting afforestation and carbon sequestration

Afforestation has been used as a tool to mitigate soil erosion and sedimentation for over 80 years in New Zealand. In the early 1990s the Government introduced the East Coast Forestry Project (more recently renamed the Erosion Control Funding Programme) to support land owners to treat vulnerable land in the East Coast region of the North Island. Afforestation initiatives increased from the late 2000s, and their scope broadened to address wider environmental issues and to promote carbon sequestration. Six principal measures to promote afforestation have been in place for part, or all, of the past 15 years. These initiatives are listed below and described in more detail in later in this section:

- New Zealand Emissions Trading Scheme (NZ ETS)
- One Billion Trees Fund (1BT)²⁰⁴
- Permanent Forest Sink Initiative (PFSI)
- Sustainable Land Management Hill Country Erosion Programme (HCEP)
- Erosion Control Funding Programme (ECFP – formerly the East Coast Forestry Project)
- Afforestation Grant Scheme (AGS).²⁰⁵

²⁰² Indigenous timber production in New Zealand is confined to privately owned forests including SILNA lands and the Longwood and Rowallan forests (Crown land under long-term forestry right to the Waitutu Holding Company) – Ministry for Primary Industries. 2017. Indigenous Forestry on Private Land: present Trends and Future Potential – An Update, p. 2.

²⁰³ Ministry for the Environment. 2021. *New Zealand's Greenhouse Gas Inventory 1990–2019*. Wellington: Ministry for the Environment, p 260. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2019/ (10 November 2022).

²⁰⁴ No longer in place, see section 4.6. The 1BT covered direct grants, joint venture and partnership projects.

²⁰⁵ No longer in place, see section 4.6.

Between 2008 and 2020 the majority of total afforestation in New Zealand can be attributed to the Government initiatives listed above. Between 1990 and 2020 these initiatives have also led to the sequestering of an estimated additional 18,310 kt CO₂ from the atmosphere. This figure includes afforestation resulting from the NZ ETS, PFSI, ECFP, 1BT, HCEP and AGS, as well as the estimated impact the NZ ETS has had on reducing pre-1990 planted forest deforestation since 2008.

The groundwork laid by these initiatives will be built upon through the emissions reduction plan released in 2022. The specific actions in the emissions reduction plan to support afforestation and to meet New Zealand's 2050 targets are set out below.

Key actions in the emissions reduction plan

Support afforestation by:

- considering amendments to the NZ ETS and resource management settings to achieve the right type and scale of forests, in the right place
- supporting land owners and others to undertake afforestation, particularly for erodible land
- providing advisory services to land users, councils, Māori and other stakeholders to support choices for sustainable afforestation.

Encourage native forests as long-term carbon sinks through reducing costs and improving incentives.

Maintain existing forests by exploring options to reduce deforestation and encourage forest management practices that increase carbon stocks in pre-1990 forests.

Grow the forestry and wood processing industry to deliver more value from low-carbon products, while delivering jobs for communities.

In Budget 2022, the New Zealand Government committed almost NZ\$329.7 million of the CERF over four years to maximise forestry's contribution to reducing emissions, boosting carbon storage and sequestration, and increasing our woody biomass supply, to help achieve New Zealand's future carbon goals.

Principal measures

New Zealand Emissions Trading Scheme

The NZ ETS is the main policy instrument to encourage afforestation and reduce deforestation for climate change purposes.²⁰⁶ The forestry sector entered the NZ ETS in 2008, and as at 30 June 2022 around 55 per cent of forests established after 31 December 1989 had been voluntarily registered in the NZ ETS.²⁰⁷

Forests established since 1 January 1990 and entered into the NZ ETS are eligible to earn emissions units that represent the carbon sequestered by the forest since the start of the

²⁰⁶ Ministry for Primary Industries. Different kinds of forest land in the ETS. Retrieved from www.mpi.govt.nz/forestry/forestry-in-the-emissions-trading-scheme/about-forestry-in-the-emissions-trading-scheme/different-kinds-of-forest-land-in-the-ets/ (14 November 2022).

²⁰⁷ New Zealand Forest Service. 2022. Emissions Trading Scheme for forestry as at 30 September 2022. Retrieved from www.mpi.govt.nz/dmsdocument/45232-Emissions-Trading-Scheme-for-Forestry-land-statistics (14 November 2022).

mandatory emissions return period in which they were registered,²⁰⁸ but can also be liable to surrender units if there is a reduction in carbon stock (depending on the accounting methodology used).²⁰⁹ The majority of land owners with exotic forests planted before 1990 face deforestation liabilities²¹⁰ under the NZ ETS if they deforest.

As noted in section 4.3.1, amendments to the NZ ETS were enacted in 2020 to improve its overall operation and effectiveness, and to ensure its settings are able to support New Zealand to meet its future emissions reduction targets. For forestry, these improvements include the following.

- Averaging accounting was introduced from 1 January 2023, which was made optional for forests registered into the NZ ETS between 1 January 2019 and 31 December 2022, and mandatory for those registered after 1 January 2023. Under averaging accounting, first rotation forests earn units up to the long-term average carbon stock of the forest based on multiple rotations, without having to surrender units at harvest. This provides a greater incentive to establish new production (harvested) forests than the stock change accounting approach, where units are earned based on the actual carbon stock of the forest and must be surrendered at harvest, as it allows a greater proportion of units to be retained (so long as the forest is replanted and remains registered in the NZ ETS) and offers simplified long-term reporting.
- A new permanent post-1989 forest category was introduced from 1 January 2023. Forest land registered as permanent must remain in the NZ ETS for at least 50 years and cannot be clear-felled during that time. If the land is clear-felled, there are substantial penalties. Permanent forests will use the stock change accounting approach. Registered forest owners will earn NZUs as long as the forest carbon stock is increasing.
- A number of operational and process changes were made to improve the NZ ETS for forestry and make it easier and more flexible for participants.

Since these amendments were enacted, rapidly rising carbon prices have resulted in an increased financial incentive to plant permanent exotic forests. This risks the displacement of other productive land uses, particularly sheep and beef farming and production forestry, as well as other climate and environmental concerns.

To address this, earlier this year the Government consulted on proposals to manage exotic afforestation incentives, particularly focusing on the new permanent post-1989 forest category that is due to become available from 1 January 2023. Following this, the Government has announced that the category will remain unchanged for now, but has committed to further work with Māori and other technical forestry experts to redesign the settings of the NZ ETS permanent forest category so that it better supports long-term indigenous carbon sinks.

²⁰⁸ The mandatory emissions return periods have been 2008–12, 2013–17 and 2018–22.

²⁰⁹ Forests registered under stock change accounting are required to surrender units back from any loss in forest carbon over the reporting period, whereas those registered under averaging accounting are not required to surrender units back, so long as they are replanted.

²¹⁰ Up to 2 hectares of pre-1990 forest per mandatory emissions return period can be deforested without liability; land owners can avoid pre-1990 deforestation liabilities by establishing an equivalent forest (an offset forest) elsewhere; some land owners can apply for exemptions from deforestation liabilities; and small areas of pre-1990 forest can be cleared without liabilities for the purpose of maintaining best-practice forest management.

Sustainable Land Management Hill Country Erosion Programme

The Sustainable Land Management Hill Country Erosion Programme helps protect New Zealand's estimated 1.4 million hectares of pastoral hill country that is classified as erosion-prone. It provides up to NZ\$10 million of targeted funding support annually to regional and unitary councils. The purpose of the Programme is to speed up the rate of treatment of erosion-prone land. The Programme was initiated in 2008 in response to significant storm events in previous years. Funding is provided for four-year projects on a contestable basis. Projects deliver sustainable land management treatments including wide-spaced poplar and willow planting, small-scale afforestation, reversion to indigenous forest and retirement of land. In the current four year funding round, land management treatments have been applied to over 26,000 hectares. The fund also supports catchment facilitation work and capability-building initiatives.

In June 2022, applications were opened for a new funding round that will commence in July 2023 and will end in 2027. The 2023 funding round will continue the momentum towards soil conservation and revegetation work under regional programmes.

Although its main purpose is to reduce erosion, the Programme also contributes to the sequestration of carbon in small-scale forests and through planting of poplars and willows.

Erosion Control Funding Programme

The Erosion Control Funding Programme (formerly the East Coast Forestry Project) was implemented in 1992 to address soil erosion in the Gisborne district. The Programme aims to encourage tree planting on severely eroding or erodible land. Land owners are eligible for government grants, which help to fund the cost of establishing and managing treatments on this land. The Programme allows a range of treatments, including indigenous or exotic afforestation, reversion to indigenous forest, and wide-spaced poplar and willow planting.

Although its main purpose is to reduce erosion, the Programme also contributes to the sequestration of carbon in forests as a co-benefit of some treatments. Around 45,000 hectares have been treated through the Programme to date.

In 2016 the scope of the fund was broadened to address erosion issues at the community and regional scales, and to deliver wider environmental, social and economic benefits for the region. Funding for community grants flows from underspent funding from the ECFP land treatment grants.

The final funding round for ECFP land treatments was held in 2018, with no further funding rounds since then. ECFP community grants are still available for catchment and community groups that meet the application criteria.

Permanent Forest Sink Initiative

The Permanent Forest Sink Initiative promotes the establishment of permanent forests on land that was unforested before 1 January 1990. It offers land owners with land registered in the PFSI the opportunity to earn emissions units for the carbon sequestered by their forests since the start of the mandatory emissions return period in which they register.

In return, participants have a legal covenant registered against their land title in perpetuity to ensure the carbon removals remain 'permanent'. The covenant is in perpetuity, even if the land is sold, although there is an ability to terminate after 50 years. Land owners are

responsible for establishing and maintaining the forest. Limited harvesting is allowed on a continuous forestry cover basis.

From 1 January 2024, the PFSI will close. PFSI participants will be able to move their forest into the new permanent forest category in the NZ ETS or they can choose to move it to the standard forestry category. They can also choose to leave the PFSI without moving to the NZ ETS.

From 1 January 2023, the new permanent forestry category will be available for forests established after 31 December 1989 that will not be clear-felled for 50 years. This will replace the PFSI.

Other measures

Woody biomass

Woody biomass offers the best alternative to coal and other carbon-intensive fuels and materials. New Zealand has a growing solid heat energy sector (based on renewable wood pellets and chips for boilers) and there have been investigations and research into the development of a liquid biofuels sector, which is building sector and investment interest. In order to offset and replace carbon emissions from fossil fuels, this initiative will:

- enable Crown Forestry to invest in commercial planting to increase supply of biomass for energy and other products in targeted areas where increased supply is required
- support research into the costs and benefits of alternative biomass crops, including business case development
- commission research to examine ways to support effective slash (forest waste) recovery to utilise biomass currently left in forests after harvest.

Native afforestation initiative

This initiative focuses on developing long-term carbon sinks and improving biodiversity.

To achieve our aspiration of increased native afforestation, we need to increase supply of seedlings and reduce the barriers to and costs of planting. This initiative is the initial stage of a multi-phase programme to support the establishment of native forests at scale to develop long-term carbon sinks. This initiative:

- will focus on the deployment and uptake of technology to increase supply and reduce the cost of high-quality native seedlings to support native afforestation at lower cost
- support development of a long-term national strategy and action plan to grow native forests and native biodiversity in partnership with rural land owners, iwi/Māori, foresters, communities and the private sector
- support research and science in forestry to identify gaps and explore innovation in propagation, planting and restoration
- increase knowledge and advice to support the growth of the nursery sector including building strong partnerships with iwi/Māori.

Maximising carbon storage

This initiative will support the increased sequestration of carbon to achieve New Zealand's future emissions targets. It aims to help reduce emissions by more than 9.3 million tonnes over 2022–35. This initiative includes:

- stimulating investment in domestic wood processing to get more value from our exports and maximise the carbon stored in manufactured wood products
- funding research to link increased carbon storage to forest management actions (eg, pest control)
- expanding the ETS look-up tables to more accurately reflect carbon stock changes.

National Environmental Standards

The National Environmental Standards for Plantation Forestry are regulations under the Resource Management Act 1991 and are the main environmental management rules for plantation forestry activities in New Zealand, including afforestation. In 2022 the Government consulted on:

- proposals to extend the scope of the standards to manage the environmental (biophysical) effects of exotic carbon forests
- options to extend the scope of regulatory controls to control the location of plantation and exotic carbon afforestation to manage social, cultural and economic effects
- a proposal to extend the scope of regulatory controls to improve wildfire risk management in plantation and exotic forests
- proposals to address matters identified through the Year One Review of the standards that was carried out in 2019–20, to better enable foresters and councils to manage the environmental effects of forestry.

Development of a forestry and wood processing industry transformation plan (ITP)

The Government's vision is that the forestry and wood processing sector generates more value for New Zealand, is a key pillar of our regional communities and underpins New Zealand's low-emissions economy.

The draft plan aims to support the industry to make better use of New Zealand's forestry resources by processing more wood onshore, producing more high-value wood products and using residues to grow the forest-based bioeconomy. This will:

- create more higher-paid jobs
- build resilience in the sector
- support our climate change goals.

The draft plan is based around four priority areas:

- growing sustainable forests for our future
- modernising and expanding the wood processing sector
- growing and diversifying domestic and export markets
- improving system settings for a thriving sector.

The final version of the Plan is expected to be released in late 2022, following the recently completed period of consultation.

4.3.8 Waste

In 2020, the waste sector was responsible for 4 per cent of New Zealand's total gross emissions and around 9 per cent of its biogenic methane emissions. While agriculture contributes to the bulk (91 per cent) of New Zealand's biogenic methane emissions, the waste sector has a key role to play in meeting New Zealand's 2030 and 2050 emissions reduction targets.

The waste chapter in the emissions reduction plan **outlines 14 new key initiatives under six focus areas.**

- 1. Enable households and businesses to reduce organic waste.**
 - Encourage behaviour to prevent waste at home.
 - Enable businesses to reduce food waste.
 - Support participation in improved kerbside collections.
- 2. Increase the amount of organic waste diverted from landfill**
 - Improve household kerbside collections of food scraps and garden waste.
 - Invest in organic waste processing and resource recovery infrastructure.
 - Require the separation of organic waste.
- 3. Reduce and divert construction and demolition waste to beneficial uses**
 - Support the building and construction sector to minimise waste through research and improved capability.
 - Invest in sorting and processing infrastructure for construction and demolition materials.
 - Enable the separation of construction and demolition materials.
- 4. Explore bans or limits to divert more organic waste from landfills**
 - Investigate banning organic waste from landfills by 2030.
- 5. Increase the capture of gas from municipal landfills**
 - Regulations will require landfill gas capture at municipal landfills.
 - Feasibility studies will determine the need for additional landfill gas capture requirements.
- 6. Improve waste data and prioritise a national waste licensing scheme**
 - Develop a national waste licensing scheme.
 - Improve information on greenhouse gas emissions from waste disposal.

To achieve its goals, the Government has developed a set of legislative instruments to reduce waste generation and waste-derived emissions.

The major legislation governing waste management in New Zealand is the Waste Minimisation Act 2008,²¹¹ which is administered by the Ministry for the Environment. The Act encourages reductions in the amount of waste generated and disposed of, which may also result in a reduction of greenhouse gas emissions. In addition, certain landfills are required to surrender units under the NZ ETS.

²¹¹ Ministry for the Environment. Waste Minimisation Act 2008. Retrieved from environment.govt.nz/acts-and-regulations/acts/waste-minimisation-act-2008/ (14 November 2022).

Waste Disposal Levy

The Waste Disposal Levy²¹² was introduced under the Waste Minimisation Act 2008 for the purpose of raising revenue for the promotion and achievement of waste minimisation. The levy encourages organisations and individuals to take responsibility for their waste generation and to find more effective ways to reduce, reuse, recycle or reprocess waste.

From 1 July 2021, the Government has progressively increased and expanded the national Waste Disposal Levy. This expansion involves:

- progressively increasing the levy rate for landfills that take household waste over a period of four years until 2024
- expanding the waste levy to cover additional landfill types, including construction and demolition and demolition fills. Previously, the waste levy only applied to municipal landfills that take household waste
- collecting better data on waste generation, disposal and management
- investing the additional waste revenue from the waste levy into initiatives that support waste reduction.

Half of the levy money goes to city and district councils to spend on promoting or achieving the waste minimisation activities set out in their waste management and minimisation plans. The remaining levy money (minus administration costs) is invested by central government in waste minimisation projects, including via the Waste Minimisation Fund.

Waste Minimisation Fund

The Waste Minimisation Fund (WMF), established under the Waste Minimisation Act 2008, provides co-benefits for emissions reductions. Through this fund, a portion of the total levy on waste disposed to landfills is allocated to waste minimisation projects. The purpose of the WMF is to support projects that increase the reuse, recovery and recycling of materials. The fund invests in a wide range of projects from infrastructure investments to behaviour change and community-centred projects.

Regulated Product Stewardship

In July 2020, the New Zealand Government announced six products to be declared 'priority products' for the establishment of Regulated Product Stewardship schemes under the Waste Minimisation Act 2008.

The products are:

- plastic packaging
- tyres
- electrical and electronic products (e-waste including batteries)
- agrichemicals and their containers
- refrigerants
- farm plastics.

²¹² environment.govt.nz/what-government-is-doing/areas-of-work/waste/waste-disposal-levy/

The Ministry for the Environment is working with stakeholders to co-design product stewardship schemes for each priority product group. Co-design of the schemes for tyres and refrigerants is currently under way. Of particular interest from an emissions perspective is product stewardship for refrigerants (found in heating and cooling devices). Product stewardship of electric vehicle batteries is also important to assist with uptake and sustainability of electric vehicles.

National Environmental Standard for Air Quality

The Ministry for the Environment also administers a National Environmental Standard for Air Quality (including control of greenhouse gas emissions at landfills), which is implemented by local and regional councils. The Standard includes specific regulations for the control of landfill methane, which requires landfill sites with a lifetime design capacity of greater than one million tonnes of refuse to collect and destroy methane emissions. This policy has had the largest impact on emissions in the waste sector to date.

Ongoing strategic changes to support emissions reductions from waste

The Ministry for the Environment is currently developing a new New Zealand Waste Strategy. The strategy will take a broader approach that goes beyond emissions reductions, with the aim of ensuring that waste is minimised and that organic and inorganic materials are recovered and available for reuse in a more circular, low-emissions economy. The updated Waste Strategy will be finalised in late 2022.

Work is also under way to develop new legislation to replace the Waste Minimisation Act 2008 and Litter Act 1979. This legislation will create new powers to support delivery of the Waste Strategy and the emissions reduction plan. Additional regulatory tools will help achieve emissions reduction goals: see the Ministry for the Environment's consultation on Taking responsibility for our waste.²¹³

4.3.9 Policy status and impacts

This section provides a description and details on the status of policies, including an estimate of mitigation impacts where available.

²¹³ consult.environment.govt.nz/waste/taking-responsibility-for-our-waste/.

Table 4.3: Progress in achievement of the quantified economy-wide emissions reduction target: information on mitigation actions and their effects (CTF table 3)

Note: CCRA = Climate Change Response Act 2002; CH₄ = methane; CO₂ = carbon dioxide; CO₂-e = carbon dioxide equivalent; GHGs = greenhouse gases; HFCs = hydrofluorocarbons; IPPU = industrial processes and product use; kt = kilotonnes; LULUCF = land use, land-use change and forestry; N₂O = nitrous oxide; NA = not applicable; NE = not estimated; NZU = New Zealand Unit; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride; TBC = to be confirmed; WAM = with additional measures; WEM = with existing measures.

Estimate of mitigation impact: Mitigation impacts were not estimated (NE) for some policies because the policy is not implemented or is in the early stages of implementation, insufficient data were available, there were model design constraints or the impact is considered negligible.

Status of implementation: Policies with a status described as WEM (with existing measures) or WAM (with additional measures) have mitigation impacts estimated from emissions projections scenarios described in chapter 5. Mitigation impacts for all other policies have been developed at policy level using other methods and have not been integrated into sector-level modelling. This also means that the estimated total mitigation impacts of policies and measures do not align with the change in emissions between the ‘without measures’ scenario and the ‘with measures’ scenario from chapter 5.

A negative estimate of mitigation impact indicates additional GHG emissions resulting from this policy or measure for this particular year.

Name of mitigation action	Sectors affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2025	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2030	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2035
Cross-cutting policies and measures: New Zealand’s emissions reduction plan and the New Zealand Emissions Trading Scheme											
Emissions reduction plan	Energy, transport, agriculture, waste, IPPU, LULUCF	CO ₂ , CH ₄ , N ₂ O, PFCs, HFCs, SF ₆	Sets out over 300 actions, policies and strategies for meeting New Zealand’s first emissions budget.	Economic, fiscal, voluntary agreement, regulatory, information, education, research	Adopted	The policies and strategies in the emissions reduction plan form a coherent, strategic package with a mutually supportive and balanced mix of emissions pricing, well-targeted regulations, tailored sectoral policies, direct investment (public and private), innovation and mechanisms to meet our climate targets and support an equitable transition to a low-emissions economy.	2022	Ministry for the Environment, Ministry for Primary Industries, Te Manatū Waka – Ministry of Transport, Ministry of Business, Innovation and Employment, The Treasury New Zealand, Ministry of Foreign Affairs and Trade, Ministry of Social Development, Ministry of Housing and Urban Development, Department of Conservation, Energy Efficiency & Conservation Authority, Waka Kotahi, Kāinga Ora, Te Arawhiti, Te Puni Kōkiri, Te Waihanga, Department of Internal Affairs	See the first emissions reduction plan for further details	NA	NA

Name of mitigation action	Sectors affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2025	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2030	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2035
New Zealand Emissions Trading Scheme (NZ ETS)	Forestry/LULUCF, energy, other (fishing), industry/ industrial processes, other (liquid fossil fuels), other (synthetic gases), waste management/ waste, agriculture	CO ₂ , CH ₄ , N ₂ O, PFCs, HFCs, SF ₆	Reduce emissions by creating a market through which emitters pay for emissions covered by the scheme.	Economic, regulatory	Implemented (WEM, WAM)	The NZ ETS requires upstream entities, such as fuel suppliers and large emitters, to pay emissions units (NZUs) to the Government for their activities that result in emissions. It also rewards entities that remove carbon from the atmosphere – which for New Zealand is predominantly through forestry sequestration. A reducing cap on emissions, and the expectation of a rising NZU price shapes future economic development by encouraging alignment of investment decisions with a low-carbon economy and influencing technology choices towards low-emissions alternatives. The NZ ETS places a price signal on the stationary energy, liquid fossil fuel, industrial process, synthetic greenhouse gas, waste and forestry sectors. There has been a phased entry of sectors since 2008.	2008	Environmental Protection Authority, Ministry for the Environment, Ministry for Primary Industries	2,520.4	4,419.1	5,638.6 ²¹⁴
Cross-cutting policies and measures: dedicated funding and finance initiatives											
Climate Emergency Response Fund (CERF)	Transport, energy, agriculture, forestry	CO ₂ , CH ₄ , N ₂ O	The CERF is a dedicated funding source for public investment on climate-related initiatives.	Fiscal	Implemented	The CERF is a Budget funding mechanism to support the Government's climate spending. The abatement impact of the policies and measures in the emissions reduction plan has been quantified as 95–228 Mt across the first, second and third emissions budget periods, reflecting a range of low to high impacts of policies and measures. The investments made through the CERF in Budget 2022 are estimated to drive 52–70% of this abatement.	2021	The Treasury	NE	NE	NE

²¹⁴ The mitigation impact reported here is for energy and transport only.

Name of mitigation action	Sectors affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2025	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2030	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2035
						In the first emissions budget period, emissions reduction plan policies and measures have been quantified to drive 5.4–11.9Mt of abatement, of which funding from the CERF in Budget 2022 is estimated to support 21–34%.					
New Zealand's Sovereign Green Bond Programme	Energy, transport, agriculture, forestry, waste	CO ₂ , CH ₄ , N ₂ O, PFCs, HFCs, SF ₆	Finance or re-finance specific government projects with positive climate and environmental government impacts.	Fiscal	Implemented	Green Bonds provide financing for existing expenditures with positive climate and environmental outcomes. Design of the Green Bond Programme has been informed by international best practice and incorporates New Zealand-specific elements. Alongside Nominal Bonds and Inflation-Indexed Bonds, Green Bonds are expected to be an important and enduring part of the New Zealand Government Bond portfolio. Green Bonds will help ensure high-quality government projects with robust environmental outcomes are financed, delivered, monitored and reported on.	2022	The Treasury	NE	NE	NE
New Zealand Green Investment Finance Limited (NZGIF)	Various	CO ₂ , CH ₄ , N ₂ O, PFCs, HFCs, SF ₆	Invest in climate mitigating technologies. <ul style="list-style-type: none"> Invest to reduce emissions. Invest on a commercial basis. Crowd-in private capital. Show market leadership. 	Fiscal	Implemented	This government-owned entity has the objective of accelerating emissions reduction in New Zealand by investing in climate-mitigating technologies. NZGIF's emissions mitigation impact is estimated as emissions reduction, ²¹⁵ crowding-in private capital, and demonstrating the benefits of low-carbon investment to the market. As at 30 June 2022, the total estimated lifetime emissions reduction of its capital committed is 580–710 kilotonnes of CO ₂ (or equivalents).	2019	New Zealand Green Investment Finance Limited	NE	NE	NE

²¹⁵ Future emissions reductions associated with a project or company over the life of the investment.

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State Sector Decarbonisation Fund (SSDF)	Energy	CO ₂	Government agencies demonstrate the action required to decarbonise.	Financial support	Implemented	The NZ\$219.437 million SSDF provides co-funding to state sector agencies to replace coal boilers with low-emissions alternatives and for other energy efficiency or renewable energy projects, including efficient lighting and electric vehicles. Three-quarters of the funding is targeted for hospitals, schools and universities, which are the biggest emitters.	2020	Energy Efficiency and Conservation Authority, Ministry of Business, Innovation and Employment, The Treasury	46.0	115.6	110.8
Cross-cutting policies and measures: public sector leadership											
Sustainable Government Procurement	Energy	CO ₂	Make sustainable procurement part of government procurement practice.	Other (System Leadership), information	Implemented	The Government Procurement Rules were updated in 2019 to include a focus on the achievement of wider social, economic, cultural and environmental outcomes that go beyond the immediate purchase of goods and services. New Government Procurement Rule introduced. Rule 20: Transitioning to a net zero emissions economy and designing waste out of the system. This directs agencies to: 1) support the procurement of low-emissions and low-waste goods, services and works 2) encourage innovation to significantly reduce emissions and waste impacts from goods and services.	2019	Ministry of Business, Innovation and Employment	NE	NE	NE
Sustainable building rating systems	Energy, construction	CO ₂	Reduce greenhouse gas emissions and construction and demolition waste associated with the construction of new non-residential government owned buildings. Support agencies to meet the requirements of the Carbon Neutral Government Programme.	Other (system leadership), information	Partially implemented	When constructing a new non-residential government-owned building, agencies are required to use an approved sustainable building rating system and achieve minimum requirements around reducing embodied and operational greenhouse gas emissions as well as building and construction waste.	2022	Ministry of Business, Innovation and Employment	NE	NE	NE

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Energy-efficient government office accommodation	Energy	CO ₂	Improve the energy performance of government office accommodation. Support agencies to meet the requirements of the Carbon Neutral Government Programme.	Other (system leadership), information	Implemented	Agencies that are subject to the Property System Lead mandate and have office accommodation over 2,000 m ² are required to begin a National Australian Built Environment Rating System New Zealand (NABERSNZ™) assessment at the next available opportunity (such as a lease renewal). Agencies entering a new lease or renewing an existing lease should target the building achieving a minimum of a 4-star rating. Agencies planning a new build project need to achieve a minimum of a 5-star rating.	2021	Ministry of Business, Innovation and Employment	NE	NE	NE
Cross-cutting policies and measures: climate innovation platforms											
Climate innovation platforms	Energy, transport, agriculture, waste, IPPU, LULUCF	CO ₂ , CH ₄ , N ₂ O, PFCs, HFCs, SF ₆	Coordinate action on key challenges and take opportunities in our shift to a low-emissions future	Other	Adopted	This all-of-government approach will use a wide range of tools and approaches including proactive policy, regulatory settings and innovation tools to ensure that ideas from here and around the world can be implemented quickly.	TBC	Ministry of Business, Innovation and Employment	NE	NE	NE
Energy: strategic approaches to manage the phase-out of fossil fuels											
Aotearoa New Zealand Energy Strategy	Energy	CO ₂ , CH ₄	Support the transition to a low-carbon economy, address strategic challenges in the energy sector and signal pathways away from fossil fuels.	Research, regulatory	Planned	The Energy Strategy will help set the pathways to navigate through the energy trilemma and to provide certainty for the sector, industry and consumers. It will set the direction for New Zealand's pathway away from fossil fuels and towards greater levels of renewable electricity and other low-emissions alternatives.	2022	Ministry of Business, Innovation and Employment	NE	NE	NE
New Zealand Energy Efficiency and Conservation Strategy (NZECS) 2017–2022	Energy	CO ₂	Develop a new New Zealand Energy Efficiency and Conservation Strategy to better align with current energy efficiency, conservation and climate change priorities.	Research, regulatory	Planned	The new strategy will better align with the Government's climate change and energy system priorities. It is intended that the new NZECS will complement, and integrate with, the broader Government-led national energy strategy.	2022	Ministry of Business, Innovation and Employment	NE	NE	NE

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Hydrogen Roadmap	Energy, industry, transport	CO ₂	Support the development of future fuels to decarbonise sectors of the economy.	Research, regulatory	Planned	The Government will develop a hydrogen roadmap for New Zealand by 2023. This roadmap will build on the Vision for Hydrogen in New Zealand, published in September 2019, to set a strategy guiding investment in hydrogen, and maximising economic benefits and emissions reductions.	2022	Ministry of Business, Innovation and Employment	NE	NE	NE
Gas Transition Plan	Energy	CO ₂ , CH ₄	Set a pathway to reduce reliance on fossil gas through a gas transition plan.	Research, regulatory	Planned	The Gas Transition Plan will set out a transition pathway for the fossil gas industry, explore opportunities for renewable gases and contribute to an equitable transition as we reduce our reliance on fossil gas.	2022	Ministry of Business, Innovation and Employment	NE	NE	NE
Energy: programmes regulating energy efficiency											
Equipment Energy Efficiency (E3) programme	Energy	CO ₂	Help households and businesses to purchase and use products that use less energy and save money.	Regulatory, information	Implemented	A joint E3 Programme has been developed with Australia. Energy efficiency measures, including energy rating labelling for a range of residential, commercial and industrial products, along with mandatory performance standards, allow both countries to set consistent standards and measures for energy efficiency.	2002	Energy Efficiency and Conservation Authority	214.6	234.0	301.4
Publicly Available Specifications (PAS)	Energy	CO ₂	Provide best-practice specifications for non-regulated products.	Voluntary documents	Implemented	EECA has worked with Standards New Zealand since 2020 to develop five PAS. This includes guidance for biomass boilers, high-temperature heat pumps, and residential and commercial electric vehicle chargers.	2020	Energy Efficiency and Conservation Authority	NE	NE	NE

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Energy: reduce emissions and energy use in industry											
Government Investment in Decarbonising Industry (GIDI) Fund	Energy	CO ₂	Accelerate the decarbonisation of industrial process heat.	Financial support	Implemented	Assists private sector businesses with the upfront capital costs of energy efficiency initiatives as well as switching from fossil fuels to renewables to accelerate their decarbonisation goals. The combined emissions reduction across the three rounds of GIDI 1.0 is 7.46 million tonnes of CO ₂ -e, equivalent to taking 134,800 cars off the road.	2020	Energy Efficiency and Conservation Authority	179.0	330.6	198.2
Expansion of GIDI Fund	Energy	CO ₂	Decarbonise businesses through a number of workstreams, including industrial process heat, commercial space and water heating, and efficient industrial equipment replacements.	Financial support	Adopted (WAM)	The expanded fund significantly increases the funding for the original GIDI Fund, and will go to market through multiple channels, including the original contestable process heat fund, as well partnerships with large energy users, equipment subsidies and infrastructure enablement.	2022	Energy Efficiency and Conservation Authority	1,080.7	2,543.1	1,709.5
Energy Transition Accelerator (ETA) Programme	Energy (commercial, industrial sector)	CO ₂	Develop long-term plans for businesses to transition to lowering emissions as much as possible.	Information, financial and industry support	Implemented	The Energy Efficiency and Conservation Authority is working with large energy users to help them develop tailored and practical low-carbon transition pathways. The goal is to facilitate long-term thinking by drafting a practical map for transition, showing what the technically and economically feasible opportunities are, including innovative technologies, energy efficiency and fuel switching.	2019	Energy Efficiency and Conservation Authority	NE	NE	NE
Technology demonstration programme	Energy (commercial, industrial)	CO ₂	Promote technology that is commercially proven, but underused in New Zealand.	Information	Implemented	The Technology demonstration programme will offer up to NZ\$2 million in the coming year (spread across several projects) to co-fund and reduce risk for underused energy-saving technology for wider market deployment. Since 2018/19, the programme has included a specific investment focus to demonstrate innovative electric heat pump technologies.	2013	Energy Efficiency and Conservation Authority	NE	NE	NE

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						Since 2013, the expected total annual emissions savings from completed and commissioned projects was 94.232 kt CO ₂ -e per annum. A further total annual emissions saving of 31.641 kt CO ₂ -e per annum is expected from projects in the pipeline.					
Energy: energy efficient communities											
Gen Less	Energy	CO ₂	Educate people and businesses about their energy choices and support the Government's wider move towards a net zero carbon New Zealand by 2050.	Information	Implemented	The Gen Less website, social media channels and direct mailing lists provide information about climate change and how to reduce energy-related emissions at household, business and national levels.	2019	Energy Efficiency and Conservation Authority	NE	NE	NE
Support for Energy Education in Communities Programme	Energy	CO ₂	Lift people out of energy hardship.	Fiscal	Implemented	Funding to build and expand the network of services to support people experiencing energy hardship to achieve warmer, more energy-efficient homes and lower their energy bills.	2020	Ministry of Business, Innovation and Employment	NE	NE	NE
Energy: further programmes to improve the energy system											
Māori and Public Housing Renewable Energy Fund and Community Energy Fund	Energy	CO ₂	Support renewable and affordable energy in communities.	Fiscal	Implemented	This fund trials community-scale renewable technologies such as modern geothermal, solar panels and batteries. The most recent round made funding available for larger, more complex, renewable energy technologies, such as small-scale hydro, wind energy generation and projects integrating remote distribution and retail solutions. The Community Energy Fund builds on and expands this.	2020	Ministry of Business, Innovation and Employment	NE	NE	NE
NZ Battery Project	Energy	CO ₂	Investigate solutions to the 'dry year problem' when hydro catchments are low and fossil fuels are used to generate electricity to cover the shortfall.	Research	Implemented	The NZ Battery Project will provide comprehensive advice on the technical, environmental and commercial feasibility of pumped hydro and other potential energy storage projects to mitigate the dry year problem.	2020	Ministry of Business, Innovation and Employment	NE	NE	NE

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Electricity Market Measures	Energy	CO ₂	Support the electricity market to transition to 100 per cent renewable generation.	Research, regulatory	Planned	Investigation of the need for and implementation of additional market mechanisms and regulation to support affordable and reliable electricity supply, while accelerating the transition to a highly renewable electricity system.	2022	Ministry of Business, Innovation and Employment	NE	NE	NE
Develop offshore energy regulatory framework	Energy	CO ₂	Enable investment in offshore renewable energy.	Regulatory	Planned	Develop regulatory settings to enable investment in offshore renewable energy (such as offshore wind farms) and innovation.	2022	Ministry of Business, Innovation and Employment	NE	NE	NE
Review national direction tools for new renewable generation and electricity infrastructure	Energy	CO ₂	Determine whether – and how – resource consent processes could be improved.	Regulatory	Planned	Review of national direction tools for enabling investment in new renewable electricity generation and infrastructure, including small-scale generation. Determine whether, and how, resource consenting processes could be improved.	2022	Ministry of Business, Innovation and Employment	NE	NE	NE
Building and construction											
National Australian Built Environment Rating System – New Zealand (NABERSNZ™)	Energy (commercial, public sector)	CO ₂	Improve the energy performance of new and existing commercial buildings.	Information	Implemented	NABERSNZ™ is a system for rating the energy efficiency of existing office buildings and identifies opportunities for implementing building energy performance improvements. Other work includes: financial grants and loans for energy audits; energy plans; monitoring and verification systems; systems optimisation; and new and emerging technologies.	2013	Energy Efficiency and Conservation Authority	NE	NE	NE
Insulation and heating grants programmes	Energy (residential)	CO ₂	Provide warmer, drier homes through improved thermal performance.	Financial and industry support	Implemented	To date, the Energy Efficiency and Conservation Authority has administered two major insulation and heating programmes. <ul style="list-style-type: none"> Warm Up New Zealand (running 2009–18) offered insulation retrofits to low-income and/or high-health-need households, as well as to general homeowners in its early years. 	2009	Energy Efficiency and Conservation Authority	NE	NE	NE

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						<ul style="list-style-type: none"> Warmer Kiwi Homes replaced Warm Up New Zealand in 2018 and added grants for heat pumps and woodburners. <p>The Energy Efficiency and Conservation Authority has taken a partnership approach by working with third-party funders in the community to leverage government grants.</p>					
Transport: reducing reliance on vehicles and supporting people to walk, cycle and use public transport											
Urban Cycleways programme	Transport	CO ₂	Accelerate investment in and uptake of cycling.	Fiscal	Implemented	This Programme optimises co-investment from central government through the Urban Cycleways Fund with funding from the National Land Transport Fund and other local funding.	2014	Waka Kotahi	NE	NE	NE
Community Connect public transport concession	Transport	CO ₂	Improve affordability of public transport for low-income New Zealanders.	Economic, fiscal	Planned	The Community Connect public transport concession will provide half-price fares for Community Service Cardholders. The Government is providing approximately \$25 million a year for this concession.	2023	Waka Kotahi, public transport authorities	5	6	0
Public transport bus decarbonisation	Transport	CO ₂	Accelerate decarbonisation of the public transport bus fleet.	Economic, fiscal, regulatory	Partially implemented	The Government will require only zero-emission public transport buses to be purchased by 1 July 2025 and is targeting full decarbonisation of the bus fleet by 2035. The Government is providing \$137 million over 12 years to support bus decarbonisation initiatives. Funding provided in 2022 for bus decarbonisation is expected to result in an emissions reduction of approximately 290,000 tonnes of CO ₂ -e over 2022–45.	2023	Te Manatū Waka – Ministry of Transport, Waka Kotahi	23	78	177
Transport: rapidly adopting low-emissions vehicles											
Road User Charges exemptions for electric vehicles	Transport	CO ₂	Encourage electric vehicle uptake in both the light and heavy fleets.	Fiscal	Implemented (WEM)	A Road User Charges exemption on light electric vehicles commenced in 2012 and will run until 31 March 2024. A new Road User Charges exemption for heavy electric vehicles was introduced in 2017 and will run until 31 December 2025.	2012	Te Manatū Waka – Ministry of Transport, Waka Kotahi	9	9	8

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Clean Vehicle Discount Scheme and Clean Vehicle Standard	Transport	CO ₂	Address both the supply of and the demand for low-emissions vehicles in New Zealand.	Fiscal, regulatory	Implemented	The Clean Vehicle Discount encourages buyer demand for low-emission vehicles by providing rebates for zero- and low-emission light vehicles, and requiring a fee be paid for high-emission vehicles registered in New Zealand for the first time. The Clean Vehicle Standard requires vehicle importers to achieve annually stricter CO ₂ targets from 2023 or otherwise face financial charges. Scenario modelling using assumed demand response to price changes suggests emissions reduction benefits between 2022 and 2050 from the Clean Vehicle Discount and the Clean Vehicle Standard policies could range between 3.8 and 15.3 million tonnes.	2021	Te Manatū Waka – Ministry of Transport, Waka Kotahi	NE	NE	NE
Low Emissions Transport Fund	Transport	CO ₂	Support the demonstration and adoption of low-emission transport technology, innovation and infrastructure to accelerate the decarbonisation of New Zealand's transport sector.	Financial support	Implemented	The Government increased the funding contribution from \$6–7 million per year to \$25 million per year by 2023/24.	2021	Energy Efficiency and Conservation Authority	NE	NE	NE
Electric vehicle charging infrastructure	Transport	CO ₂	Provide a long-term strategic direction as New Zealand's electric vehicle infrastructure expands.	Other	Planned	This strategy (a discussion document for it is due at the end of 2022) will set out the Government's vision and policy objectives around electric vehicle charging.	TBC	Te Manatū Waka – Ministry of Transport	NE	NE	NE

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Vehicle Fuel Economy Labelling	Transport	CO ₂	Allow consumers to make more informed vehicle purchase choices, and to place an appropriate value on fuel economy.	Regulatory, information	Implemented	This compulsory programme requires vehicle traders and online vendors to display information relating to fuel economy. Updated 2022 to better show CO ₂ emissions, a stricter star rating scheme, and any rebate/charge under the Clean Vehicle Discount scheme. The Energy Efficiency and Conservation Authority estimates that the Vehicle Fuel Economy Labelling programme will encourage CO ₂ savings of 41 kt CO ₂ -e per year by 2020.	2008	Energy Efficiency and Conservation Authority	NE	NE	NE
Transport: begin work now to decarbonise heavy transport and freight											
Freight and Supply Chain Strategy	Transport	CO ₂	Reduce emissions from heavy road freight.	Education	Planned	Developing a Freight and Supply Chain Strategy in collaboration with iwi/Māori, local government and industry. It will set out system-wide actions that need to happen across the sector to achieve our decarbonisation, resilience, productivity and wellbeing outcomes.	2023	Te Manatū Waka – Ministry of Transport	NE	NE	NE
Sustainable Biofuels Obligation	Transport	CO ₂	Help overcome the cost and risk barriers to sustainable biofuels uptake.	Regulatory	Planned	The Sustainable Biofuels Obligation will require fuel suppliers that purchase or import fuel for use in Aotearoa to reduce the total emissions of the fuels they sell by a set percentage each year through the deployment of sustainable biofuels.	2024	Te Manatū Waka – Ministry of Transport and Ministry of Business, Innovation and Employment; Environmental Protection Agency as regulatory agency	513	659	1,001
Transport: Cross-cutting measures to contribute to the delivery of a low-emissions transport system											
Government Policy Statement (GPS) on Land Transport 2021	Transport	CO ₂	Invest in rail, public transport and active modes of transport to mitigate emissions and avoid further increases.	Regulatory, fiscal	Implemented	The GPS on land transport sets the Government's priorities for land transport investment over a 10-year period. It also sets out how money from the National Land Transport Fund is spent on activities such as public transport, state highway improvements, local roads and road safety.	2021	Te Manatū Waka – Ministry of Transport, Waka Kotahi	NE	NE	NE

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Industry											
Kigali Amendment to the Montreal Protocol	IPPU	HFCs	Phase-down of consumption of HFC gases.	Regulatory	Implemented (WEM)	Staged phase-down on consumption (production, importation and exportation) of bulk HFCs.	2020	Ministry for the Environment	NE	NE	NE
Proposals to prohibit import and sale of pre-charged equipment containing HFCs	IPPU	HFCs	Reduce HFCs emissions by prohibiting their use where alternatives are available.	Regulatory	Planned (WAM)	Prohibiting the import and sale of pre-charged equipment containing HFCs in cases where alternatives are available.	TBC	Ministry for the Environment	NE	NE	NE
Action plan for decarbonising industry	Energy	CO ₂	Decarbonise industry.	Research, regulatory	Planned	The Government will set an action plan for decarbonising industry by the end of 2024. The plan will support existing industries to decarbonise and innovative low-emissions industries to grow. The plan will sit within the energy strategy to align with the broader approach for decarbonising the energy sector, including ensuring competitive energy prices and security of supply.	2022	Ministry of Business, Innovation and Employment	NE	NE	NE
Agriculture											
New Zealand Emissions Trading Scheme (NZ ETS)	Agriculture	CO ₂ , CH ₄ , N ₂ O, PFCs, HFCs, SF ₆	Reduce emissions by creating a market through which emitters pay for emissions covered by the scheme.	Economic, regulatory	Implemented (WEM)	The NZ ETS covers all sectors and all gases with reporting and/or surrender obligations – that is, all emissions except for biological emissions from agriculture. The 2012 amendments to the CCRA removed the date for biological emissions from agriculture to assume surrender obligations. The mitigation impacts noted here relate to land-use change. There has been a phased entry of sectors since 2008.	2008	Environmental Protection Authority, Ministry for the Environment, Ministry for Primary Industries	589.4	903.2	1,215.3

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Pricing on agricultural emissions with 95% free allocation	Agriculture	CH ₄ , N ₂ O	Encourage reduction in agricultural emissions.	Economic, regulatory	Planned (WEM)	The Climate Change Response (Emissions Trading Reform) Amendment Bill will put a price on agricultural emissions from 2025, with free allocation set at 95%. In the meantime, a formal sector–Government partnership is helping to prepare for emissions pricing, including by enabling on-farm emissions reporting while considering an alternative pricing mechanism. The Climate Change Commission has carried out a review of progress in 2022.	2020	Ministry for the Environment, Ministry for Primary Industries	123.5	649.8	1,136.0
Centre for Climate Action on Agricultural Emissions	Agriculture	CH ₄ , N ₂ O, CO ₂	Accelerate the development of greenhouse gas mitigations	Research, commercialisation, information, capability building	Planned	The Centre will include a new public–private joint venture with a focus on product development and commercialisation to drive research and development activity.	TBC	Ministry for Primary Industries	NE	NE	NE
Global Research Alliance on Agricultural Greenhouse Gases (GRA)	Agriculture	CH ₄ , N ₂ O, CO ₂	Increase international collaboration on and investment in research on increasing agricultural and food production, without growing greenhouse gas emissions.	Research, information, training, education	Implemented	New Zealand plays an active role in supporting the GRA through funding and delivery of education, training and public awareness, funding of mitigation research projects and funding of regional and international collaboration in addition to co-chairing the GRA's Livestock Research Group and hosting the GRA Secretariat and Special Representative.	2009	Secretariat support and co-Chair of the Livestock Research Group provided by New Zealand Ministry for Primary Industries	NE	NE	NE
New Zealand Agricultural Greenhouse Gas Research Centre	Agriculture	CH ₄ , N ₂ O, CO ₂	Focus on ways to reduce on-farm CH ₄ and N ₂ O emissions and enhance soil carbon.	Research, information, capability building, education	Implemented	Brings together nine primary sector research organisations.	2009	Ministry for Primary Industries	NE	NE	NE
Sustainable Food and Fibre Futures	Agriculture	CH ₄ , N ₂ O, CO ₂	Invest in innovative projects to grow New Zealand's food and fibre industries sustainably.	Research, information, training	Implemented	Provides funding for programmes of research and innovation.	2018	Ministry for Primary Industries	NE	NE	NE

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Sustainable Land Management and Climate Change Research Programme	Agriculture	CH ₄ , N ₂ O, CO ₂	Research programmes in agriculture and forestry sectors.	Research, information, education, capability building, extension	Implemented	Initiatives and programmes in the agricultural and forestry sectors that focus on adaptation to climate change.	2007	Ministry for Primary Industries	NE	NE	NE
Synthetic nitrogen fertiliser cap (N-cap)	Agriculture	N ₂ O	Limit the impacts of synthetic nitrogen fertiliser on freshwater ecosystems following application to land. The synthetic fertiliser cap will have the co-benefit of a reduction in synthetic nitrogen fertiliser applied to land, and modelled reduction in N ₂ O emissions.	Regulatory	Implemented (WEM)	From 1 July 2021, a cap on the use of synthetic nitrogen fertiliser applies on any contiguous parcel of pastoral land. The cap has been set at 190 kg per hectare per year.	2021	Ministry for the Environment and regional and local councils	0.0	71.7	149.8
Essential Freshwater Package (excluding the impact of the N-cap)	Agriculture	CH ₄ , N ₂ O	Improve the quality of freshwater in New Zealand. Its implementation will have a co-benefit of more streamside planting (to reduce rural runoff), retention of more natural wetlands, and potentially less intensive stocking. These actions will contribute to carbon capture and reduce emissions.	Regulatory	Implemented (WEM)	The National Policy Statement for Freshwater Management provides national policy direction to regional councils on freshwater management. These measures will impact emissions from agriculture through their influence on animal numbers.	2020	Regional and local councils	82.2	424.5	767.5
Land use, land-use change and forestry (LULUCF): principal measures											
NZ ETS	LULUCF	CO ₂	Promote afforestation and disincentivise planted forest deforestation.	Fiscal	Implemented (WEM)	The NZ ETS is a key tool for meeting domestic and international climate change targets. Owners of post-1989 eligible forest can earn NZUs for carbon sequestered. There are also liabilities for forest carbon loss, via harvesting or deforestation.	2008	Ministry for Primary Industries	4,569.7	10,109.0	16,394.3

Name of mitigation action	Sectors affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2025	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2030	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2035
Afforestation Grant Scheme	LULUCF	CO ₂	Promote the establishment of production and permanent forests on previously unforested land. Reduce erosion by encouraging tree planting on erosion-prone land. Enhance the sequestration of carbon in forest sinks. Increase the area of new forests that meet the afforestation/ reforestation definition under the Kyoto Protocol in New Zealand.	Fiscal	Implemented (WEM)	Under the Afforestation Grant Scheme, landowners who have received a grant have ongoing obligations to maintain their grant forests for a minimum 10-year period.	2008–18	Ministry for Primary Industries	713.4	703.6	774.5
One Billion Trees Programme	LULUCF	CO ₂	Increase tree planting across New Zealand. The goal is to double the current planting rate to reach one billion trees planted by 2028.	Fiscal	Implemented (WEM)	This \$176.8 million fund ran for three years from August 2018 until its closure on 30 June 2021. Existing funding agreements extend into the future and will receive continued support and relationship management as these projects progress to completion.	2018–21	Ministry for Primary Industries	932.9	1,111.8	1,283.4
Sustainable Land Management Hill Country Erosion Programme	LULUCF	CO ₂	Protect New Zealand's estimated 1.4 million hectares of pastoral hill country that is classified as erosion-prone.	Fiscal	Implemented (WEM)	It provides up to NZ\$10 million of targeted funding support annually to regional and unitary councils. The purpose of the Programme is to speed up the rate of treatment of erosion-prone land.	2009	Ministry for Primary Industries	485.0	694.2	724.1
Erosion Control Funding Programme	LULUCF	CO ₂	Provide funding to land owners to prevent and control erosion.	Fiscal	Implemented (WEM)	The grant can be used to control erosion on the worst eroding or erosion-prone land in the district, by providing effective tree cover through planting or encouraging natural reversion to native bush.	1993–2018	Ministry for Primary Industries	246.8	698.8	1,273.3
Permanent Forest Sink Initiative (PFSI)	LULUCF	CO ₂	Enable land owners to receive New Zealand Units for permanent forest sinks.	Fiscal	Implemented (WEM)	Discontinue the PFSI at the end of 2021 and replace it with a new activity in the NZ ETS that encourages the establishment of permanent post-1989 forests.	2008–22	Ministry for Primary Industries	214.4	178.5	166.0

Name of mitigation action	Sectors affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2025	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2030	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2035
LULUCF: other measures											
Woody biomass	LULUCF	CO ₂	Directly increase biomass supply and stimulate private sector investment to create further supply.	Fiscal	Planned (WAM)	Investment in commercial planting to increase the supply of biomass; and research into alternative biomass crops, and effective forest waste recovery for biomass.	2023	Ministry for Primary Industries	-75.4	288.6	309.8
Native afforestation initiative	LULUCF	CO ₂	Increase the supply of native seedlings and reducing the barriers and cost for planting. It is the first stage of a multi-phase project to support establishing native forests at scale to develop long-term carbon sinks.	Fiscal	Planned (WAM)	Deployment and uptake of technology; development of a long-term strategy and actions plan with partners and stakeholders; research and innovation; and increased knowledge and advice to support nursery sector growth.	2025	Ministry for Primary Industries	31.1	282.3	740.1
Maximising carbon storage	LULUCF	CO ₂	Support the increased sequestration of carbon.	Fiscal	Planned (WAM)	Stimulate investment in domestic wood processing to increase value from exports and maximise carbon stored in manufactured wood products; fund research and expand look-up tables to more accurately reflect carbon stock changes.	2024	Ministry for Primary Industries	149.1	843.0	1,507.0
National Environmental Standards	LULUCF	CO ₂	Ensure the environmental effects of all exotic afforestation are managed; improve wildfire risk management planning; better enable foresters and councils to manage the environmental effects of forestry; and consult on options for extending regulatory controls to control the location of plantation and exotic carbon afforestation.	Regulatory	Planned	Proposals and options for managing plantation and exotic carbon forestry under the resource management system. Consultation commenced October 2022.	TBC	Ministry for the Environment, Ministry for Primary Industries	NE	NE	NE

Name of mitigation action	Sectors affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2025	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2030	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2035
Develop forestry and wood processing industry transformation plan (ITP)	Forestry	CO ₂	Proposes a vision and actions to transform the forestry and wood processing sector so that the sector generates more value for New Zealand, is a key pillar of our regional communities, and underpins New Zealand's low-emissions economy.	Fiscal	Adopted	The ITP is being developed in partnership with Māori, industry and workers to deliver more value from our existing and future forest estate, stimulate production of new cost-effective low-emissions products and wood-based biofuels and provide sustainable jobs across the regions.	TBC	Ministry for Primary Industries	NE	NE	NE
Waste											
Emissions reduction plan – existing waste sector policies	Waste	CH ₄ , N ₂ O	This represents the set of policies that are already adopted under the emissions reduction plan for the waste sector, covering various waste reduction programmes.	Regulatory, fiscal voluntary agreement, information, education, research	Adopted (WEM)	<ul style="list-style-type: none"> Implement organic waste reduction behaviour change programmes. Standardise residential kerbside collection – provision of food scraps collections. Require businesses to separate food waste. Invest in organic waste processing and resource recovery infrastructure to support an increase in food, garden, paper/cardboard and wood waste diversion from landfill. Improve landfill gas capture systems. Implementation year varies by policy. 	2023	Ministry for the Environment, regional and local councils	27.4	96.9	139.2
Emissions reduction plan – additional waste sector policies	Waste	CH ₄ , N ₂ O	This represents several planned policies under the emissions reduction plan for the waste sector, focusing on landfill gas capture.	Regulatory	Planned (WAM)	<ul style="list-style-type: none"> Limits and bans organic waste to landfill by 2030. Expands landfill gas capture systems to more landfills. Implementation year varies by policy.	2023	Ministry for the Environment, regional and local councils	0	176.5	258.2
Waste Disposal Levy under the Waste Minimisation Act 2008	Waste	CO ₂ , CH ₄ , N ₂ O	Encourage waste minimisation and decrease waste disposal to protect the environment from harm and provide environmental, social, economic and cultural benefits.	Regulatory	Implemented (WEM)	The Waste Disposal Levy rate for landfills that take household waste is progressively increasing over four years from \$10 per tonne, set in 2009, to \$60 per tonne as of July 2024.	2010	Ministry for the Environment	32.3	64.5	79.8

Name of mitigation action	Sectors affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2025	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2030	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2035
Waste Minimisation Fund (WMF)	Waste	CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆	Increase resource efficiency; increase reuse, recovery and recycling; and decrease waste to landfill.	Fiscal	Implemented	A levy is imposed on waste disposed to landfill and generates funds for waste minimisation activities. These funds are distributed to territorial authorities and waste minimisation projects (via the WMF). Additional funding from the Climate Emergency Response Fund is available for infrastructure projects to reduce emissions from waste in 2022–24.	2010	Ministry for the Environment	NE	NE	NE
Regulated Product Stewardship	Waste, IPPU	CO ₂ , CH ₄ , HFCs, SF ₆	Implement regulations to increase circular economy and place responsibilities for managing end-of-life products on producers, importers and retailers rather than on communities, councils, neighbours and nature.	Regulatory	Adopted	The Ministry for the Environment is working with stakeholders to co-design product stewardship schemes for six priority products: plastic packing, tyres, electrical and electronic products, agrichemicals and their containers, refrigerants, farm plastics. Co-design of the schemes for tyres and refrigerants is currently under way. Of particular interest from an emissions perspective is product stewardship for refrigerants (found in heating and cooling devices). Product stewardship of electric vehicle batteries is also important to assist with uptake and sustainability of electric vehicles.	2020	Ministry for the Environment	NE	NE	NE

Name of mitigation action	Sectors affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2025	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2030	Estimate of mitigation impact (not cumulative) (kt CO ₂ -e) 2035
National Environmental Standard for Air Quality	Waste	CH ₄	Effectively manage discharges to air of greenhouse gases (mainly CH ₄) generated from large landfills.	Regulatory	Implemented (WEM)	The landfill gas standards currently require landfill sites with a lifetime design capacity of greater than 1 million tonnes of refuse to collect and destroy CH ₄ emissions. Amendments proposed under the emissions reduction plan will require all municipal landfills to capture gas, including sites with less than 1 million tonnes capacity. Standard came into effect in 2004, with full compliance required by 2007.	2004	Ministry for the Environment, regional and local councils	605.3	657.2	691.6
Tokelau											
Tokelau Renewable Energy Project	Tokelau	CO ₂ , CH ₄	Provide reliable, adequate, and efficient energy for the people of Tokelau through the use of solar photovoltaic power.	Fiscal	Implemented (WEM)	In 2012, the installation of about 4,000 solar panels across Tokelau's three atolls was completed. Each of the three Tokelau atolls now has a significant array of solar panels that cater for almost all local electric power requirements.	2012	Ministry of Foreign Affairs and Trade	1	1	1

4.4 Economic and social impacts of response measures

This section outlines Aotearoa New Zealand’s approach and actions aimed at minimising adverse social, environmental and economic impacts that may result from the implementation of the climate change policies and measures.

4.4.1 Transitioning to a low-emissions and climate resilient economy

Transitioning to a low-emissions and climate-resilient future provides an opportunity for New Zealand to transform its economy, work together to improve wellbeing, become more productive, increase resilience and reduce inequality.

The Climate Change Commission’s modelling indicates that New Zealand would face higher economic costs if it delays necessary aspects of the low-emissions transition. Delaying key actions such as the move to electric vehicles and more efficient farm practices would lead to higher-cost actions in the future. The overall impact to GDP would be higher – potentially reducing GDP by up to 1 per cent in 2035 if these key measures are not successfully rolled out.

Transitioning to a low-emissions, climate-resilient economy will require a range of changes across the economy. Many businesses will need to adopt new technology and ways of working, and some workers will need new skills. However, some communities, low-income households and other vulnerable groups may face transition impacts and increasing costs. The Government is committed to supporting low-income families, households and other vulnerable groups who may face transition impacts and require access to resources and technologies to help them reduce emissions.

The emissions reduction plan sets out a mix of pricing, regulation and other policies to achieve a low-emissions, equitable transition. Addressing the economic and social impacts of response measures is a core part of the emissions reduction plan. Due to the wide scope of the ERP, it is difficult to forecast the exact economic and fiscal implications of our transition.

Over the longer term, the transition to a low-emissions economy can be expected to reduce waste, increase efficiency and improve productivity as a result of adopting low-emissions technology and business practices.

Key actions in the emissions reduction plan

The Government’s approach to supporting New Zealanders through the transition is built around five objectives and the following actions from the emissions reduction plan.

Seize the opportunities of the transition

- Action 3.1.1: Equip all children and young people for the transition.
- Action 3.1.2: Create an accessible, responsive and flexible tertiary education and training system.

Support proactive transition planning

- Action 3.2.1 Develop an equitable transition strategy.
- Action 3.2.2 Support regions and industries to manage the transition.
- Action 3.2.3 Implement the Just Transition Partnerships Programme.

Enable an affordable and inclusive transition

- Action 3.3.1 Develop an income insurance scheme.
- Action 3.3.2 Improve welfare system income adequacy.
- Action 3.3.3 Strengthen employment support services.

Build the evidence base and tools to monitor and assess impacts

- Action 3.4 Build the evidence base and monitor and assess impacts.

Encourage informed public participation

- Action 3.5.1 Inform low-emissions choices through a Climate Information Centre.
- Action 3.5.2 Enable inclusive and participatory climate responses.
- Action 3.5.3 Support localised and community-based solutions.

Alongside these actions, the emissions reduction plan identifies a range of initiatives to support an affordable and inclusive transition for individuals, whānau (families) and households.

Transport, energy and waste are key areas where targeted policies will help mitigate the impacts of the transition. These policies include the following:

Sector	Targeted policies
Transport	<ul style="list-style-type: none">• working with local government to make public transport more affordable, with a particular focus on low-income users• working with local government to deliver public transport, walking and cycling improvements in low socio-economic areas and for transport-disadvantaged groups• increasing access to low- and zero-emissions vehicles for low-income households by supporting social leasing schemes and trialling an equity-oriented vehicle scrap and replace scheme
Energy	<ul style="list-style-type: none">• helping households reduce their energy bills and keep their homes healthy, warm and dry, with funding for heating and insulation upgrades through Warmer Kiwi Homes• introducing Healthy Homes Standards to raise the quality of rental homes²¹⁶• supporting community renewable energy projects for Māori and public housing, such as solar panels and batteries• delivering the Support for Energy Education in Communities Programme to provide community-level education to assist people to achieve warmer homes and lower energy bills

²¹⁶ [www.hud.govt.nz/our-work/healthy-homes-standards/#:~:text=The%20Residential%20Tenancies%20\(Healthy%20Homes,insulation](http://www.hud.govt.nz/our-work/healthy-homes-standards/#:~:text=The%20Residential%20Tenancies%20(Healthy%20Homes,insulation)

Sector	Targeted policies
Waste	<ul style="list-style-type: none"> • supporting waste minimisation initiatives, including waste avoidance programmes for urban and rural households, funded by revenue raised through the waste disposal levy • supporting Māori communities to manage waste, such as the Para Kore programme, which operates in marae, kōhanga reo, kura and other Māori community organisations to provide education and training in waste management.

Impacts on workers

The Government has released an Employment Strategy and seven supporting Action Plans, which recognise that climate change – among other trends – could drive significant changes in the nature of work, and set out actions to help workers through the transition equitably. These actions include a focus on access to lifelong learning to support career transitions, for example through reforming vocational education.

The Government is also bringing together key stakeholders to prepare for the future. Regional Skills Leadership Groups were formed in June 2020 to achieve a more coordinated labour market view and plan for current and future workforce needs in their regions. Some of these have a focus on climate, according to the characteristics of their regions. The Government has also established the Tripartite Future of Work forum, bringing together business and union stakeholders to identify opportunities to support businesses and workers to meet the challenges and take the opportunities that change represents.

Risk of emissions leakage

A number of firms carrying out eligible emitting activities that are emissions intensive and involve international trade are allocated free emissions units (known as industrial allocation) to reduce the risk of emissions leakage. This is where climate policy such as emissions pricing results in production, firms or investment moving offshore to jurisdictions with weaker climate policy to reduce compliance costs. This has the potential to increase global emissions²¹⁷ and result in economic regrets for no climate benefit. A phase-out of industrial allocation began in 2021, reducing allocations by 1 percentage point per annum, with the rate increasing in later decades. The Government is also working on reforming industrial allocation policy to correct the amount of free allocation that industries receive due to the evidence that some are receiving more than their emissions costs.

Impact analysis requirement for regulatory proposals

Government agencies are required to provide a Regulatory Impact Statement (RIS) on the impact analysis relating to a regulatory proposal, which includes consideration of the economic and social impacts of the proposal. The RIS provides a high-level summary of the problem being addressed, the options and their associated costs and benefits, the consultation undertaken, and the proposed arrangements for implementation and review.

²¹⁷ This could occur if the production moves to a jurisdiction without an emissions cap, and if the alternative production is more emissions intensive.

To help ensure that the regulatory process is open and transparent, RISs prepared to support the consideration of regulatory proposals are published at the time the relevant Bill is introduced to Parliament or the regulation is gazetted, or at the time of ministerial release.²¹⁸

4.5 Monitoring, evaluation and review

This section sets out the frameworks in place for how the Government will monitor, evaluate and report on the implementation and success of the climate change policies and measures.

4.5.1 Monitoring and reporting will allow Aotearoa New Zealand to stay on track and manage unexpected impacts

The Climate Change Commission and government agencies are responsible for monitoring and regularly reporting on progress towards the sector sub-targets²¹⁹ and emissions budgets, as well as the implementation of emissions reduction plans. Regular reporting will allow risks and uncertainties to be proactively managed.

Climate Change Commission

The Commission provides an external monitoring role that will supplement the work carried out by government agencies. The Commission and government agencies will be responsible for monitoring and regularly reporting on progress towards the sector sub-targets and emissions budgets, as well as the implementation of emissions reduction plans.

The CCRA requires the Commission to monitor and review the Government's progress towards its emissions reduction and adaptation goals. Under sections 5ZK and 5ZL of the CCRA, the Commission must report annually on the Government's progress in implementing the plan and again at the end of each emissions budget period on how emissions budgets were or were not met. The Government is required to publicly respond to these reports.

Climate Change Chief Executives Board

A new public sector Climate Change Chief Executives Board (the Board) has been established as an interdepartmental executive board under the Public Service Act 2020. The Board is chaired by the Secretary for the Environment and reports directly to the Prime Minister. By bringing together the chief executives of key government agencies, the Board provides cross-government oversight of the emissions reduction plan. The Board will also oversee the national adaptation plan, with a focus on adaptation set to increase over time.

The Board currently focuses on helping agencies coordinate implementation of the emissions reduction plan, as well as monitoring and reporting on progress against emissions budgets and sector sub-targets. It also functions to identify barriers and opportunities for emissions reduction, and to advise on managing any unexpected impacts, overshoots and under-performance against sub-targets.

²¹⁸ For further details, refer to the Treasury's website:
www.treasury.govt.nz/publications/legislation/regulatory-impact-assessments.

²¹⁹ Sub-targets will help to track progress across key sectors over each emissions budget period. Unlike emissions budgets, they are not legislated.

With regards to adaptation, the Board will report to the Prime Minister annually on the overall implementation of the national adaptation plan, and every two years on the sufficiency of actions in addressing the risks within the scope of the national adaptation plan. The Board will also maintain key stakeholder relationships as needed to drive forward New Zealand's climate change work programme.

The New Zealand Emissions Trading Scheme

The NZ ETS is New Zealand's principal policy response to climate change.

The CCRA includes a clause enabling the Minister for Climate Change to initiate a review of the operation and effectiveness of the NZ ETS at any time.

Resource management system review

The Resource Management Act 1991, New Zealand's key piece of legislation for managing natural and physical resources, has undergone an extensive review. The scope of the review was to look at how the RMA interfaces with the Local Government Act 2002, the Land Transport Management Act 2003 and the Climate Change Response (Zero Carbon) Amendment Act 2019, to achieve improved integrated management. The review considered how to integrate plans and process across this legislation to address the following environmental problems:

- increasing pressure on New Zealand's natural environment
- urban areas struggling to keep pace with population growth
- the urgent need to reduce carbon emissions and adapt to climate change
- the need to ensure that Māori have an effective role in the system, consistent with the principles of Te Tiriti o Waitangi
- the need to improve system efficiency and effectiveness.

New resource management legislation is due to be introduced to the House in late 2022. This legislation will provide for climate change mitigation as an outcome to be achieved under the Natural and Built Environments Act, for national direction to be developed under the National Planning Framework to direct climate mitigation outlines through the planning system, and for the emissions reduction plan to have legal weight in planning decision-making.

Review of the effectiveness of the Waste Disposal Levy

The Minister for the Environment must undertake a statutory review of the effectiveness of the waste disposal levy to monitor progress and to ensure the policy tool remains appropriate. The review must be undertaken at intervals of no more than three years after the last review. The next review is due in 2023. When reviewing the levy, the Minister:

- must consider whether the amount of waste disposed of in New Zealand has decreased
- must consider whether the amount of waste reused, recycled or recovered in New Zealand has increased
- must consider the advice of the Waste Advisory Board
- may consider any other matters that he or she thinks relevant.

Following the last review in 2019/20, a range of measures were put in place to improve the levy's effectiveness (see section 4.3.8).

Energy Efficiency and Conservation Act 2000 and Energy Efficiency (Energy Using Products) Regulations 2002 – Regulatory Amendment Project

A review of the Energy Efficiency and Conservation Act 2000 and Energy Efficiency (Energy Using Products) Regulations 2002 was carried out in 2019. The review found that despite the achievements of the product regulations to date, enhancements could be made to improve cooperation and effectiveness under the E3 programme. The proposed enhancements are grouped into five sections.

1. **Future-proofing the System** aims to expand the requirements to reflect product innovation and streamline the decision-making process for amending and improving regulations to respond to product and market changes. It also expands the role EECA currently plays in managing emissions abatement.
2. **Consistent and Fair Regulation** aims to expand the regulations to reflect the evolving ways that goods can be bought or sold in the market. It also proposes to regularly review the energy efficiency regime to ensure New Zealand does not fall behind trade partners and has high-performing products.
3. **Improving System Administration** aims to make the system easier to administer, as well as rebalancing the costs of administering the system to make it fairer for the regulator and regulated parties.
4. **Ensuring Effective Compliance** looks to expand EECA’s monitoring, inspection and investigation powers and enforcement measures to improve compliance outcomes.
5. **Delivering Good and Fair Process** clarifies responsibilities for regulated parties and provides greater predictability regarding new or updated requirements, making it easier to comply, and providing a process for those affected by regulatory decisions to be heard.

4.6 Policies and measures no longer in place

The mix of policy tools will change over time, responding and adapting to changing circumstances. Different tools are needed as we build the foundations for meaningful change and emphasis shifts over time.

The following policies and measures that were reported on in the *Seventh National Communication* are no longer in place.

Name of policy or programme	Status
Business Growth Agenda	No longer in place.
Low-emissions economy transition hub	No longer in place.
ENERGYWISE consumer information programme	This has been replaced by the Gen Less programme, which was subsequently launched in October 2019. Refer to ‘Gen Less’ in section 4.3.2.
Warm Up New Zealand: Healthy Homes insulation programme	This has been replaced by the Warmer Kiwi Homes programme. Refer to ‘Insulation and heating grants programmes’ in section 4.3.3.
Roads of national significance	This is no longer an active government policy. Refer to ‘Begin work now to decarbonise heavy transport and freight’ in section 4.3.4.

Name of policy or programme	Status
Primary Growth Partnership	In 2018 the Primary Growth Partnership and the Sustainable Farming Fund were replaced by the Sustainable Food and Fibre Futures fund. Refer to section 4.3.6.
Sustainable Farming Fund	In 2018, the Primary Growth Partnership and the Sustainable Farming Fund were replaced by the Sustainable Food and Fibre Futures fund. Refer to section 4.3.6.
Biological Emissions Reference Group	The Biological Emissions Reference Group was set up in 2016. The Group published its final report in December 2018.
Forestry Reference Group	The Forestry Reference Group ended in 2019.
Afforestation Grant Scheme	The Afforestation Grant Scheme was a funding programme that ran between 2015 and 2020. The scheme was replaced by the One Billion Trees Fund in December 2018.
One Billion Trees Fund	This NZ\$176.8 million fund ran for three years from August 2018 until its closure on 30 June 2021. Existing funding agreements extend into the future and will receive continued support and relationship management as these projects progress to completion.

5 Projections

Key points

- The effects of Aotearoa New Zealand’s key quantifiable policies and measures on our greenhouse gas emissions and removals are projected out to 2035.
- Three scenarios are modelled, ‘With existing measures’, ‘without measures’ and ‘with additional measures’.
- New Zealand’s gross emissions (excluding emissions and removals from the land use, land-use change and forestry (LULUCF) sector) were reported as 78.8 million tonnes of carbon dioxide equivalent (Mt CO₂-e) in 2020 (20.8 per cent above 1990 levels).
- New Zealand’s net emissions (including emissions and removals from the LULUCF sector) are reported as 55.5 Mt CO₂-e in 2020 (26.1 per cent above 1990 levels).
- Under the ‘with existing measures’ scenario (which does not capture most of the new policies in the emissions reduction plan):
 - New Zealand’s gross emissions (excluding emissions and removals from the LULUCF sector) are projected to be 66.7 Mt CO₂-e (2.3 per cent above 1990 levels) in 2035.
 - New Zealand’s net emissions (including emissions and removals from the LULUCF sector) are projected to be 41.2 Mt CO₂-e (6.3 per cent below 1990 levels) in 2035.
 - New Zealand’s net emissions are projected to be 30.7 Mt CO₂-e lower in 2035 than projected in the ‘without measures’ scenario.
- In comparison to *New Zealand’s Fourth Biennial Report* published in 2019:²²⁰
 - New Zealand’s gross emissions are projected to be 7.6 per cent lower in 2035 than projected in the *Fourth Biennial Report*.
 - New Zealand’s net emissions are projected to be 28.8 per cent lower in 2035 than projected in the *Fourth Biennial Report*.
- Care needs to be taken when assessing the trends in net emissions as they are strongly influenced by the harvest and growth cycles of New Zealand’s production forests, which can mask policy impacts.

5.1 Introduction

This chapter presents Aotearoa New Zealand’s projected greenhouse gas emissions and removals under the following three scenarios:²²¹

- ‘with existing measures’ (WEM) – currently implemented and adopted policies and measures
- ‘without measures’ (WOM) – excludes implemented, adopted and planned policies and measures

²²⁰ Ministry for the Environment. 2019. *New Zealand’s Fourth Biennial Report Under the United Nations Framework Convention on Climate Change*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/assets/Publications/Files/fourth-biennial-report.pdf (1 December 2019).

²²¹ These projections do not measure progress towards New Zealand’s domestic emissions budgets, or New Zealand’s first Nationally Determined Contribution under the Paris agreement, and do not take into account all of the policies in New Zealand’s first emissions reduction plan.

- ‘with additional measures’ (WAM) scenario²²² – includes *planned* policies and measures, in addition to implemented and adopted policies and measures.

Section 5.2 estimates the impacts of the three policy scenarios on New Zealand’s gross and net greenhouse gas emissions (ie, under the WEM, WOM and WAM scenarios) from 1990 to 2035, disaggregated by sector and by gas.

The projections are calibrated against estimates reported in *New Zealand’s Greenhouse Gas Inventory 1990–2020*,²²³ alongside the historical and projected key assumptions driving the emission scenarios.

Section 5.3 discusses the combined assessed effect of policies and measures.

Changes since New Zealand’s last biennial report submission are presented in section 5.4, including a detailed breakdown by sector.

Lastly, section 5.5 presents information on the methodologies applied, as well as underlying assumptions specific to each sector and sensitivity analyses.

5.2 Projections under the United Nations Framework Convention on Climate Change

Aotearoa New Zealand’s reported (historical) and projected gross greenhouse gas emissions²²⁴ are summarised in figure 5.1. Figure 5.2 summarises New Zealand’s historical and projected net greenhouse gas emissions.²²⁵

The estimates for 1990–2020 are consistent with data reported in *New Zealand’s Greenhouse Gas Inventory 1990–2020*, while the estimates for 2021–35 are projections. The timing for when each policy and measure impacts each sector and scenario are provided in table 5.1.

New Zealand’s gross greenhouse gas emissions were 78.8 million tonnes of carbon dioxide equivalent (Mt CO₂-e) in 2020 (20.8 per cent above 1990 gross emissions). Under the WEM scenario, gross emissions are projected to remain steady in the short term, before decreasing to 73.3 Mt CO₂-e in 2025 and to 66.7 Mt CO₂-e in 2035 (2.3 per cent above 1990 gross emissions).

Under the WEM scenario New Zealand’s net greenhouse gas emissions are projected to increase to 63.8 Mt CO₂-e in 2025 (45.0 per cent above 1990 net emissions) before decreasing to 41.2 Mt CO₂-e (6.3 per cent below 1990 net emissions) in 2035. The increase in net emissions from 2017 to 2025 is due to higher than usual harvest rates occurring in production forests over this period. However, the LULUCF sector is expected to see a reversal in this trend from around 2025 due to the replanting of these harvested forests, and additional sequestration from projected afforestation activities. See section 5.5.5 for more information.

²²² See tables 5.1 and 5.9 for the additional policies considered in this scenario.

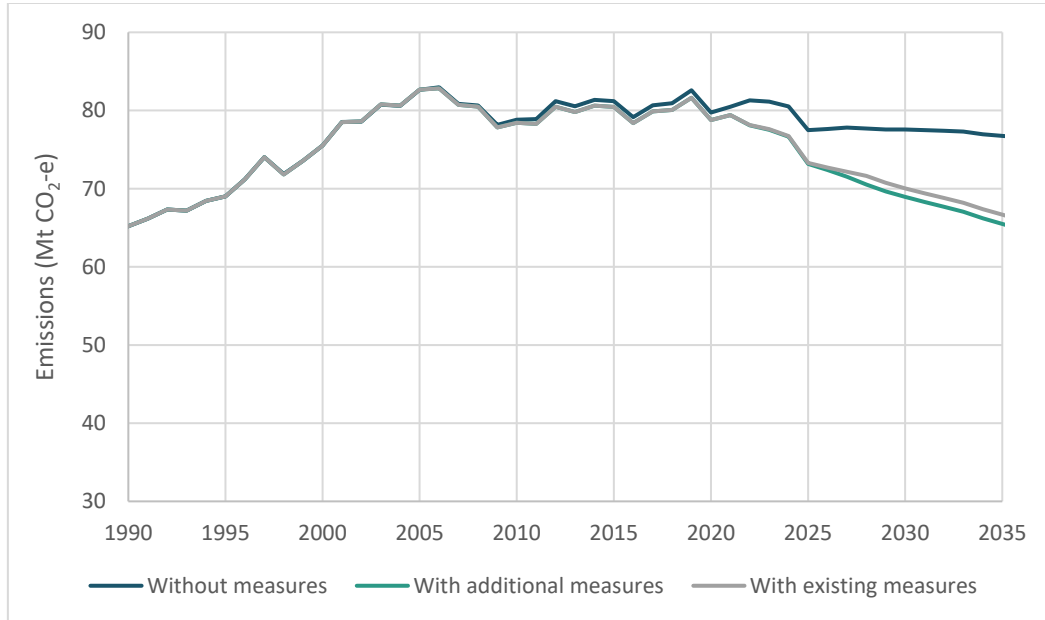
²²³ Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020 (18 August 2022).

²²⁴ Gross emissions are New Zealand’s total emissions from Agriculture, Energy, IPPU and Waste sectors as well as gross emissions from Tokelau.

²²⁵ Net emissions are made up of gross emissions combined with emissions and removals from the LULUCF sector.

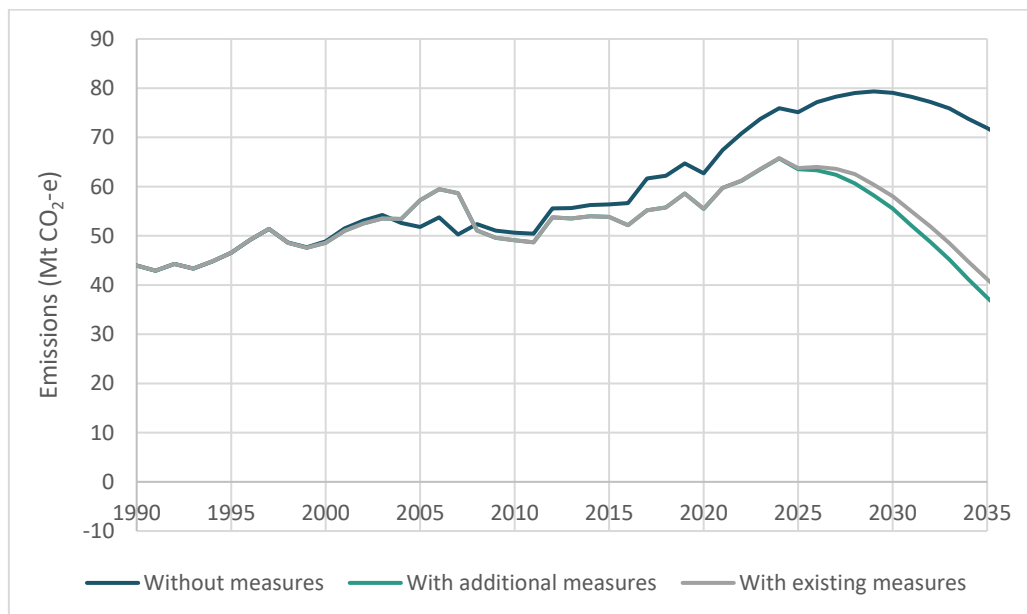
The gap between the WOM and WEM estimates shows the impact of the policies and measures introduced by the New Zealand Government on emissions. These projections do not capture most of the new policies included in New Zealand’s first emissions reduction plan, published in May 2022.

Figure 5.1: New Zealand’s gross emissions under the WEM, WOM and WAM scenarios, 1990–2035 (excluding emissions and removals from LULUCF)



Note: LULUCF = land use, land-use change and forestry; Mt CO₂-e = million tonnes of carbon dioxide equivalent; WAM = with additional measures; WEM = with existing measures; WOM = without measures. Excludes indirect emissions (such as carbon monoxide, nitrogen oxides, non-methane volatile organic compounds and sulphur oxides) and emissions from international transport.

Figure 5.2: New Zealand’s net emissions under the WEM, WOM and WAM scenarios, 1990–2035 (including emissions and removals from LULUCF)



Note: LULUCF = land use, land-use change and forestry; Mt CO₂-e = million tonnes of carbon dioxide equivalent; WAM = with additional measures; WEM = with existing measures; WOM = without measures. Excludes indirect emissions (such as carbon monoxide, nitrogen oxides, non-methane volatile organic compounds and sulphur oxides) and emissions from international transport.

5.2.1 Policies and measures considered under the WEM, WOM and WAM scenarios

Table 5.1 gives an overview of the policies and measures considered under the different scenarios. For details about each policy and measure, see chapter 4.

Table 5.1: Policies and measures included in the WEM, WOM and WAM scenarios

Policy or measure	Timeframe implemented	Sector	WEM	WOM	WAM	Remarks
New Zealand Emissions Trading Scheme	2008–	Cross-sectoral ²²⁶	✓		✓	Obligations for: forestry from 2008; stationary energy, industrial processes and transport from 2010; fluorinated gases from 2013; waste from 2013
GIDI ²²⁷ expansion	2026–	Energy			✓	GIDI expansion from 2026
Regulatory amendment project (Energy Efficiency and Conservation Act)	2025–	Energy			✓	
Road User Charges exemptions for EVs	2012–2024, 2025	Transport	✓		✓	For light EVs until 2024, heavy EVs until 2025
Kigali Amendment to the Montreal Protocol	2020–	IPPU	✓		✓	
Proposals to prohibit imports of pre-charged equipment containing high global warming potential HFCs	2023–	IPPU			✓	
Emission pricing on agricultural emissions with 95% free allocation	2025–	Agriculture	✓		✓	Planned policy and measure
Synthetic nitrogen fertiliser cap (N-cap)	2021–	Agriculture	✓		✓	
Essential Freshwater package (excluding the impact of the N-cap)	2020–	Agriculture	✓		✓	
Afforestation Grant Scheme	2008–2018 ²²⁸	LULUCF	✓		✓	

²²⁶ The impact of the NZ ETS is only quantified for energy and forestry.

²²⁷ Government Investment in Decarbonising Industry Fund <https://www.eeca.govt.nz/co-funding/industry-decarbonisation/about-the-government-investment-in-decarbonising-industry-fund/>

²²⁸ The Afforestation Grant Scheme and Erosion Control Funding Programme were replaced by the One Billion Trees Programme in December 2018. Planned planting already funded under these schemes will continue until 2028.

Policy or measure	Timeframe implemented	Sector	WEM	WOM	WAM	Remarks
Permanent Forest Sink Initiative	2008–2021 ²²⁹	LULUCF	✓		✓	
Sustainable Land Management Hill Country Erosion Programme	2009–	LULUCF	✓		✓	
Erosion Control Funding Programme ²³⁰	1993–2018 ²³¹	LULUCF	✓		✓	
One Billion Trees Programme	2018–2028	LULUCF	✓		✓	
Maximising carbon storage	2024–	LULUCF			✓	
Native afforestation initiative	2025–	LULUCF			✓	
Woody biomass	2023–	LULUCF			✓	
National Environmental Standard for Air Quality (landfill methane)	2005–	Waste	✓		✓	
Waste Disposal Levy	2010–	Waste	✓		✓	
Emissions reduction plan – existing waste sector policies	2023–	Waste	✓	✓	✓	The ‘without measures’ scenario does not exclude the impact of these policies
Emissions reduction plan – additional waste sector policies	2023–	Waste			✓	
Tokelau Renewable Energy Project	2012–	Tokelau	✓		✓	

Note: Under the WAM scenario, some measures are strengthened compared with the WEM scenario (see remarks column). EVs = electric vehicles; GIDI = Government Investment in Decarbonising Industry; HFCs = hydrofluorocarbons; IPPU = industrial processes and product use; LULUCF = land use, land-use change and forestry; WAM = with additional measures; WEM = with existing measures; WOM = without measures.

²²⁹ The Permanent Forest Sink Initiative was discontinued at the end of 2021 and replaced with a new activity in the NZ ETS.

²³⁰ Impacts from the Erosion Control Funding Programme are calculated from the year following its establishment in 1992.

²³¹ The Afforestation Grant Scheme and Erosion Control Funding Programme were replaced by the One Billion Trees Programme in December 2018. Planned planting already funded under these schemes will continue until 2028.

5.2.2 Details on scenarios

Table 5.2 provides further details on the scenarios used in the analysis.

Not all implemented policies and measures that are likely to have a significant emissions impact were able to be quantified under WEM and WAM due to data constraints, lack of certainty, and model design constraints.

Table 5.2: Details on scenarios

Scenario	Description	Notes
'With existing measures' (WEM) scenario	Currently implemented and adopted policies and measures	This scenario reflects the current state of legislation, also taking into account the stipulated strengthening of existing policies and measures (ie, any strengthening foreseen under current legislation)
'Without measures' (WOM) scenario	Excludes all implemented, adopted and planned policies and measures to the extent possible	This scenario acts as a reference scenario against which WEM and WAM can be compared
'With additional measures' (WAM) scenario	Includes <i>planned</i> policies and measures, in addition to implemented and adopted policies and measures	This scenario considers the planned strengthening of existing policies and measures, as well as new policies and measures that have been approved but are not yet implemented into law. Because only a small number of policies are approved but not in law at any one time, this is reflected in the size of the difference between WEM and WAM

5.2.3 Key assumptions and variables

An overview of the key assumptions used for modelling of the WEM, WOM and WAM scenarios is presented in table 5.3. For further key variables and assumptions used in the projections analysis (CTF table 5), please see appendix C.1 and sector-specific information in section 5.5.

Projections and their underlying assumptions are inherently uncertain. New Zealand's population and gross domestic product (GDP) are assumed to increase over the coming decades. Net migration is anticipated to be at 35,100 people per year in 2025, decreasing to 25,000 by 2035, while the New Zealand dollar (NZ\$)–United States dollar (US\$) exchange rate is assumed to remain constant at the long-term historical average of 0.65. The effective carbon price in the WEM scenario is assumed to increase from NZ\$64 in 2025 to NZ\$115 in 2035. This increase is not intended as a forecast of the expected New Zealand Unit (NZU) price, and it does not preclude future decisions that the Government is yet to agree to or adopt that may alter the NZU price.

As well as including assumptions about net migration, the labour force and the NZ\$–US\$ exchange rate, a variation of the carbon price projections was used in the energy and transport modelling, as presented in table 5.4.

Table 5.3: Summary of key assumptions for modelling New Zealand’s greenhouse gas emission projections, 1990–2035

Key underlying assumptions	Historical							Projected		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Population (30 June, million inhabitants)	3.46	3.67	3.86	4.13	4.35	4.59	5.09	5.32	5.55	5.76
Gross domestic product (real 2009/10 NZ\$ billion)	112.7	130.5	152.1	184.1	196.7	225.3	261.9	294.2	323.9	354.0
WEM, WAM carbon price (NZ\$ tonne CO ₂ -e)							\$25	\$64	\$97	\$115
WOM carbon price (NZ\$ tonne CO ₂ -e)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0

Note: CO₂e = carbon dioxide equivalent; WAM = with additional measures; WEM = with existing measures; WOM = without measures.

Table 5.4: Summary of key assumptions for energy and transport for modelling New Zealand’s greenhouse gas emission projections, 1990–2035

Key underlying assumptions	Historical							Projected		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Population (30 June, million inhabitants)	3.46	3.67	3.86	4.13	4.35	4.59	5.09	5.28	5.58	5.80
Gross domestic product (real 2009/10 NZ\$ billion)	112.7	130.5	152.2	184.2	196.8	225.9	253.3	291.4	325.3	351.7
Net migration (thousand people)								35.1	32.8	25
Exchange rate (NZ\$/US\$)							0.64	0.65	0.65	0.65
WEM, WAM carbon price (NZ\$ tonne CO ₂ -e)								\$82	\$140	\$167
Labour force (million people)							2.84	3.02	3.21	3.34

Note: CO₂e = carbon dioxide equivalent; WAM = with additional measures; WEM = with existing measures.

5.2.4 Projected greenhouse gas emissions and removals

Tables 5.5 and 5.6 detail New Zealand’s greenhouse gas emissions by sector and by gas under the WEM, WOM and WAM scenarios. The information contained in these tables is the same as the information in common tabular format (CTF) tables 6a, 6b and 6c reproduced in appendix C. For New Zealand’s progress against the 2013–20 emissions reduction target, see the *Fifth Biennial Report*, figure 3.1 in chapter 3. Figures 5.3 and 5.4 present the WEM, WOM and WAM scenarios, disaggregated by sector and gas. Note the WAM scenario estimates what emissions would be if current policies and measures continued as assumed in the WEM scenario, agriculture was included in the New Zealand Emissions Trading Scheme (NZ ETS) with 95 per cent free allocation and the carbon price increased at a faster rate.

Table 5.5: New Zealand greenhouse gas emissions by sector, 1990–2035 (Mt CO₂-e)

Sector		Historical						Projected			
		1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Energy	WEM	15.75	15.62	18.37	21.59	18.90	18.60	18.29	13.59	12.05	10.99
	WOM	15.75	15.62	18.37	21.59	18.90	18.60	18.29	15.91	16.05	15.99
	WAM	15.75	15.62	18.37	21.59	18.90	18.60	18.29	13.59	11.34	10.49
Transport	WEM	8.13	10.25	11.65	13.06	13.35	13.81	13.18	15.11	14.80	13.75
	WOM	8.13	10.25	11.65	13.06	13.35	13.81	13.18	15.33	15.23	14.41
	WAM	8.13	10.25	11.65	13.06	13.35	13.81	13.18	15.11	14.80	13.75
IPPU	WEM	3.58	3.17	3.44	4.06	4.59	5.14	4.62	4.02	3.91	3.72
	WOM	3.58	3.18	3.45	4.04	4.56	5.13	4.61	4.25	4.22	4.10
	WAM	3.58	3.17	3.44	4.06	4.59	5.14	4.62	3.94	3.81	3.48
Agriculture	WEM	33.79	35.73	37.61	39.57	37.71	39.42	39.43	37.43	36.30	35.33
	WOM	33.79	35.73	37.61	39.57	37.71	39.56	39.82	38.23	38.35	38.60
	WAM	33.79	35.73	37.61	39.57	37.71	39.42	39.43	37.39	36.17	35.11
Waste	WEM	3.94	4.23	4.43	4.38	3.87	3.49	3.27	3.14	2.98	2.88
	WOM	3.94	4.23	4.43	4.38	4.30	4.09	3.85	3.78	3.71	3.66
	WAM	3.94	4.23	4.43	4.38	3.87	3.49	3.27	3.14	2.84	2.66
Tokelau	WEM	0.003	0.003	0.003	0.004	0.005	0.003	0.004	0.004	0.004	0.003
	WOM	0.003	0.003	0.003	0.004	0.005	0.003	0.004	0.004	0.004	0.003
	WAM	0.003	0.003	0.003	0.004	0.005	0.003	0.004	0.004	0.004	0.003
Total (excluding LULUCF)	WEM	65.20	69.01	75.52	82.67	78.43	80.45	78.78	73.29	70.04	66.68
	WOM	65.20	69.02	75.53	82.65	78.82	81.19	79.74	77.49	77.56	76.76
	WAM	65.20	69.01	75.52	82.67	78.43	80.45	78.78	73.17	68.96	65.49
LULUCF	WEM	-21.23	-22.45	-26.93	-25.42	-29.33	-26.61	-23.31	-9.53	-12.01	-25.48
	WOM	-21.23	-22.47	-26.65	-30.84	-28.21	-24.80	-17.04	-2.37	1.48	-4.86
	WAM	-21.23	-22.45	-26.93	-25.42	-29.33	-26.61	-23.31	-9.64	-13.43	-28.03
Total (including LULUCF)	WEM	43.97	46.57	48.58	57.24	49.10	53.84	55.47	63.76	58.03	41.20
	WOM	43.97	46.54	48.88	51.81	50.61	56.39	62.70	75.12	79.05	71.90
	WAM	43.97	46.57	48.58	57.24	49.10	53.84	55.47	63.53	55.53	37.46

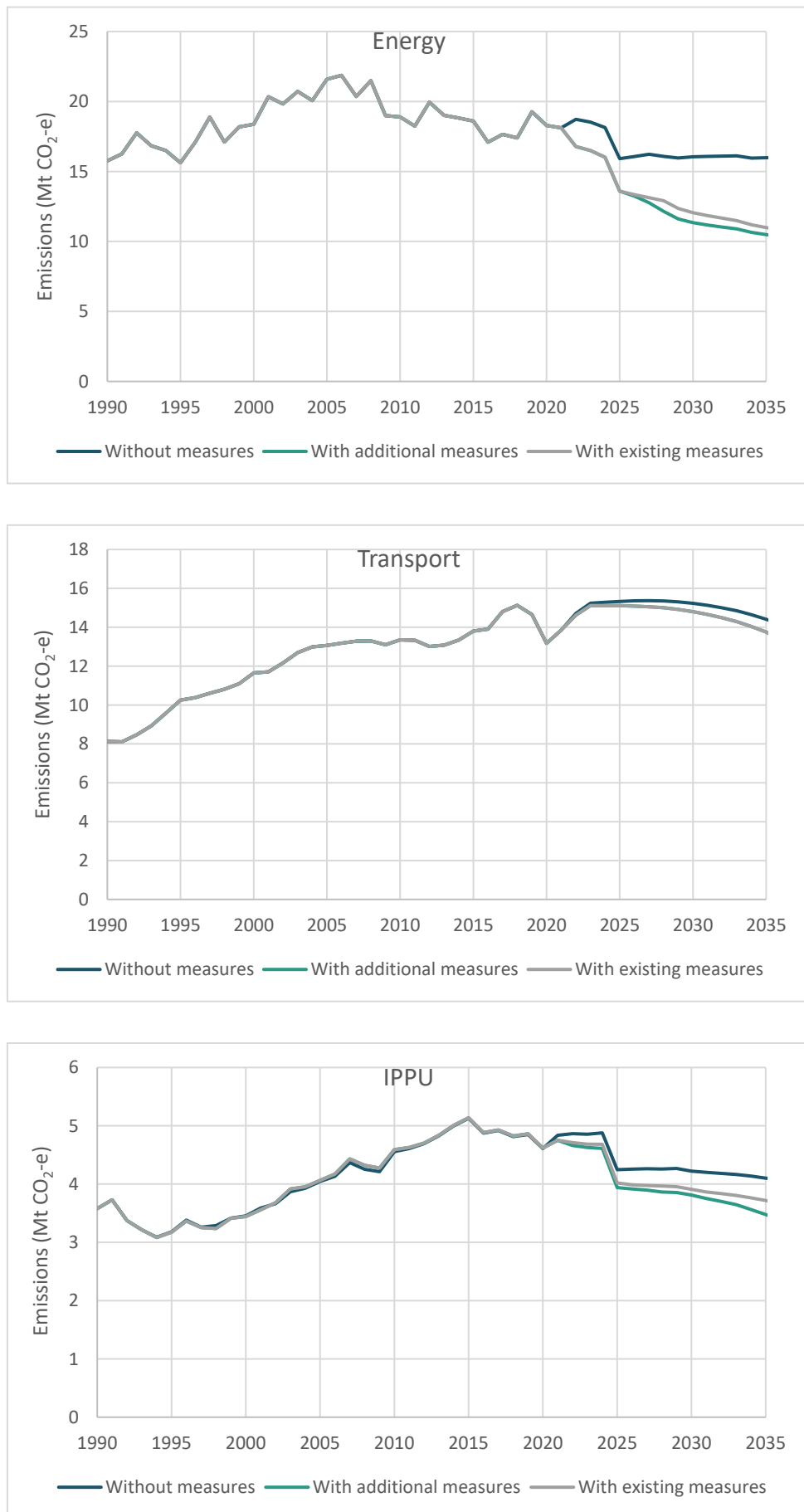
Note: IPPU = industrial processes and product use; LULUCF = land use, land-use change and forestry; Mt CO₂-e = million tonnes of carbon dioxide equivalent; WAM = with additional measures; WEM = with existing measures; WOM = without measures. Numbers may not add to totals due to rounding to two decimal places.

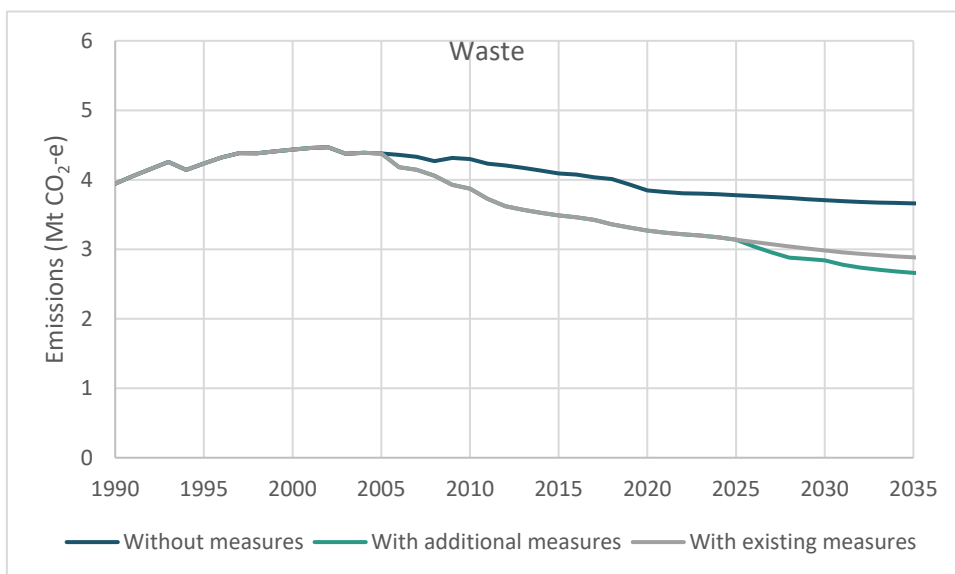
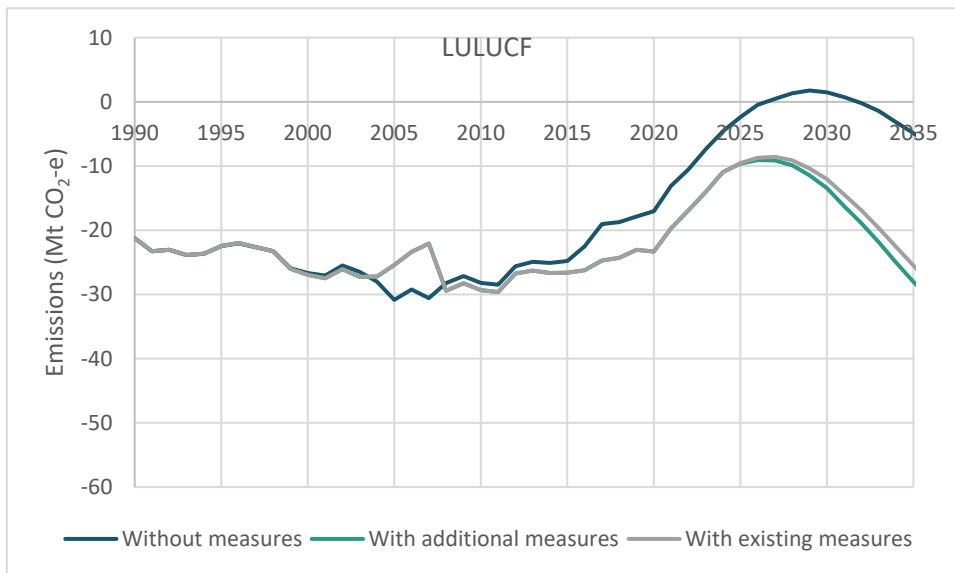
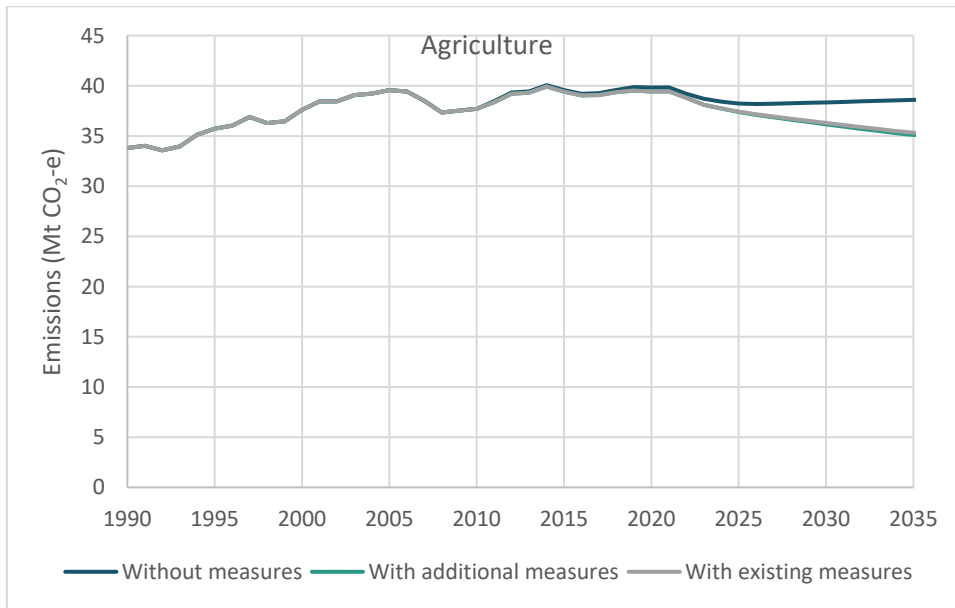
Table 5.6: New Zealand greenhouse gas emissions by gas, 1990–2035 (Mt CO₂-e)

Gas		Historical						Projected			
		1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
CO ₂	WEM	25.50	28.00	32.25	37.42	34.81	35.81	34.46	31.28	29.42	27.29
	WOM	25.50	28.00	32.25	37.42	34.81	35.81	34.46	33.81	33.86	32.99
	WAM	25.50	28.00	32.25	37.42	34.81	35.81	34.46	31.28	28.70	26.79
CH ₄	WEM	32.97	34.24	35.95	36.52	34.76	34.99	34.27	32.57	31.51	30.68
	WOM	32.97	34.24	35.95	36.52	35.19	35.72	35.19	33.89	33.88	34.03
	WAM	32.97	34.24	35.95	36.52	34.76	34.99	34.27	32.53	31.23	30.24
N ₂ O	WEM	5.79	6.57	7.00	7.93	7.68	8.19	8.46	8.12	7.89	7.68
	WOM	5.79	6.57	7.00	7.93	7.68	8.20	8.52	8.25	8.29	8.33
	WAM	5.79	6.57	7.00	7.93	7.68	8.19	8.46	8.11	7.89	7.67
HFCs	WEM	0.00	0.02	0.23	0.69	1.10	1.39	1.48	1.30	1.21	1.01
	WOM	0.00	0.03	0.24	0.68	1.07	1.38	1.47	1.53	1.52	1.39
	WAM	0.00	0.02	0.23	0.69	1.10	1.39	1.48	1.22	1.11	0.76
PFCs	WEM	0.91	0.15	0.07	0.07	0.05	0.06	0.09	0.00	0.00	0.00
	WOM	0.91	0.15	0.07	0.07	0.05	0.06	0.09	0.00	0.00	0.00
	WAM	0.91	0.15	0.07	0.07	0.05	0.06	0.09	0.00	0.00	0.00
SF ₆	WEM	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02
	WOM	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02
	WAM	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02
NF ₃		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (excluding LULUCF)	WEM	65.20	69.01	75.52	82.67	78.43	80.45	78.78	73.29	70.04	66.68
	WOM	65.20	69.02	75.53	82.65	78.82	81.19	79.74	77.49	77.56	76.76
	WAM	65.20	69.01	75.52	82.67	78.43	80.45	78.78	73.17	68.96	65.49
CO ₂ (including LULUCF)	WEM	3.88	5.10	4.83	11.49	5.04	8.83	10.79	21.40	17.05	1.47
	WOM	3.88	5.07	5.12	6.08	6.16	10.64	17.06	31.09	34.99	27.78
	WAM	3.88	5.10	4.83	11.49	5.04	8.83	10.79	21.29	14.92	-1.59
CH ₄ (including LULUCF)	WEM	33.04	34.31	36.02	36.63	34.86	35.07	34.35	32.66	31.59	30.76
	WOM	33.04	34.31	36.02	36.63	35.28	35.80	35.27	33.97	33.96	34.11
	WAM	33.04	34.31	36.02	36.63	34.86	35.07	34.35	32.62	31.32	30.33
N ₂ O (including LULUCF)	WEM	6.12	6.95	7.41	8.33	8.04	8.49	8.74	8.38	8.16	7.95
	WOM	6.12	6.95	7.41	8.33	8.04	8.50	8.79	8.52	8.55	8.60
	WAM	6.12	6.95	7.41	8.33	8.04	8.49	8.74	8.38	8.15	7.93
Total (including LULUCF)	WEM	43.97	46.57	48.58	57.24	49.10	53.84	55.47	63.76	58.03	41.20
	WOM	43.97	46.54	48.88	51.81	50.61	56.39	62.70	75.12	79.05	71.90
	WAM	43.97	46.57	48.58	57.24	49.10	53.84	55.47	63.53	55.53	37.46

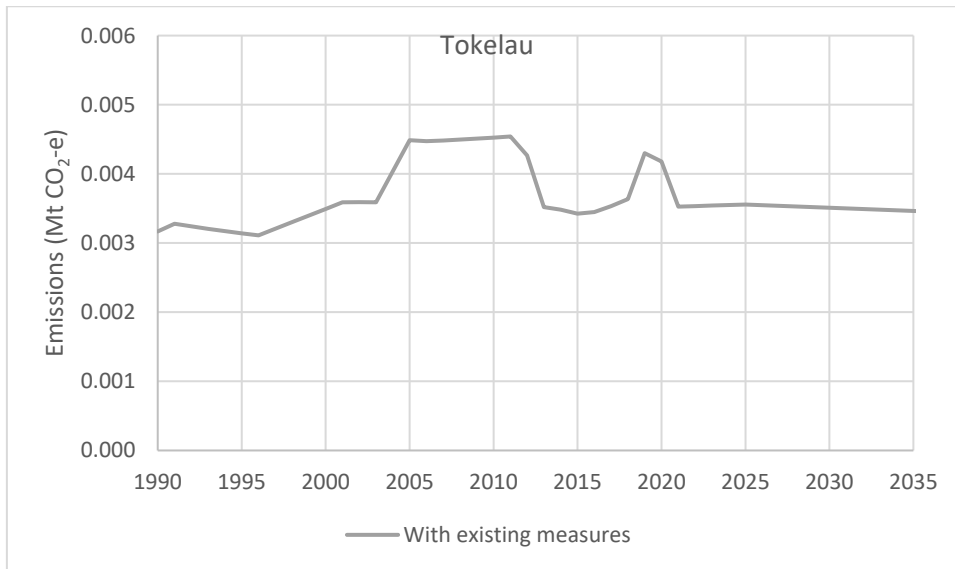
Note: CH₄ = methane; CO₂ = carbon dioxide; HFCs = hydrofluorocarbons; LULUCF = land use, land-use change and forestry; Mt CO₂-e = million tonnes of carbon dioxide equivalent; NF₃ = nitrogen trifluoride; NO = not occurring; N₂O = nitrous oxide; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride; WAM = with additional measures; WEM = with existing measures; WOM = without measures.

Figure 5.3: Greenhouse gas emissions (and removals) for the WEM, WOM and WAM scenarios by sector, 1990–2035



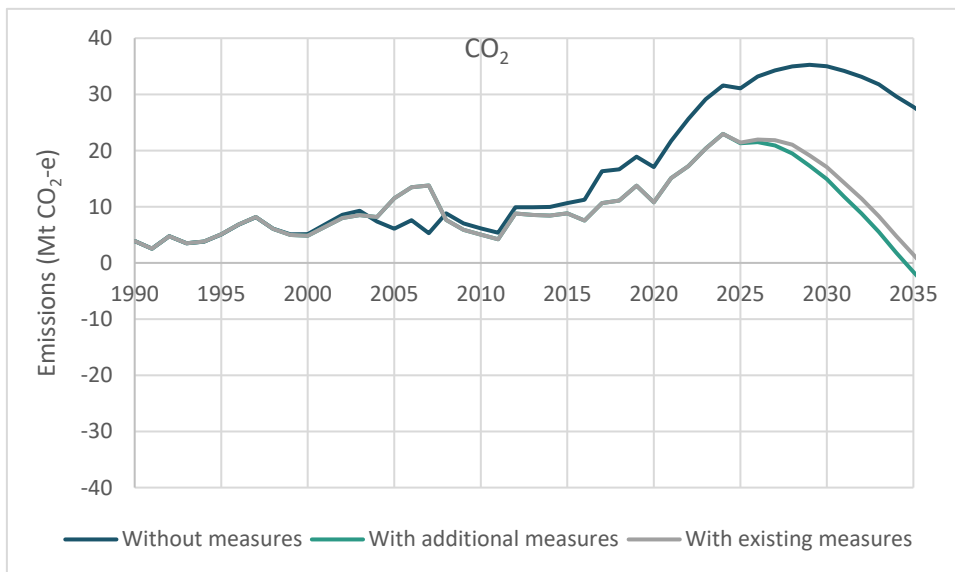


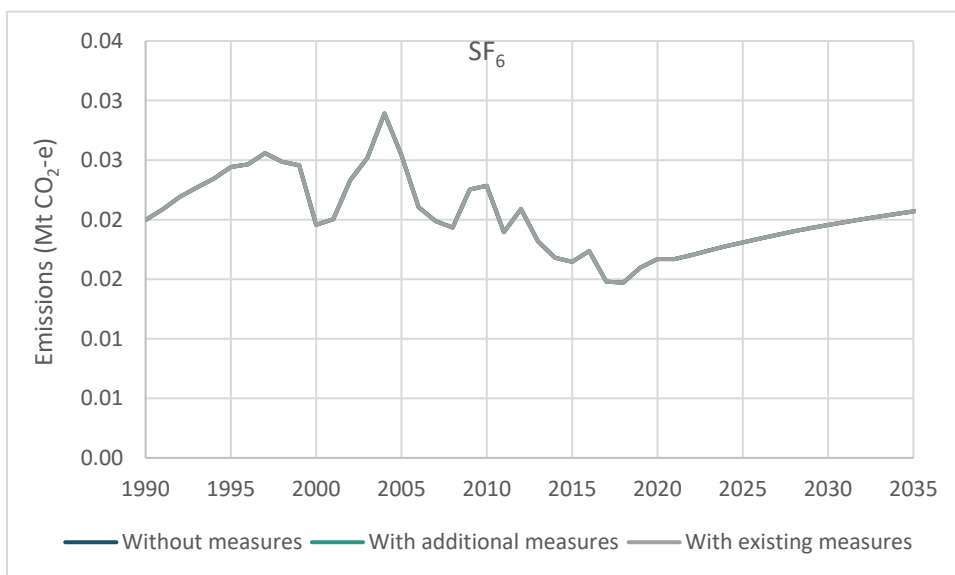
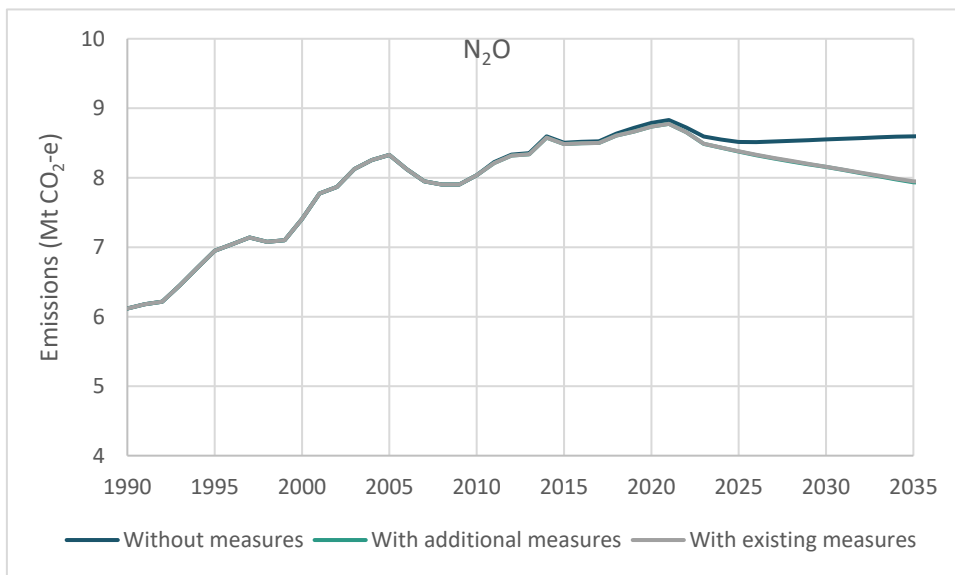
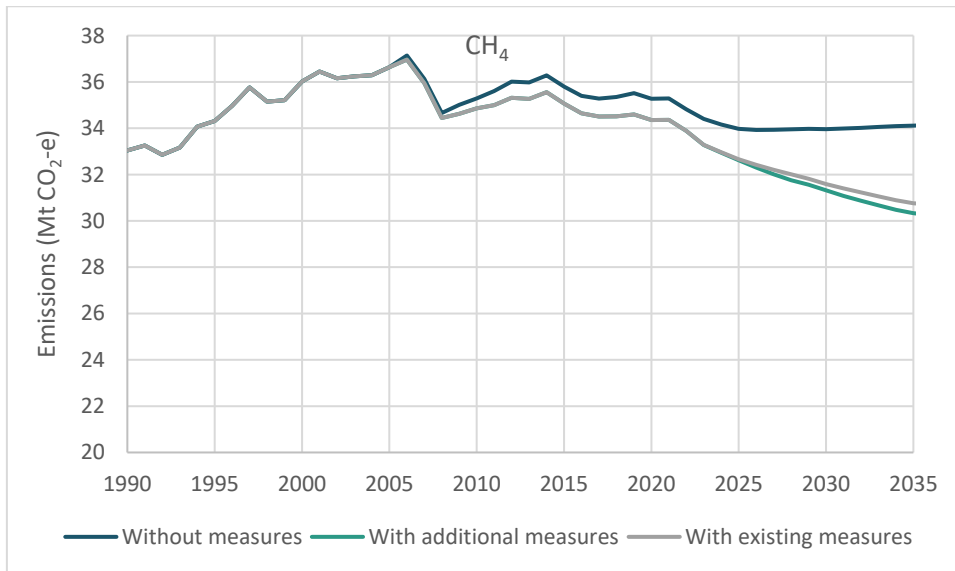
Note: The 'without measures' scenario does not exclude the impact of existing policies and measures under the emissions reduction plan for waste.

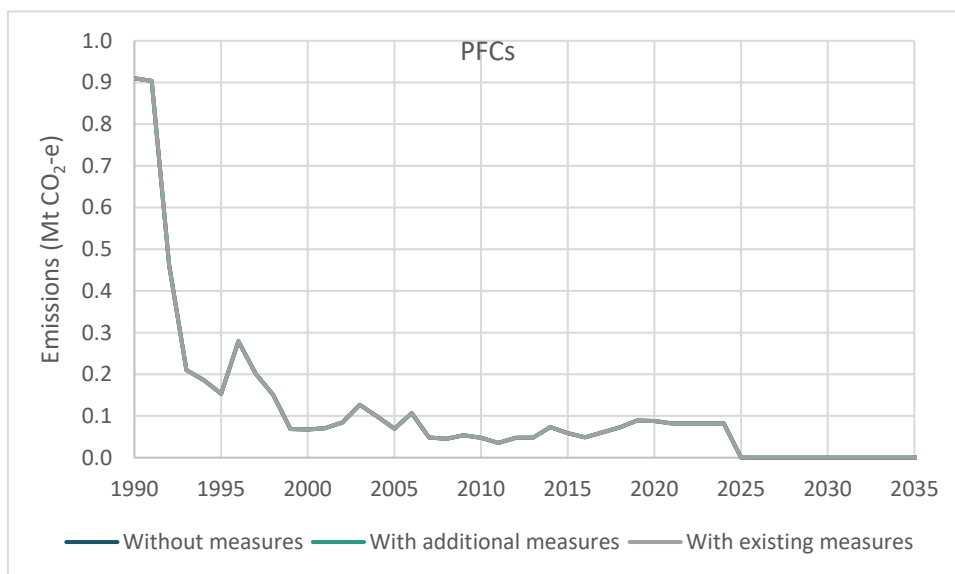
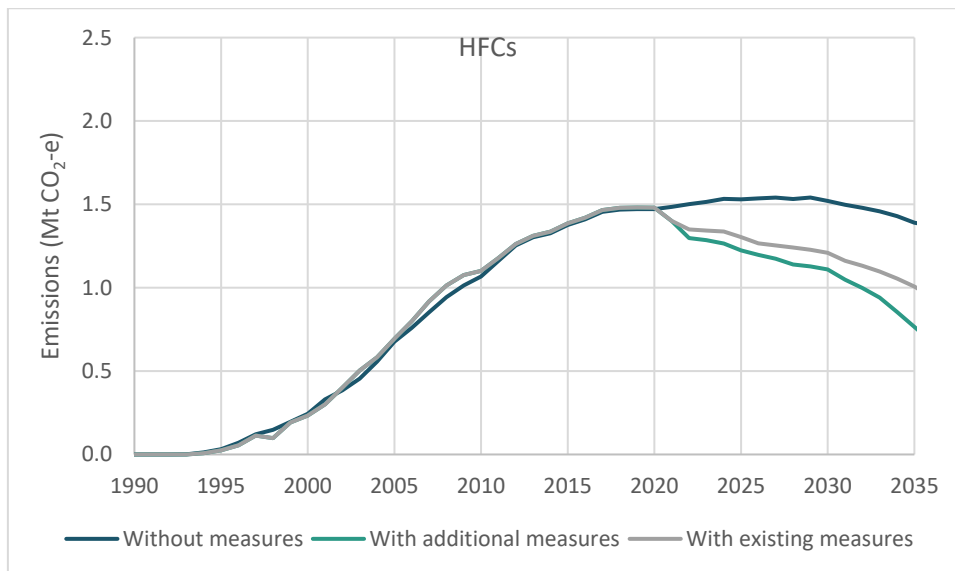


Note: y-axis varies in scale between sectors. IPPU = industrial processes and product use; LULUCF = land use, land-use change and forestry; Mt CO₂-e = million tonnes of carbon dioxide equivalent; WAM = with additional measures; WEM = with existing measures; WOM = without measures; WAM = with additional measures. Tokelau does not have WOM and WAM scenarios.

Figure 5.4: Net greenhouse gas emissions for the WEM, WOM and WAM scenarios by gas, 1990–2035







Note: y-axis varies in scale between gases. All gases are reported in million tonnes of carbon dioxide equivalent (Mt CO₂-e). CH₄ = methane; CO₂ = carbon dioxide; HFCs = hydrofluorocarbons; LULUCF = land use, land-use change and forestry; N₂O = nitrous oxide; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride; WAM = with additional measures; WEM = with existing measures; WOM = without measures.

5.3 Assessment of the total effect of policies and measures

5.3.1 Total effect of currently implemented and adopted policies and measures

The quantified effect of currently implemented and adopted policies and measures, calculated based on the difference between WOM and WEM scenarios (emissions and removals), is presented in table 5.7 by sector and table 5.8 by gas. For 2025, the total effect of currently implemented and adopted policies and measures excluding LULUCF is estimated to be a reduction of 4.2 Mt CO₂-e (annual reduction, not cumulative). When LULUCF is included, the total effect in 2025 is estimated to be 11.4 Mt CO₂-e. In 2035, the total effect of currently implemented and adopted policies and measures is estimated to be 10.1 Mt CO₂-e (30.1 Mt CO₂-e including LULUCF).

Table 5.7: Total effect of current policies and measures by sector, 1990–2035 (kt CO₂-e)

Sector	Historical							Projected		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Energy	NA	0	0	0	0	0	0	2,323	4,002	4,996
Transport	NA	0	0	0	0	0	0	218	434	657
IPPU	NA	7	10	-18	-34	-10	-9	227	311	383
Agriculture	NA	0	0	0	0	146	396	793	2,048	3,267
LULUCF	NA	-29	286	-5,415	1,120	1,809	6,270	7,162	13,496	20,616
Waste	NA	NA	NA	0	427	603	578	639	725	776
Tokelau	NA	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total	NA	-22	296	-5,433	1,513	2,549	7,235	11,362	21,015	30,694

Note: IPPU = industrial processes and product use; kt CO₂-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry; NA = not applicable; NE = not estimated. An increase in net emissions to the atmosphere is expressed as a negative (-) while a reduction in net emissions to the atmosphere is expressed as a positive.

Table 5.8: Total effect of current policies and measures by gas, 1990–2035 (kt CO₂-e)

Gas	Historical							Projected		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
CO ₂	NA	-29	286	-5,415	1,120	1,809	6,270	9,684	17,941	26,311
CH ₄	NA	0	0	0	427	731	919	1,317	2,370	3,352
N ₂ O	NA	0	0	0	0	18	55	134	394	648
HFCs	NA	7	10	-18	-34	-10	-9	227	311	383
PFCs	NA	NE	NE	NE	NE	NE	NE	NE	NE	NE
SF ₆	NA	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total	NA	-22	296	-5,433	1,513	2,549	7,235	11,362	21,015	30,694

Note: CH₄ = methane; CO₂ = carbon dioxide; HFCs = hydrofluorocarbons; kt CO₂-e = kilotonnes of carbon dioxide equivalent; NA = not applicable; NE = not estimated; N₂O = nitrous oxide; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride. An increase in net emissions to the atmosphere is expressed as a negative (-), while a reduction in net emissions to the atmosphere is expressed as a positive.

5.3.2 Total effect of additional policies and measures

The quantified effect of additional policies and measures, calculated based on the difference in emissions and removals between WEM and WAM scenarios emissions and removals, is presented in table 5.9 by sector and table 5.10 by gas. For 2025, the total effect of additional policies and measures including LULUCF is estimated to be a reduction of 0.2 Mt CO₂-e (annual reduction, not cumulative). In 2035, the total effect of additional policies and measures is estimated to reduce emissions by 3.7 Mt CO₂-e (1.2 Mt CO₂-e excluding LULUCF).

Table 5.9: Total effect of additional policies and measures by sector, 1990–2035 (kt CO₂-e)

Sector	1990	2020	2025	2030	2035
Energy	0	0	2	713	503
Transport	0	0	0	0	0
IPPU	0	0	79	100	242
Agriculture	0	0	42	133	222
LULUCF	0	0	105	1,414	2,557
Waste	NA	NA	0	142	223
Total	0	0	228	2,502	3,747

Note: IPPU = industrial processes and product use; kt CO₂-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry; NA = not applicable; NE = not estimated. An increase in net emissions to the atmosphere is expressed as a negative (-), while a reduction in net emissions to the atmosphere is expressed as a positive.

Table 5.10: Total effect of additional policies and measures by gas, 1990–2035 (kt CO₂-e)

Gas	1990	2020	2025	2030	2035
CO ₂	0	0	107	2,127	3,060
CH ₄	0	0	37	273	432
N ₂ O	0	0	5	3	14
HFCs	0	0	79	100	242
PFCs	0	NE	NE	NE	NE
SF ₆	0	NE	NE	NE	NE
Total	0	0	228	2,502	3,747

Note: CH₄ = methane; CO₂ = carbon dioxide; HFCs = hydrofluorocarbons; kt CO₂-e = kilotonnes of carbon dioxide equivalent; N₂O = nitrous oxide; NE = not estimated; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride.

5.4 Differences from the *Fourth Biennial Report*

Table 5.11 summarises the differences in greenhouse gas emissions projections between this report and *New Zealand's Fourth Biennial Report under the United Nations Framework Convention on Climate Change*²³² (*Fourth Biennial Report*), which was based on projections produced in 2019. The main differences between the two projections include: additional implemented and adopted policies; re-estimations of the impact of policies; and revised carbon price, population growth and economic growth assumptions.

Since the *Fourth Biennial Report*, the assumed 2025 carbon price has been revised up to NZ\$64 (138.1 per cent increase) to reflect current NZ ETS market prices, while the 2030 carbon price is 223.0 per cent higher than assumed in the *Fourth Biennial Report*. Projections of population have also been revised up, increasing from the *Fourth Biennial Report* by 0.4 per cent in 2025 and 0.4 per cent in 2030. Economic growth is assumed to be the same as in the *Fourth Biennial Report* (see table 5.11).

²³² Ministry for the Environment. 2019. *New Zealand's Fourth Biennial Report under the United Nations Framework Convention on Climate Change*. Wellington: Ministry for the Environment. Retrieved from <https://environment.govt.nz/assets/Publications/Files/fourth-biennial-report.pdf> (1 December 2019).

Table 5.11: Revision of assumptions since *New Zealand's Fourth Biennial Report*

Variable	Fourth Biennial Report			Fifth Biennial Report			Change (%)		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
Population (millions)	5.00	5.29	5.52	5.09	5.32	5.55	1.8	0.4	0.4
GDP (real 2009/10 NZ\$ billion)	261.9	294.2	323.9	261.9	294.2	323.9	0.0	0.0	0.0
Exchange rate (NZ\$/US\$)	0.65	0.65	0.65	0.65	0.65	0.65	0.0	0.0	0.0
Effective carbon price (NZ\$ per tonne CO ₂ -e)	25.00	26.88	30.00	25.00	64.00	97.00	0.0	138.1	223.3
Effective carbon price used for energy and transport (NZ\$ tonne CO ₂ -e)	25.00	26.88	30.00	25.00	82.00	140.00	0.0	205.1	366.7

Note: CO₂-e = carbon dioxide equivalent; GDP = gross domestic product.

The projections have also been updated to include improvements to the historical inventory and other improvements to methods, emission factors and activity data. The effects of changes to the inventory are summarised in chapter 3.

The net effect of these changes is to decrease projected 2025 WEM gross emissions by 5.4 Mt CO₂-e (6.9 per cent) since the *Fourth Biennial Report*, as shown in table 5.12. The projected decrease in gross emissions is mainly due to decreased emissions projections for energy (3.0 Mt CO₂-e, 18.1 per cent). Net emissions are also projected to be 8.3 Mt CO₂-e (11.5 per cent) lower than previously forecast.

In 2030, gross emissions are projected to be 5.2 Mt CO₂-e (6.9 per cent) lower than reported in the *Fourth Biennial Report*. This reduction is primarily due to reduced emissions from energy (3.3 Mt CO₂-e, 21.4 per cent) and IPPU (1.7 Mt CO₂-e, 29.8 per cent). Net emissions are projected to be 8.0 Mt CO₂-e (12.2 per cent) lower than previously forecast.

Table 5.12: Comparison of WEM projections (including LULUCF) with *Fourth Biennial Report* (Mt CO₂-e)

Gas	Projected emissions 2025				Projected emissions 2030			
	BR4	BR5	Absolute change	Change (%)	BR4	BR5	Absolute change	Change (%)
CO ₂	28.7	21.4	-7.3	-25.3	24.1	17.1	-7.1	-29.3
CH ₄	32.5	32.7	0.2	0.6	31.5	31.6	0.1	0.4
N ₂ O	8.7	8.4	-0.3	-4.0	8.4	8.2	-0.3	-3.3
HFCs	2.1	1.3	-0.8	-38.3	2.0	1.2	-0.8	-39.0
PFCs	0.1	0.0	-0.1	-100.0	0.1	0.0	-0.1	-100.0
SF ₆	0.02	0.02	0.0	12.9	0.02	0.02	0.0	28.7
Sector								
Agriculture	36.7	37.4	0.8	2.1	35.5	36.3	0.8	2.4
Energy	16.6	13.6	-3.0	-18.1	15.3	12.1	-3.3	-21.4
IPPU	5.7	4.0	-1.7	-29.5	5.6	3.9	-1.7	-29.8
Transport	15.8	15.1	-0.7	-4.1	14.9	14.8	-0.2	-1.0
Waste	4.0	3.1	-0.9	-21.5	4.0	3.0	-1.0	-24.6
LULUCF	-6.7	-9.5	-2.9	42.7	-9.2	-12.0	-2.8	30.7
Total gross emissions	78.7	73.3	-5.4	-6.9	75.3	70.0	-5.2	-6.9
Total net emissions	72.0	63.8	-8.3	-11.5	66.1	58.0	-8.0	-12.2

Gas	Projected emissions 2035			
	BR4	BR5	Absolute change	Change (%)
CO ₂	17.0	1.5	-15.5	-91.4
CH ₄	31.1	30.8	-0.3	-1.1
N ₂ O	8.3	7.9	-0.4	-4.6
HFCs	1.4	1.0	-0.4	-27.5
PFCs	0.1	0.0	-0.1	-100.0
SF ₆	0.01	0.02	0.0	42.5
Sector				
Agriculture	35.0	35.3	0.3	0.8
Energy	14.1	11.0	-3.1	-22.0
IPPU	5.0	3.7	-1.3	-25.4
Transport	14.1	13.8	-0.4	-2.5
Waste	3.9	2.9	-1.0	-26.5
LULUCF	-14.3	-25.5	-11.2	78.4
Total gross emissions	72.2	66.7	-5.5	-7.6
Total net emissions	57.9	41.2	-16.7	-28.8

Note: BR4 = *Fourth Biennial Report*; BR5 = *Fifth Biennial Report*; CH₄ = methane; CO₂ = carbon dioxide; HFCs = hydrofluorocarbons; IPPU = industrial processes and product use; LULUCF = land use, land-use change and forestry; Mt CO₂-e = million tonnes of carbon dioxide equivalent; N₂O = nitrous oxide; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride. A decrease from BR4 to BR5 in net emissions to the atmosphere is expressed as a negative (-) in the absolute change and percentage, while an increase in net emissions to the atmosphere is expressed as a positive. Numbers may not add to totals due to rounding to one decimal place.

Sector-specific differences from the *Fourth Biennial Report* are described under their respective headings below.

5.5 Overview of methods by sector

The methodologies applied to calculate Aotearoa New Zealand's greenhouse gas emission scenarios are tailored to the particular characteristics of each sector, while using key underlying assumptions that are consistent across sectors. To provide a basic understanding of the models and approaches used, details relevant for each sector are summarised in table 5.13 and discussed in the following sections.

Table 5.13: Overview of models and approaches used to project New Zealand's greenhouse gas emissions from different sectors

Sector(s)	Gases	Type and characteristics of approach or model	Original purpose of approach or model	Strengths and weaknesses	Accounting of overlaps and synergies
Energy and transport	CO ₂ , CH ₄ , N ₂ O	Bottom-up estimates based on economic data, energy sector data and inventory models	Assessment of electricity demand and generation scenarios in New Zealand	Use of economic modelling, industry forecasts and expert opinion to generate activity data inputs and assumptions Difficulty in modelling the	Accounts for anticipated changes in production levels across industries Does not account for changes in energy demand

Sector(s)	Gases	Type and characteristics of approach or model	Original purpose of approach or model	Strengths and weaknesses	Accounting of overlaps and synergies
				expected effect of carbon prices and other policies and measures outside of the electricity sector Limited representation of potential mitigation technologies	for land use activities
Industrial processes and product use (IPPU)	CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆	Top-down estimates based on historical emissions, industry forecasts and regulation of imports of F-gases	Projection of IPPU greenhouse gases	Calculations at the level of single gases and by inventory category level	
Agriculture	CO ₂ , CH ₄ , N ₂ O	Bottom-up estimates based on economic data, agricultural data and inventory models	Projection of agricultural production	Use of economic modelling and expert opinion to generate activity data inputs Difficulty in modelling the expected effect of carbon prices	Accounts for interactions between the effects of different policies and measures
Land use, land-use change and forestry (LULUCF)	CO ₂ , CH ₄ , N ₂ O	Bottom-up modelling approach, based on historical and projected activity data to determine the impact of policies and measures	Projection of LULUCF greenhouse gas emissions and removals	Model allows for scenario building. Activity data and emission factors either based on either <i>New Zealand's Greenhouse Gas Inventory 1990–2020</i> or expert external research and analysis	Accounts for interactions between the effects of different policies and measures
Waste	CO ₂ , CH ₄ , N ₂ O	Bottom-up estimates using inventory models in line with 2006 IPCC guidelines for national greenhouse gas inventories	Greenhouse gas inventory	Calculations are consistent with the inventory at category level, requiring a full set of projections of activity data and emission factors	Policies and measures are assumed to target distinct sources of greenhouse gases
Tokelau	CO ₂ , CH ₄ , N ₂ O, HFCs	A hybrid top-down, bottom-up approach, based on historical emissions	Projection of Tokelau's emissions	Based on historical trends and prepared at the level of single gases	Policies and measures adopted by New Zealand (including the NZ ETS) do not extend to Tokelau
International transport	CO ₂ , CH ₄ , N ₂ O	Top-down estimates, based on historical emissions	Projection of international transport greenhouse gases	Based on historical trends and prepared at the level of single gases	NA

Note: CH₄ = methane; CO₂ = carbon dioxide; F-gases = fluorinated gases; HFCs = hydrofluorocarbons; IPCC = Intergovernmental Panel on Climate Change; N₂O = nitrous oxide; NA = not applicable; NZ ETS = New Zealand Emissions Trading Scheme; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride.

5.5.1 Energy

Emissions from the energy sector are anticipated to slowly decline over the medium term. Emissions are projected to decrease from 18.3 Mt CO₂-e in 2020 to 11.0 Mt CO₂-e in 2035 (table 5.14).

In the longer term, the main driver for greenhouse gas emissions from stationary energy is economic activity. Total energy demand is expected to continue to grow throughout the modelled period, but at the same time the emission intensity of energy (emissions per unit of energy delivered) is expected to decline.

Thermal baseload electricity generation is expected to be replaced mainly by a combination of wind, geothermal and gas-fired peaking plants, resulting in lower emissions. The following decommissioning schedule is currently anticipated:

- Stratford Combined Cycle Gas Turbine (380 megawatts) in 2023
- Whirinaki Diesel Peaker (155 megawatts) in 2024
- Huntly Coal Power station (400 megawatts) in 2030/31.

Manufacturing and construction is projected to remain the largest contributor to energy sector emissions, with smaller amounts coming from the primary, commercial and residential subsectors.

Table 5.14: Historical and projected energy sector emissions by gas and subsector under the ‘with existing measures’ scenario, 1990–2035 (Mt CO₂-e)

Gas	Historical							Projected		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
CO ₂	14.6	14.4	17.0	20.2	17.3	17.5	17.5	12.7	11.2	10.1
CH ₄	1.1	1.1	1.3	1.2	1.5	0.9	0.7	0.8	0.8	0.8
N ₂ O	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Total	15.8	15.6	18.4	21.6	18.9	18.6	18.3	13.6	12.1	11.0

Note: CH₄ = methane; CO₂ = carbon dioxide; Mt CO₂-e = million tonnes of carbon dioxide equivalent; N₂O = nitrous oxide.

Methodology

The energy sector modelling system is composed of two main models: the Supply and Demand Energy Model (SADEM) and the Generation Expansion Model (GEM). SADEM performs three key functions. First, it projects energy demand for all sectors of the economy based on exogenous projections of population and economic growth, and incorporating econometric relationships based on historical relationships and observed trends of energy efficiency growth. Second, it provides a central hub to incorporate electricity supply information from GEM. Finally, it calculates projections of energy sector greenhouse gas emissions by applying emission factors.

GEM is used to project the timing and type of new-generation plant built. GEM is a long-term planning model used to study capacity expansion specifically in the New Zealand electricity sector. While it is most often used to conduct research on generation capacity expansion given a fixed transmission network, it can also be configured to simultaneously optimise generation and transmission capacity investment decisions. However, GEM only considers large-scale generation that is connected to the grid. GEM requires fuel prices and electricity demand projections from SADEM as inputs.

Electricity intensity in the residential sector is a measure of electricity used per capita. We have continued to apply our methodology and judgement on the projected trend of electricity intensity of the residential sector. In this *Fifth Biennial Report*, we assume a negative historical trend will continue, with a rate of decline in electricity intensity of around 0.8 per cent per year until 2030.

Electrification is the process of powering by electricity, changing away from end uses that have historically been met by the combustion of fossil fuels. In this *Fifth Biennial Report*, we continue to assume that some low-grade heat will be electrified. Much of this electrification can be accomplished using heat pumps that have a relatively high coefficient of performance. As a result of the electrification of process heat, about 0.7 terawatt hours of energy is switched from the combustion of fossil fuels to electricity in 2035.

Differences from the *Fourth Biennial Report*

Some minor adjustments were made to sub-modules of the model.

Strengths and weaknesses of models or approach

The GEM is technically a comprehensive model of the New Zealand electricity system. However, the model does not account for departures from assumptions underlying a perfect competition framework. GEM is formulated as a mixed integer programming (MIP) problem with a cost-minimisation objective function. Selecting from a large list of potential new generation facilities, the model determines which plant to construct and in which year each new plant is to be commissioned, all the while satisfying a number of technical, physical and economic constraints. Each potential new plant is characterised by parameters describing attributes such as location, technology, fuel type, capacity, capital cost and operating costs. The model is typically run for a series of scenarios describing possible future outcomes for factors such as demand for electricity (energy and peak), hydro and thermal fuel availability, fuel prices, plant costs, and policies such as carbon pricing, renewables targets or transmission pricing. Under each scenario, a build plan and a supporting set of prices are generated. The time horizon over which the model is operated is typically 20–40 years.

GEM is written and solved using the GAMS modelling software. Input data are supplied to the model in the form of GDX files. Model output is produced as a collection of GDX and CSV files.

SADEM projects energy demand for all sectors in the economy. However, the modelling is of the energy sector only, not of the entire economy. SADEM also has limited representation of potential mitigation technologies and their uptake in response to a carbon price. The main drivers in this modelling are exogenous (eg, GDP, oil and carbon prices), meaning that secondary effects are not modelled (eg, the potential link between oil and carbon prices and GDP is not included). Because SADEM has been developed in house, it offers the flexibility to be further modified and improved.

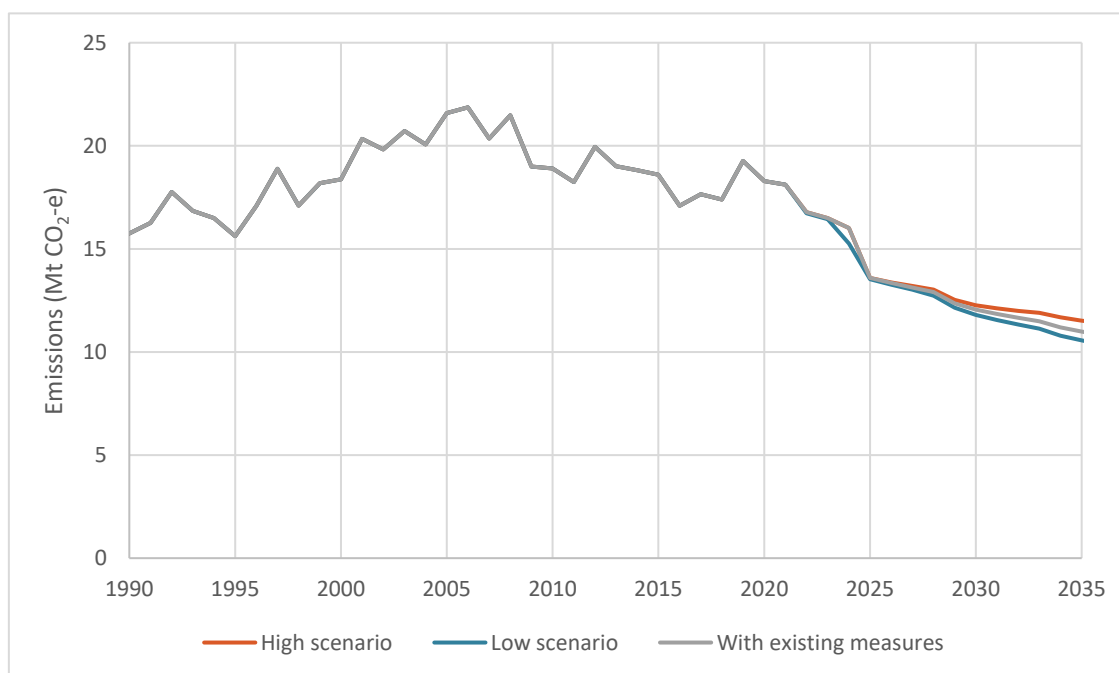
Historical emission factors are used to estimate future emissions. However, there is inherent uncertainty around the impact of new energy developments, particularly (for instance) the location and nature of future geothermal fields and the technologies used to extract and generate electricity from geothermal fluids.

Sensitivity analysis for energy emissions

To understand the potential uncertainty range of projected emissions from energy, a set of high- and low-emissions scenarios (relative to the WEM scenario) is estimated. The results from these scenarios are displayed in table 5.15 and figure 5.5.

Under a low-emissions scenario, emissions are 3.6 per cent lower than 2035 emissions in the WEM scenario. Under the high-emissions scenario, emissions are 4.0 per cent higher.

Figure 5.5: Projected energy emissions under ‘with existing measures’, high- and low-emissions scenarios (Mt CO₂-e)



Note: Mt CO₂-e = million tonnes of carbon dioxide equivalent.

Table 5.15: Projected energy emissions under ‘with existing measures’, high- and low-emissions scenarios, 1990–2035 (Mt CO₂-e)

Scenario	1990	2020	2025	2030	2035	Change from WEM in 2035 (%)
High emissions	15.8	18.1	13.6	12.3	11.5	4.5
WEM	15.8	18.3	13.6	12.1	11.0	0
Low emissions	15.8	18.3	13.5	11.8	10.6	-3.6

Note: Mt CO₂-e = million tonnes of carbon dioxide equivalent; WEM = with existing measures.

5.5.2 Transport

Emissions from transport activities are expected to rise in the short term due to growth in travel demand. They are then anticipated to plateau at 15.1 Mt CO₂-e in 2023, before declining due to the uptake of electric vehicles (EVs) (which predominantly use renewable electricity) and continued improvements in fuel efficiency for new vehicles without the implementation of any specific policy or measure. In 2035 emissions from transport are projected to be 13.8 Mt CO₂-e (table 5.16).

The New Zealand vehicle fleet is near saturation on a per capita basis. Because New Zealand has a slow rate of vehicle replacement, the vehicle fleet is older than in many other countries; consequently, fuel efficiency improvements or the uptake of EVs will take longer to have an effect in New Zealand relative to other developed countries.

Table 5.16: Historical and projected transport sector emissions by gas and subsector under the ‘with existing measures’ scenario, 1990–2035 (Mt CO₂-e)

Gas	Historical						Projected			
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
CO ₂	7.9	10.0	11.4	12.8	13.1	13.6	13.1	15.0	14.7	13.6
CH ₄	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N ₂ O	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Total	8.1	10.2	11.6	13.1	13.3	13.8	13.2	15.1	14.8	13.8

Note: CH₄ = methane; CO₂ = carbon dioxide; Mt CO₂-e = million tonnes of carbon dioxide equivalent; N₂O = nitrous oxide.

Methodology

The transport sector also incorporates the improvements that were made to the energy projections outlined above. Road transport projections were modelled using the Ministry of Transport’s Vehicle Fleet Emissions Model (VFEM)²³³ and were informed by the latest road transport statistics and vehicle efficiency trends. VFEM uses a detailed bottom-up approach for developing the projections by considering individual road vehicle type, power type, vehicle size and age. VFEM is SAS-based and needs exogenous input data from several sources such as vehicle kilometres travelled and scrappage patterns, from which it can then project future energy use and emissions.

EVs continue to increase in popularity as car manufacturers bring new and improved models to the market or have announced plans for future models. This trend has already been incorporated into our projections, so our EV assumptions for the *Fifth Biennial Report* remain largely unchanged compared from the *Fourth Biennial Report*. We project that EVs will comprise 13.3 per cent of the light vehicle fleet and 4.0 per cent of the heavy vehicle fleet by 2035.

For more information, see appendix B.1, CTF table 5 and *Electricity Demand and Generation Scenarios: Scenario and results summary*.²³⁴

Strengths and weaknesses of the models or approach

Strengths of VFEM

- VFEM uses a bottom-up approach – that is, emissions are estimated and projected at very detailed levels.
- Where possible, New Zealand-specific data are used, including on vehicle fleet mix and travel.

²³³ Ministry of Transport. 2022. *Vehicle Fleet Emissions Model*. Retrieved from www.transport.govt.nz/assets/Uploads/Data/Transport-outlook-updated/Vehicle-Fleet-Emissions-Model-Documentation-20220608.pdf (22 November 2022).

²³⁴ Ministry of Business, Innovation and Employment. 2019. *Electricity Demand and Generation Scenarios: Scenario and Results Summary*. Wellington: Ministry of Business, Innovation and Employment. Retrieved from www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-modelling/electricity-demand-and-generation-scenarios/ (24 September 2019).

- In particular, real-world fuel use data in New Zealand are used.
- The model incorporates a high degree of expert judgement where possible.

Weaknesses of VFEM

- Due to the long time horizon, large uncertainty might be associated with its long-term projections.
- This is particularly true for projections for uptake of EV heavy vehicles resulting from limited data and information available.
- Given the complex structure of the model, it may not be easy to project the impacts of some interventions.

Due to time and capacity constraints, some existing interventions could not be included in this *Fifth Biennial Report*, for example clean car policies. The Ministry of Transport plans to include more measures in the modelling work for future reporting.

5.5.3 Industrial processes and product use

In New Zealand, carbon dioxide (CO₂) emissions from IPPU result from the manufacture of iron, steel, aluminium, urea, cement, lime and hydrogen, as well as from the production of methanol. Large-scale manufacturing in New Zealand is dominated by a small number of firms. As a result, projections from these sources are subject to an unusually high degree of variability because small changes in one firm (or a closure) will significantly affect the total emissions. Many of these industries are assumed to be at or near production capacity, so their emissions are projected to remain constant unless a closure date for a particular site is assumed.

Emissions from the IPPU sector are projected to generally steadily decrease from 4.6 Mt CO₂-e in 2020 to 3.7 Mt CO₂-e in 2035 (table 5.17). However, a significant step change is expected with the closure of New Zealand's sole aluminium smelter at Tiwai Point, which would reduce emissions by 0.6 Mt CO₂-e (a 0.5 Mt reduction in CO₂ emissions and a 0.1 Mt CO₂-e reduction in PFC emissions). It has been assumed this closure will occur in 2024, as publicly announced by the smelter's owner in 2021. There is still a reasonable level of uncertainty around whether the smelter will close or continue to operate because in 2022 the smelter's owner issued a statement that it now saw a viable future for the smelter to continue operating beyond 2024. Emissions of perfluorocarbons (PFCs) are also expected to stop occurring in New Zealand with the closure of the aluminium smelter.

Aside from the reductions anticipated through the closure of the aluminium smelter, CO₂ emissions are expected to remain relatively constant from the IPPU sector.

The non-CO₂-based components of IPPU include emissions of hydrofluorocarbons (HFCs), PFCs, sulphur hexafluoride (SF₆) used in electricity transmission and distribution, and methane (CH₄) from the production of methanol, as well as nitrous oxide (N₂O) emissions from the application and use of medical products. Emissions of nitrogen trifluoride (NF₃) do not occur in New Zealand, because the industries that could be potential sources of the gas do not exist in the country and no nitrogen trifluoride is imported.

The emissions from methanol production are expected to step down to zero by 2040 as all methanol production facilities are anticipated to be closed by 2040. The emissions from SF₆ and N₂O are expected to slowly increase out to 2050 but remain at relatively low levels.

Emissions of PFCs declined during the 1990s as a result of the Tiwai Point aluminium smelter making changes to its processing and control methods. The smelter also closed one of its four potlines in 2012 and then re-opened it in 2018, which is likely to have caused variation in perfluorocarbon emissions from aluminium processing.

Hydrofluorocarbon emissions are expected to have reached a peak level at around 1.5 Mt CO₂-e from 2017 to 2020. Starting in 2021, HFC emissions are then expected to steadily decline, reaching 1.0 CO₂-e Mt in 2035 and 0.6 CO₂-e Mt in 2050. The use of HFCs has grown rapidly since the early 1990s when they replaced chlorofluorocarbons, which are being phased out under the Montreal Protocol. The phase-down of HFC consumption in New Zealand is expected to reduce HFC emissions in line with the Kigali Amendment to the Montreal Protocol.²³⁵ The HFC phase-down, likely along with the recently increased NZ ETS price, has already started to have an impact on HFC consumption, which in turn is expected to impact emissions. Note that New Zealand's ratification of the Kigali Amendment does not extend to Tokelau.²³⁶

As the NZ ETS price has recently increased substantially, it has become evident that NZ ETS pricing has had a major impact on a few sectors that use HFCs while having no significant impact on most other sectors. The combination of NZ ETS pricing, Kigali Amendment phase-down and particularly international shifts in equipment design to use lower global warming potential alternatives are expected to have a significant impact on driving reductions in emissions from HFCs in all sectors. The expected level of impact is highly uncertain in each user sector, and it is not possible to separately attribute the impacts of NZ ETS pricing, Kigali Amendment phase-down and international technology shifts.

Table 5.17: Historical and projected IPPU emissions by gas under the 'with existing measures' scenario, 1990–2035 (kt CO₂-e)

Gas	Historical							Projections		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
CO ₂	2,520	2,814	2,922	3,209	3,319	3,510	2,864	2,547	2,551	2,554
CH ₄	28	79	139	20	48	107	96	58	29	29
N ₂ O	102	79	61	45	53	60	74	94	101	107
HFCs	0	25	234	694	1,101	1,386	1,480	1,303	1,209	1,006
PFCs	910	153	68	69	48	59	88	0	0	0
SF ₆	20	24	20	25	23	16	17	18	20	21
NF ₃	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	3,580	3,174	3,443	4,062	4,591	5,137	4,618	4,020	3,910	3,718

Note: CH₄ = methane; CO₂ = carbon dioxide; HFCs = hydrofluorocarbons; IPPU = industrial processes and product use; kt CO₂-e = kilotonnes of carbon dioxide equivalent; N₂O = nitrous oxide; NF₃ = nitrogen trifluoride; NO = not occurring; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride.

²³⁵ Ministry for the Environment. nd. *Kigali Amendment to the Montreal Protocol*. Retrieved from environment.govt.nz/what-government-is-doing/international-action/vienna-convention-and-montreal-protocol/kigali-amendment-to-the-montreal-protocol/ (22 November 2022).

²³⁶ United Nations. 2019, 3 October. Amendment to the Montreal Protocol on substances that deplete the ozone layer, New Zealand: Territorial exclusion in respect of Tokelau. Retrieved from treaties.un.org/doc/Publication/CN/2019/CN.490.2019-Eng.pdf (5 November 2019).

Methodology

The CO₂, CH₄ and PFC emissions projections are estimated largely by holding emissions constant where facilities are assumed to be at production capacity and reducing emissions when site closures are expected to occur. The methanol production facilities Motunui 1 and Motunui 2 plants are assumed to close in 2030 and 2040 respectively, while the Waitara Valley Plant (idled in 2021) is assumed to stay closed.

Projected emissions of SF₆ and N₂O were modelled from forecast activity informed by historical trends and relationships to population and economic growth.

Projections of HFC emissions were prepared through an assessment of the volume and composition of the stockpile of HFC gases in New Zealand and estimates on New Zealand's projected drawdown, reuse, destruction and emissions of those gases. This assessment considered historical trends and analysis on the impact of the Kigali Amendment phase-down, international equipment changes resulting from European Union fluorinated gas regulations, emissions pricing, stakeholder transition plans and likely new technology shifts.

For HFC emissions, the WOM scenario does not include any impact from the Kigali Amendment phase-down and assumes no NZ ETS price, as well as negligible recycled imports, and only includes internationally driven technology shifts. The WAM scenario includes additional estimated impacts of proposals to prohibit imports of pre-charged equipment containing high global warming potential HFCs and increased recovery rates resulting from competition to be included in regulations for the refrigerant recovery sector.

The key assumptions for each HFC emissions scenario are outlined in table 5.18.

Table 5.18: Summary of IPPU key assumptions applied to the scenarios

Key underlying assumptions	Unit	Scenarios	2025	2030	2035
Upper limit in importation of new HFCs	Percentage of 1,796 kt CO ₂ -e baseline*	WEM/WAM/High/Low	47.7%	29.8%	19.4%
GWP limits on new pre-charged equipment		WEM/High/Low	NA	NA	NA
		WAM	Yes	Yes	Yes
Refrigerants recovery rate	Percentage of retired volumes	WEM	9%	10%	12%
		High	9%	12%	14%
		Low	9%	10%	11%
		WAM	12%	12%	18%

Note: *Ozone Layer Protection Act 1996 regulations as at 10 December 2018, Schedules 6+1AA, relating to a High Court amendment. GWP = global warming potential; HFCs = hydrofluorocarbons; IPPU = industrial processes and product use; kt CO₂-e = kilotonnes of carbon dioxide equivalent; WAM = with additional measures; WEM = with existing measures.

Estimated impact of 'additional measures' on HFC emissions

Two significant policy changes are planned to reduce HFC emissions as part of New Zealand's first emissions reduction plan, although the details and timing have yet to be confirmed. The WAM scenario shows a major impact in the timing of stocks and emissions because of the sharp global warming potential deadlines for new equipment as currently proposed and also a smaller impact from competition in the refrigerant recovery sector. The combined impact of these WAM policies would reduce 2035 HFC emissions in the WEM scenario by 24.0 per cent, but more significantly they would reduce 2050 HFC emissions by 83.0 per cent.

Strengths and weaknesses of models or approach

The compilation of HFC emissions includes a highly detailed assessment process for different sectors and uses of HFCs. The approach used is a considerable revision and improvement from previously prepared projections. However, there is still a high level of uncertainty as there are many interacting factors, limited domestic and international evidence, and a significant ongoing policy programme to address HFC emissions.

The mitigation impact of emissions pricing under the NZ ETS is not quantified for non-HFC IPPU emissions beyond the extent that a rising NZ ETS price may be a contributing factor to anticipated specific site closures. This includes the estimated mitigation impact of the phase-down of free allocation of units to large trade-exposed industrial emitters within the NZ ETS.

The assumption around the anticipated closure of New Zealand's sole aluminium smelter is consistent with the assumptions made in the preparation of the energy sector projections.

Historically, imports and exports of bulk HFCs and equipment containing HFCs have fluctuated significantly year to year. For example, stockpiling of bulk imported F-gases is suspected to have occurred from 2010 to 2012, before the January 2013 introduction of F-gases into the NZ ETS, and around 2016 to 2017 in response to increasing NZ ETS prices and the prospect of a Kigali Amendment phase-down permit system. These types of fluctuations distort year-to-year importation and consumption data that are used to inform historical and projected IPPU emissions.

The impact of a rising NZ ETS price for the WEM and WAM scenarios has been assessed for different refrigeration sectors for HFCs. However, these impacts are highly uncertain as there is a limited evidence base for the elasticity of refrigerant usage with respect to an emissions price.

Projected PFC, SF₆, CH₄, N₂O and CO₂ greenhouse gas emissions are unchanged in the WOM and WAM scenarios relative to the WEM scenario. This is due to insufficient information about the historical and future impact of carbon price on the emissions of these gases.

Differences from the *Fourth Biennial Report*

Several improvements and updated assumptions have been made to the model for HFC emissions, including updated NZ ETS price pathway assumptions and quantification of the impact that NZ ETS pricing has on HFC emissions. Other improvements include changes to reflect the latest activity data and revised projections of activity data such as adjustments to the level of refrigerant reuse in some sectors, which has been observed to be increasing. This better understanding has resulted in a 39 per cent drop in emissions in the HFC projection for 2030 compared with the *Fourth Biennial Report*.

Updated assumptions of anticipated specific industrial site closures have been included in these IPPU projections. This improved understanding has significantly impacted projected emissions from aluminium production (largely CO₂ and PFCs) and impacted the projected pathway for methanol production emissions (largely CH₄).

Sensitivity analysis for IPPU emissions

To understand the potential uncertainty range of projected emissions from hydrofluorocarbons, a set of high and low emissions scenarios (relative to the WEM scenario) is estimated for HFC emissions. The low- and high-emissions scenarios estimate the impacts of respectively high

and low NZ ETS price pathways on technology shifts and maintenance (leakage rates) for each sector compared with the WEM scenario. In contrast to the scenarios developed for the *Fourth Biennial Report*, these scenarios do not include impacts from low and high GDP growth. No additional scenarios have been projected for emissions from other IPPU gases.

Under a low-emissions scenario, HFC emissions are 5.4 per cent lower than 2035 emissions in the WEM scenario. Under the high-emissions scenario, emissions are 4.9 per cent higher. For the total IPPU sector, these estimates are respectively 1.5 per cent lower and 1.3 per cent higher.

Sensitivity analysis has been carried out to highlight the importance of the average 15-year residence time of HFCs in most refrigeration and air-conditioning equipment. A 10-year residence time, representing a faster transition to lower global warming potential technologies, would reduce 2035 HFC emissions in the WEM scenario by 26.1 per cent. A 20-year residence time, perhaps representing a slower transition where equipment operators extend the useful lifetime because of the high capital cost of shifting to lower global warming potential technologies, would increase 2035 HFC emissions in the WEM scenario by 11.7 per cent.

5.5.4 Agriculture

In 2035, greenhouse gas emissions from agriculture are projected to be 35.3 Mt CO₂-e (4.3 per cent above 1990 levels, 10.7 per cent below 2005 levels and 10.4 per cent below 2020 levels). Table 5.19 presents historical and projected emissions for the agriculture sector.

Agricultural emissions in New Zealand are projected to fall between 2020 and 2035 due to:

- a continued decline in the amount of land used for agriculture, including a decrease in the dairy cow population and a continued decline in the sheep and beef populations
- an increased focus on afforestation and reduced incentive to deforest, as a result of government schemes and policies such as the NZ ETS
- changes in farm management practices due to improving environmental outcomes and the implementation of the Essential Freshwater package,²³⁷ a cap on synthetic nitrogen fertiliser use²³⁸ and the introduction of pricing on agricultural emissions through He Waka Eke Noa – Primary Sector Climate Action Partnership²³⁹
- continued reductions in emissions intensity (emissions per unit of product) as a result of ongoing improvements in animal productivity and on-farm efficiency. (Based on past performance trends, it is projected that per-dairy cow milk production will increase by 10.3 per cent and per-lamb carcass weights will increase by 8.4 per cent.)

²³⁷ Ministry for Primary Industries. Protecting freshwater health. Retrieved from www.mpi.govt.nz/agriculture/farm-management-the-environment-and-land-use/protecting-freshwater-health/ (22 November 2022).

²³⁸ Ministry for the Environment. Synthetic nitrogen fertiliser cap. Retrieved from environment.govt.nz/acts-and-regulations/freshwater-implementation-guidance/agriculture-and-horticulture/synthetic-nitrogen-fertiliser-cap-in-place-from-1-july/ (22 November 2022).

²³⁹ He Waka Eke Noa. Retrieved from <https://hewakaekenoa.nz/> (22 November 2022).

Table 5.19: Historical and projected agriculture sector emissions by gas under the ‘with existing measures’ scenario, 1990–2035 (Mt CO₂-e)

Gas	Historical						Projected			
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
CO ₂	0.34	0.58	0.79	1.06	0.96	1.05	0.95	0.97	0.94	0.91
CH ₄	28.10	29.04	30.32	31.10	29.55	30.66	30.47	28.86	28.00	27.28
N ₂ O	5.36	6.11	6.51	7.41	7.20	7.70	8.00	7.59	7.35	7.14
Total	33.79	35.73	37.61	39.57	37.71	39.42	39.43	37.43	36.30	35.33

Note: CH₄ = methane; CO₂ = carbon dioxide; Mt CO₂-e = million tonnes of carbon dioxide equivalent; N₂O = nitrous oxide.

Methodology

Forecasts of future agricultural activity were estimated using a number of modelling tools and assumptions, then inserted into the agricultural greenhouse gas inventory model to obtain emissions projections out to 2035. Emission projections use the same methodology and country-specific emission factors used in the compilation of *New Zealand’s Greenhouse Gas Inventory 1990–2020*,²⁴⁰ sometimes referred to as New Zealand’s National Inventory Report.

Assumptions for productivity, animal population, land use and crop production for the WEM scenario have been informed through consultation with literature, experts and representatives from the major industry bodies.

Productivity inputs for the four major livestock categories (dairy, sheep, beef and deer) are modelled by an internal projections model, the Pastoral Supply Response Model (PSRM), which is also used for the *Situation and Outlook for Primary Industries* quarterly reports. For more information, see appendix B.2.

Table 5.20 summarises the changes in emissions, animal numbers, and production that are projected between 2020 and 2035. In the dairy sector, emissions are projected to decrease by 6.0 per cent, while total milk production is projected to decrease by 4.7 per cent. Sheep emissions are projected to fall by 15.1 per cent by 2035, while total sheep *meat* production is expected to fall by 14.4 per cent over the same period.

²⁴⁰ Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/assets/publications/GhG-Inventory/New-Zealand-Greenhouse-Gas-Inventory-1990-2020-Chapters-1-15.pdf (26 July 2022).

Table 5.20: Projected change in emissions, production and animal numbers between 2020 and 2035 under a ‘with existing measures’ scenario for dairy, sheep and beef sectors

Projected change in emissions by activity (kt CO ₂ -e)			
	Dairy	Beef	Sheep
2020	18,481.78	7,101.98	9,308.17
2035	17,371.52	6,055.07	7,906.29
Change 2020–35 (%)	–6.0 %	–14.7 %	–15.1 %
Projected change in total production			
	Total dairy milk production (million litres)	Total beef meat production (million kg)*	Total sheep meat production (million kg)**
2020	21,148.49	207.12	92.83
2035	20,149.28	188.00	75.68
Change 2020–35 (%)	–4.7 %	–9.2 %	–18.5 %
Projected change in animal numbers (thousands)			
	Dairy cattle	Beef cattle	Sheep
2020	6,361.40	3,889.99	26,821.85
2035	5,708.64	3,272.62	21,074.85
Change 2020–35 (%)	–10.3 %	–15.9 %	–21.4 %

Note: * Includes meat from adult beef cattle, heifers, steers and bulls. ** Includes mutton and lamb. kg = kilogram; kt CO₂-e = kilotonnes of carbon dioxide equivalent.

Differences from the *Fourth Biennial Report*

The differences between the projected emissions and removals in the *Fourth Biennial Report*²⁴¹ and the *Fifth Biennial Report* for the agriculture sector are due to improvements in methodologies, emission factors and projections of future agricultural activity.

The new WEM projections have altered the expected effects of implementing the National Policy Statement for Freshwater Management (NPS-FM)²⁴² and the effects of forestry policies and schemes on agricultural land use. Some of the more significant changes are summarised below. More detailed explanations on methodological and emission factor changes are contained in New Zealand’s greenhouse gas inventories from 2020 to 2022.²⁴³

²⁴¹ Ministry for the Environment. 2019. *New Zealand’s Fourth Biennial Report Under the United Nations Framework Convention on Climate Change*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/assets/Publications/Files/fourth-biennial-report.pdf (26 July 2020).

²⁴² New Zealand Government. 2020. *National Policy Statement for Freshwater Management 2020*. Wellington: New Zealand Government.

²⁴³ Ministry for the Environment. 2020. *New Zealand’s Greenhouse Gas Inventory 1990–2018*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/assets/Publications/Files/new-zealands-greenhouse-gas-inventory-1990-2018-vol-1.pdf (22 November 2022). Ministry for the Environment. 2021. *New Zealand’s Greenhouse Gas Inventory 1990–2019*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/assets/Publications/New-Zealands-Greenhouse-Gas-Inventory-1990-2019-Volume-1-Chapters-1-15.pdf (22 November 2022). Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/assets/publications/GhG-Inventory/New-Zealand-Greenhouse-Gas-Inventory-1990-2020-Chapters-1-15.pdf (26 July 2022).

Changes in methodologies and emission factors

The following changes to New Zealand's agriculture inventory were implemented after the publication of the *Fourth Biennial Report*.²⁴⁴

- use of revised activity data for the proportion of dairy goats in the overall farmed goat population
- improvements to the equations used to estimate energy efficiency for maintenance for cattle, sheep and deer
- revised N₂O emission factors for livestock excreta, as well as an updated methodology for allocating excreta to different hill slopes
- a minor correction to the sheep nitrogen excretion calculations
- updated values for pasture quality for Tier 2 livestock categories
- updating the activity data for organic soils
- refining estimates of nitrogen leaching for cropping systems
- updating the assumptions regarding the purity of agricultural lime.

Projections of future agricultural activity

Differences in emissions projections are also due to recent improvements in the PSRM (eg, new data, equations and assumptions), which is used to provide projections of agricultural activity data. This also includes more recent afforestation data, which are assumed to displace agricultural livestock. Recent projections from this model now have a small decrease for future dairy production, compared with projections used in previous national communications and biennial reports.

By combining PSRM projections with assumptions on the effect of the NPS-FM, agricultural pricing and the cap on synthetic nitrogen fertilisers, it is projected that dairy cattle populations will decline due to constraints on land availability and the introduction of water quality objectives. Sheep and beef populations will also continue to decline.

Effect of policy measures

The new WEM projection in this report has updated the expected effects of the NPS-FM based on discussions with subject matter experts. It also included an analysis on the expected impact of the cap on synthetic nitrogen fertiliser, based on farm-level data across New Zealand. It is expected that the combinations of these measures will act to reduce animal numbers and subsequently reduce production.

The new projections also account for the expected indirect effects of government schemes and policies that encourage afforestation. The WEM projections also assume that agricultural emissions will be priced via the NZ ETS backstop option at a discount rate of 95 per cent. This is based on previous modelling carried out by Manaaki Whenua Landcare Research²⁴⁵ and has been extrapolated to take into consideration the carbon price pathway.

²⁴⁴ Ministry for the Environment. 2019. *New Zealand's Fourth Biennial Report Under the United Nations Framework Convention on Climate Change*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/assets/Publications/Files/fourth-biennial-report.pdf (26 July 2020).

²⁴⁵ Djanibekov U, Samarasinghe O, Greenhalgh S. 2019. *Modelling of Agricultural Climate Change Mitigation Policy Scenarios*. Prepared for the Ministry for Primary Industries by Manaaki Whenua Landcare Research. Retrieved from www.mpi.govt.nz/dmsdocument/39095/direct (22 November 2022).

Strengths and weaknesses of models or approach

The main strength of this modelling approach for agriculture emissions projections is the use of both economic modelling and expert opinion to generate activity data inputs. Outputs from the PSRM have been sense-checked and combined with insights and opinions from subject matter experts to estimate the expected effect of the NPS-FM. Another strength is the use of projection data from the LULUCF sector to help inform assumptions on agricultural land use. This ensures that the emissions projections for agriculture and LULUCF are based on consistent assumptions.

Conversely, the weaknesses of the modelling approach mostly arise due to the timeframe of the projections. The PSRM was originally designed to estimate animal numbers and production five years into the future, while agriculture projections described in this section partially use the PSRM to estimate emissions up to 15 years into the future. Over this period, there are a number of long-term economic trends (such as commodity prices) that are extremely difficult to model. Further, there are uncertainties over long-term climate variables and how these will affect agricultural production and emissions.

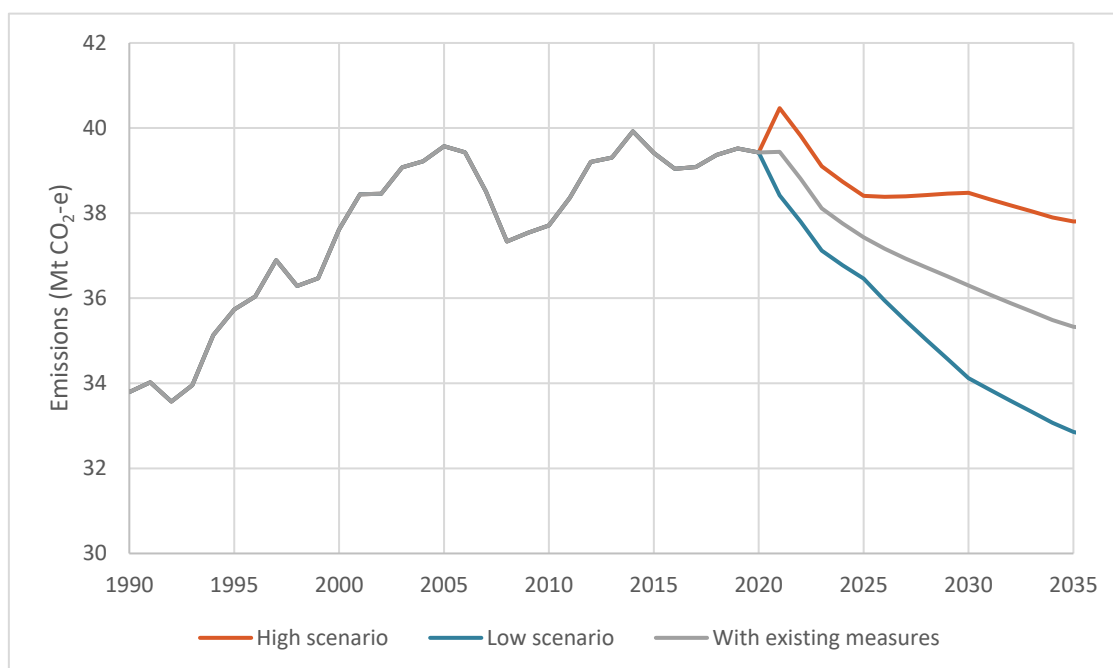
Another weakness results from the difficulty in modelling the expected effect of carbon prices on agricultural land use (versus forestry) and resulting emissions. The carbon price in the NZ ETS has risen rapidly in recent years as demand for NZUs has increased. Historically, the carbon prices being seen today (NZ\$72.55 spot price as at 26 July 2022) have never been experienced before, so the effect of the price continuing to rise has to be based on modelling rather than empirical data.

There are also uncertainties over the expected effects of the NPS-FM, cap on synthetic nitrogen fertiliser and agricultural emissions pricing and the extent to which these policies will affect animal numbers and fertiliser use.

Sensitivity analysis for agriculture emissions

To understand the potential uncertainty range of projected emissions from agriculture, emissions from the 2022 *Greenhouse Gas Inventory* were compared with past projections. The uncertainty in this year's projection model has been designed to reflect the previous performance of the model. The results are displayed in table 5.21 and figure 5.6.

Figure 5.6: Projected emissions from agriculture, under ‘with existing measures’, with uncertainty envelope, 1990–2035 (Mt CO₂-e)



Note: Mt CO₂-e = million tonnes of carbon dioxide equivalent.

Table 5.21: Projected emissions from agriculture, under ‘with existing measures’, high- and low-emissions scenarios, 1990–2035 (Mt CO₂-e)

Scenario	1990	2020	2025	2030	2035	Change from WEM in 2035 (%)
Low emissions	33.79	39.42	36.46	34.12	32.86	-7.0 %
WEM	33.79	39.42	37.43	36.30	35.33	0 %
High emissions	33.79	39.42	38.41	38.48	37.80	7.0 %

Note: Mt CO₂-e = million tonnes of carbon dioxide equivalent; WEM = with existing measures.

By 2035, emissions under the high-emissions scenario are 7.0 per cent higher than 2035 emissions in the WEM scenario, and emissions under the low-emissions scenario are 7.0 per cent lower.

More details on the estimated uncertainty are provided in appendix B.2.

5.5.5 Land use, land-use change and forestry

In 2020, New Zealand's LULUCF²⁴⁶ sector comprised around 7.845 million hectares of natural forest and just over 2.1 million hectares of planted forest.²⁴⁷ Projected LULUCF emissions and removals are significantly influenced by New Zealand's planted forest age-class profile and harvesting rates. New Zealand has undergone three periods of significant afforestation and reforestation; the subsequent growth, harvest and replanting cycles of these plantation forests will continue to affect New Zealand's emissions and removals well into the future.

New Zealand's LULUCF sector is currently a net sink of carbon dioxide. In 1990, the LULUCF sector contributed –21.2 Mt CO₂-e net emissions (table 5.22), compared with –23.3 Mt CO₂-e in 2020. The main reason for the decline in removals from 2010 is an increase in forest harvesting of New Zealand's sustainable plantation forests. See *New Zealand's Greenhouse Gas Inventory 1990–2020* for a more detailed explanation of the change.²⁴⁸

Net emissions in New Zealand's LULUCF sector are projected to continue to decline in the 2020s as plantation forests established in the late 1980s and early 1990s are harvested for timber. However, the LULUCF sector is expected to see an increase in net removals in the late 2020s due to the growth from the replanted forests following harvest and the additional sequestration from projected afforestation activities.

Table 5.22: Historical and projected LULUCF emissions and removals by gas under the 'with existing measures' scenario, 1990–2035 (Mt CO₂-e)

Gas	Historical							Projected		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
CO ₂	–21.6	–22.9	–27.4	–25.9	–29.8	–27.0	–23.7	–9.9	–12.4	–25.8
CH ₄	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N ₂ O	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
Total	–21.2	–22.4	–26.9	–25.4	–29.3	–26.6	–23.3	–9.5	–12.0	–25.5

Note: Removals are expressed as negatives (–) and represent net carbon dioxide (CO₂-e) removed from the atmosphere, while emissions are expressed as positives (+) and represent net CO₂-e emissions to the atmosphere. CH₄ = methane; LULUCF = land use, land-use change and forestry; Mt CO₂-e = million tonnes of carbon dioxide equivalent; N₂O = nitrous oxide.

²⁴⁶ The term LULUCF is used to refer to the forestry and other land use categories of the 'Agriculture, forestry and other land use' chapter of: International Panel on Climate Change (IPCC). 2006. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Prepared by the National Greenhouse Gas Inventories Programme for the IPCC. Hayama: Institute for Global Environmental Strategies. Retrieved from www.ipcc-nggip.iges.or.jp/public/2006gl/ (22 November 2022). These are used for *reporting* to the UNFCCC and are distinct from the *accounting* guidelines used to determine forestry's contribution towards meeting emissions reduction targets.

²⁴⁷ The area of planted forest is based on New Zealand greenhouse gas inventory gross stocked area standard, which includes forest tracks, skid sites and unstocked areas. For more detail, see Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment, section 6.4. Retrieved from environment.govt.nz/assets/publications/GHG-Inventory/New-Zealand-Greenhouse-Gas-Inventory-1990-2020-Chapters-1-15.pdf (26 July 2022).

²⁴⁸ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment, section 6.1. Retrieved from environment.govt.nz/assets/publications/GHG-Inventory/New-Zealand-Greenhouse-Gas-Inventory-1990-2020-Chapters-1-15.pdf (26 July 2022).

Methodology

Projected emissions and removals from the LULUCF sector are calculated using methodologies consistent with those used within *New Zealand's Greenhouse Gas Inventory 1990–2020*²⁴⁹ (the Inventory). Activity data and emission factors used in the Inventory comprise the historical time series (1990–2020) used in this report. The modelling takes a bottom-up approach to projecting the WEM projections. Each LULUCF policy and measure is calculated on an individual basis using a bottom-up approach, with the total for each policy and measure subtracted from the WEM scenario to provide an accurate estimate of the WOM scenario.

As with projections of emissions for any sector, the LULUCF sector is sensitive to the underlying assumptions used. It is challenging to arrive at absolute values of future rates of afforestation, deforestation, harvesting, pre-1990 natural forest sequestration and harvested wood products. Projections of activity data and emission factors are based on external research and analysis, with a range of upper and lower removals to reflect the variability in predictions.

Main assumptions

The main drivers and assumptions used in the LULUCF projections are detailed below.

Pre-1990 natural forests

New Zealand's pre-1990 natural forest is separated into two sub-categories: pre-1990 regenerating forest and pre-1990 tall forest. Carbon stock changes of these forest categories are reported in the Inventory. In 2020 the pre-1990 natural forest estate was a net sink, sequestering around -1.4 Mt CO₂. The regenerating component of the pre-1990 forest estate was a net sink whereas the tall forest component was a net source of emissions.

Activity data and emission factors for New Zealand's pre-1990 natural forest from the Inventory are used for the historical time series 1990–2020. Pre-1990 natural forest projections from 2021 to 2035 assume the continued rate of change for pre-1990 tall and regenerating natural forests.²⁵⁰

The rate of carbon stock change in pre-1990 tall forest is -0.01 ± 0.19 t C ha⁻¹yr⁻¹, while for pre-1990 regenerating forest the rate of change is 0.43 ± 0.51 t C ha⁻¹yr⁻¹. The uncertainty in the report's estimate has been applied to the lower and upper removal scenarios to represent sensitivity in measurement, sampling and model uncertainty.

²⁴⁹ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020 (18 August 2022).

²⁵⁰ Carbon stocks in tall pre-1990 natural forest have previously been reported as being in steady state because the annual net change is not statistically significant (Paul T, Kimberley MO, Beets PN. 2021. Natural forests in New Zealand – a large terrestrial carbon pool in a national state of equilibrium. *Forest Ecosystems* 8(34). URL: link.springer.com/article/10.1186/s40663-021-00312-0). New Zealand received a recommendation from the expert review team (L.18, UNFCCC. 2020. FCCC/ARR/2019/NZL. Report on the individual review of the annual submission of New Zealand submitted in 2019. In-country Review. URL: unfccc.int/sites/default/files/resource/NewZealand_complete.pdf) to review this position and to report the losses and associated uncertainty occurring in this forest class regardless of the statistical significance. Therefore, the pre-1990 natural forest carbon stock change per hectare estimate has been revised for the 2022 submission to report carbon stock changes occurring in the tall forest category.

Pre-1990 planted forest and sustainable forest harvesting

In 1990, pre-1990 planted forests were a net sink, sequestering around –19.1 Mt CO₂. This has decreased to around –7.7 Mt CO₂ in 2020, due to an increase in rates of harvesting. The activity data and emission factors from *New Zealand's Greenhouse Gas Inventory 1990–2020*,²⁵¹ combined with projections of harvesting and replanting, are used to determine pre-1990 planted forest emissions and removals from 2021 to 2035.

Projections of pre-1990 planted forest harvest are sourced from the *Wood Availability Forecast – New Zealand 2021 to 2060* (the Wood Availability Forecast).²⁵² Almost all forest harvesting in New Zealand (99.9 per cent) occurs in planted production forests.²⁵³ Planted forest harvesting area, age and net emissions from 1990 to 2020 are sourced from the Inventory. Projections are modelled from historical forest plantings and assume a target rotation length of 28–30 years.

Afforestation and sustainable forest harvesting

Historical post-1989 forest activity data and emission factors are sourced from the Inventory. Estimated post-1989 planted forest age-class data from the Inventory are combined with projected afforestation scenarios from 2021, and the 2021 Wood Availability Forecast to estimate emissions and removals out to 2035. The 2021 Wood Availability Forecast indicates that harvest levels will increase over the 2020s, which is reflected in the LULUCF projections with lower net removals over this period.

Projected afforestation scenarios from 2021 onwards are based on the University of Canterbury's School of Forestry report, *Afforestation and Deforestation Intentions Survey 2021*.²⁵⁴ The report shows exotic afforestation intentions estimated at 41,500 hectares in 2021 and intentions to establish 63,300 hectares in 2022 (47,900 hectares was confirmed at the time of the survey), with exotic afforestation intentions ranging between 31,355 and 46,500 hectares per year from 2023 to 2030. The survey also reported native forest afforestation estimated at 7,000 hectares in 2021, and intentions of 5,300 hectares in 2022 which then decreased to around 2,000 hectares per year by 2030.

Harvested wood products

New Zealand's planted forests are dominated by radiata pine. Its wood is used in a wide range of applications including timber-frame construction, packaging, plywood, medium-density fibreboard, posts and poles, and mechanical and chemical pulping. The methodology used to estimate net removals from harvested wood products over the projected period can be found in the Inventory.

²⁵¹ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment, section 6.3. Retrieved from environment.govt.nz/assets/publications/GhG-Inventory/New-Zealand-Greenhouse-Gas-Inventory-1990-2020-Chapters-1-15.pdf (26 July 2022).

²⁵² Ministry for Primary Industries. 2021. *Wood Availability Forecast – New Zealand 2021 to 2060*. Wellington: Ministry for Primary Industries. URL: www.mpi.govt.nz/dmsdocument/47671-Wood-Availability-Forecast-New-Zealand-2021-to-2060 (22 November 2022).

²⁵³ Consistent with the 2020 *Greenhouse Gas Inventory* (section 6.3), any harvesting that occurs in natural forests is captured within the natural forest carbon stock and stock change estimates. Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/assets/publications/GhG-Inventory/New-Zealand-Greenhouse-Gas-Inventory-1990-2020-Chapters-1-15.pdf (26 July 2022).

²⁵⁴ Manley B. 2021. *Afforestation and Deforestation Intentions Survey 2021: Final report*. Prepared for the Ministry for Primary Industries by Professor B Manley, School of Forestry, University of Canterbury. Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/dmsdocument/52405-Afforestation-and-Deforestation-Intentions-Survey-2021 (22 November 2022).

Deforestation

Historical planted and natural forest deforestation activity data and emission factors are sourced from the Inventory. Projections of planted production forest deforestation are sourced from the *Afforestation and Deforestation Intentions Survey 2021*.²⁵⁵ With most of New Zealand's planted forestry estate privately owned, the three deforestation scenarios reflect the impact of land-use economics, carbon emissions unit price, and central and local government policies. Projections of pre-1990 natural forest deforestation are based on historical trends.²⁵⁶

Non-CO₂ emissions

Historical non-CO₂ emissions are sourced from the Inventory. Non-CO₂ emissions are not a significant source of emissions for New Zealand's LULUCF sector, with projections based on historical trends.

Effect of policies and measures in the LULUCF sector

The WOM projection excludes the estimated historical and projected effects of the NZ ETS and government forestry initiatives on net LULUCF removals (see table 5.23 and figure 5.7). The methods in determining the carbon impact of each policy are briefly described below.

New Zealand Emissions Trading Scheme

The NZ ETS estimates in CTF table 3 (see chapter 4, section 4.3.9, table 4.3) are a combination of 'additional' afforestation and 'avoided' deforestation that could be attributed to the NZ ETS. The impact the NZ ETS has had on afforestation and deforestation varied between 2008 and 2020 depending on the carbon price at the time. The WOM scenario excludes the estimated impact of the NZ ETS on levels of afforestation and on pre-1990 planted forest deforestation.

The assessment of the historical and projected impact is primarily based on annual evaluation surveys, research and modelling conducted by the University of Canterbury's School of Forestry.²⁵⁷ Surveys conducted by the university are used to estimate the amount of deforestation that would occur 'with' and then 'without' the existence of the NZ ETS. The deforestation estimates 'without the NZ ETS' were correlated with historical and projected deforestation rates to determine the impact of the NZ ETS at that time.

In calculating the impact of the NZ ETS on afforestation, only afforestation since the establishment of the NZ ETS in 2008 is considered as being attributable. This creates a distinction between forests that were established before and after the NZ ETS came into effect, and ensures only forests established as a direct result of that initiative are included. Research and analysis conducted by the University of Canterbury are used to estimate the

²⁵⁵ Ibid.

²⁵⁶ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment, table 6.3.7. Retrieved from environment.govt.nz/assets/publications/GhG-Inventory/New-Zealand-Greenhouse-Gas-Inventory-1990-2020-Chapters-1-15.pdf (26 July 2022).

²⁵⁷ Manley B. 2021. *Afforestation and Deforestation Intentions Survey 2021: Final report*. Prepared for the Ministry for Primary Industries by Professor B Manley, School of Forestry, University of Canterbury. Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/dmsdocument/52405-Afforestation-and-Deforestation-Intentions-Survey-2021 (22 November 2022).

impact of the NZ ETS carbon price on afforestation rates in New Zealand.²⁵⁸ The research findings provide estimated afforestation 'with' and 'without' carbon prices and are used as a measure of the 'additional' afforestation since 2008 that can be attributed to the establishment of the NZ ETS. The results of this research were then correlated with afforestation rates and carbon prices from 2008 to 2020, and 'with existing measures' projections from 2021 to 2035, to determine the impact that carbon price has had on afforestation.

Government-funded forestry initiatives

The WOM scenario also assumes the exclusion of afforestation as a direct result of government forestry initiatives, such as the Afforestation Grant Scheme, Permanent Forest Sink Initiative, Sustainable Land Management Hill Country Erosion Programme, Erosion Control Funding Programme and the One Billion Trees Programme. See chapter 4 for further details of these government-funded forestry initiatives. The estimated impact of the various government forestry initiatives is provided in CTF table 3 (see chapter 4, section 4.3.9, table 4.3). Net removal estimates are based on methodologies in the Inventory, and simulate forest growth using activity data on forest area, age and species.

Effect of additional measures

The WAM scenario includes measures already implemented (WEM) and those planned, but currently not implemented (see table 5.23 and figure 5.7). The WAM scenario includes three initiatives that have been funded through the newly established Climate Emergency Response Fund.²⁵⁹ The three additional forestry initiatives are:

- a) Establishing Native Forests at Scale to Develop Long-term Carbon Sinks and Improve Biodiversity
- b) Increasing Woody Biomass Supply to Replace Coal and other Carbon Intensive Fuels and Materials
- c) Maximising Carbon Storage: Increasing Natural Sequestration to Achieve New Zealand's Future Carbon Goals.

For more information on the WAM initiatives refer to *Aotearoa New Zealand's first emissions reduction plan: Technical information annex*.²⁶⁰ Compared with the WEM scenario, these three WAM initiatives are estimated to sequester around $-2.6 \text{ Mt CO}_2\text{-e}$ ²⁶¹ of additional LULUCF removals in the year 2035.

²⁵⁸ Manley B. 2019. *Impacts of Carbon Prices on Forest Management*. Prepared for the Ministry for Primary Industries by Professor B Manley, School of Forestry, University of Canterbury. Wellington: Ministry for Primary Industries. Retrieved from www.teururakau.govt.nz/dmsdocument/37113/direct (22 November 2022).

²⁵⁹ New Zealand Government. 2022. Climate Change Emergency Fund, pp 12–13. Retrieved from www.beehive.govt.nz/sites/default/files/2022-05/CERF%20investments.pdf (22 November 2022).

²⁶⁰ Ministry for the Environment. 2022. *Aotearoa New Zealand's first emissions reduction plan: Technical information annex*, pp 34–35. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/assets/publications/Files/Aotearoa-New-Zealands-first-emissions-reduction-plan-Technical-information-annex.pdf (22 November 2022).

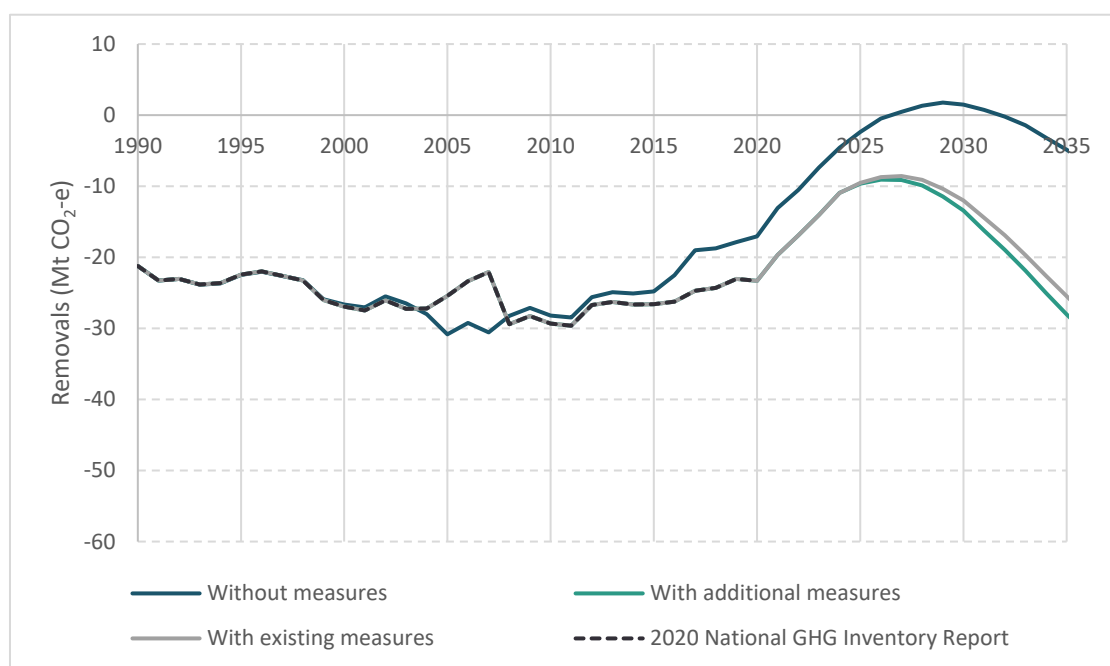
²⁶¹ This figure differs to that derived from table 5.23 due to rounding.

Table 5.23: Net LULUCF removals under ‘with existing measures’ and ‘without measures’ scenario, and with ‘additional measures’ 1990–2035 (Mt CO₂-e)

LULUCF scenario	1990	2020	2025	2030	2035
With existing measures (WEM)	-21.2	-23.3	-9.5	-12.0	-25.5
Without measures (WOM)	-21.2	-17.0	-2.4	1.5	-4.9
With additional measures (WAM)	-21.2	-23.3	-9.6	-13.4	-28.0

Note: LULUCF = land use, land-use change and forestry; Mt CO₂-e = million tonnes of carbon dioxide equivalent.

Figure 5.7: Net LULUCF removals under ‘with existing measures’ and ‘without measures’ scenarios, and with ‘additional measures’ 1990–2035 (Mt CO₂-e)



Note: GHG = greenhouse gas; LULUCF = land use, land-use change and forestry; Mt CO₂-e = million tonnes of carbon dioxide equivalent.

Differences from the *Fourth Biennial Report* and *Seventh National Communication*

The differences between LULUCF projections in this report and those in the *Fourth Biennial Report* and *Seventh National Communication*²⁶² are mainly due to general improvements to *New Zealand’s Greenhouse Gas Inventory* activity data and emission factors, revised afforestation projections due to the inclusion of the *Afforestation and Deforestation Intentions Survey 2021*, updated harvesting data sourced from the *Wood Availability Forecast* and revised estimates of pre-1990 natural forest sequestration. The main contributing factors are summarised below.

²⁶² Ministry for the Environment. 2017. *New Zealand’s Seventh National Communication: Fulfilling reporting requirements under the United Nations Framework Convention on Climate Change and the Kyoto Protocol*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-seventh-national-communication-under-the-united-nations-framework-convention-on-climate-change-and-the-kyoto-protocol/ (22 November 2022).

LULUCF inventory emission factors have improved continuously for the forest land category, with activity data improvements across all land use categories. As an example, the continuous improvement between the 2015 and 2020 LULUCF inventories has resulted in a 12 per cent increase in removals for 2015 and a 30 per cent decrease in removals in 1990.

The findings from the *2021 Afforestation and Deforestation intentions Survey 2021*²⁶³ show an increase in intended exotic afforestation over the projection period, with exotic afforestation around 36,000 hectares in 2030, compared with around 15,000 hectares per year projected in the *Seventh National Communication* and 26,000 hectares per year projected in the *Fourth Biennial Report*. The increase in projected afforestation can be largely attributed to a significant rise in the New Zealand unit carbon price that post-1989 forest owners receive within the NZ ETS.²⁶⁴

The *Fourth Biennial Report* and *Seventh National Communication* projected production planted forest harvesting from research and analysis completed by *Scion* in 2015.²⁶⁵ Harvesting projections have been updated based on the most recent research and analysis completed in 2021. The *Wood Availability Forecast* shows slightly higher harvest levels over the 2020s than previously assumed. For example, total forest harvesting in the *Fourth Biennial Report* was projected to be around 591,000 hectares over 2021–2030, compared with around 668,000 hectares harvested over the same period in the *Wood Availability Forecast*.

Revised pre-1990 natural forest emission factors have resulted in lower removals over inventory reporting and projection periods. In this report, projected removals from pre-1990 natural forests are around –1.4 Mt CO₂-e per year compared with around –6.1 Mt CO₂-e per year as reported in the *Seventh National Communication*²⁶⁶ and 2.7 Mt CO₂-e per year as reported in the *Fourth Biennial Report*.

Table 5.24 and figure 5.8 provides net removals from the inventory for 1990 and 2020, and projected net removals ‘with existing measures’ upper removals (low-emissions), base (WEM) and lower removals (high-emissions) scenarios. The upper and lower removals scenarios reflect the variability in future rates of afforestation, deforestation, harvesting, pre-1990 forests and harvested wood products.

²⁶³ Manley B. 2021. *Afforestation and Deforestation Intentions Survey 2021: Final report*. Prepared for the Ministry for Primary Industries by Professor B Manley, School of Forestry, University of Canterbury. Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/dmsdocument/52405-Afforestation-and-Deforestation-Intentions-Survey-2021 (22 November 2022).

²⁶⁴ Ministry for Primary Industries. *Forestry in the Emissions Trading Scheme*. Retrieved from www.mpi.govt.nz/forestry/forestry-in-the-emissions-trading-scheme/ (22 November 2022).

²⁶⁵ Scion. 2014. *Post-2020 LULUCF Projections: Greenhouse gas emissions and removals under alternative accounting scenarios*. Prepared for the Ministry for Primary Industries by Scion. Wellington: Ministry for the Environment.

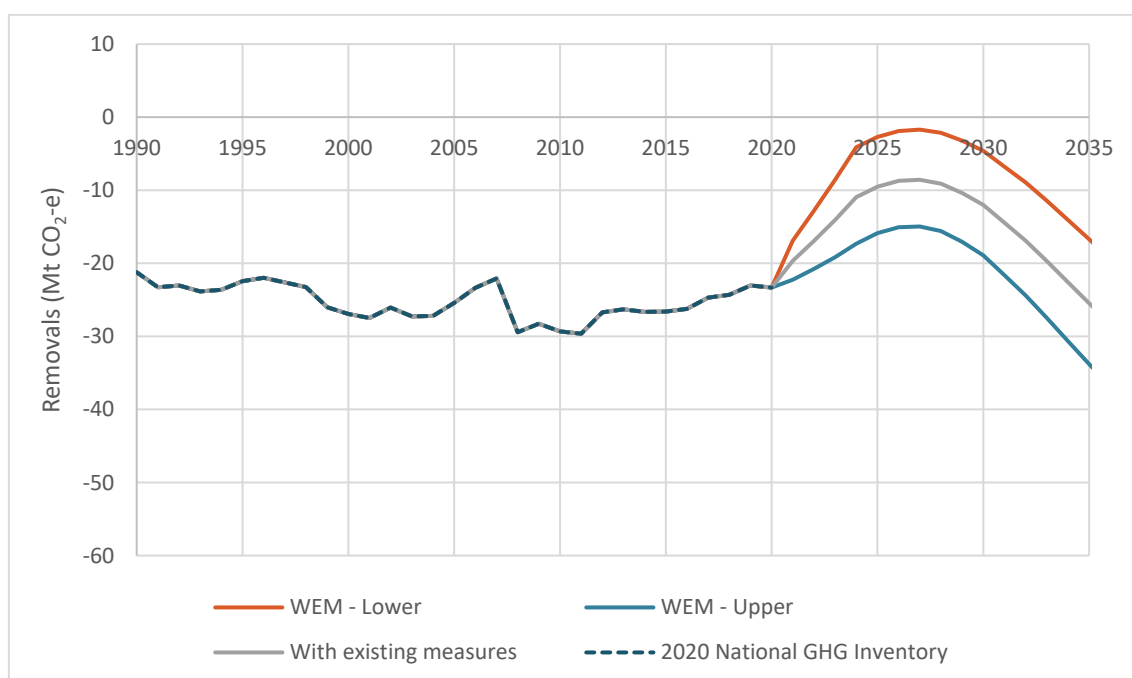
²⁶⁶ The *Seventh National Communication* assumed 6.1 Mt CO₂-e removed per year versus 2.7 Mt CO₂-e removed per year projected in the *Fourth Biennial Report*.

Table 5.24: Projected net LULUCF removals under ‘with existing measures’, lower removals and upper removals scenarios, 1990–2035 (Mt CO₂-e)

Scenario	1990	2020	2025	2030	2035
Lower removals (high-emissions scenario)	-21.2	-23.3	-2.7	-4.6	-16.7
With existing measures	-21.2	-23.3	-9.5	-12.0	-25.5
Upper removals (low-emissions scenario)	-21.2	-23.3	-15.9	-18.9	-33.8

Note: Removals are expressed as negatives (–) and represent net carbon dioxide (CO₂) removed from the atmosphere, while emissions are expressed as positives (+) and represent net CO₂ emissions to the atmosphere. LULUCF = land use, land-use change and forestry; Mt CO₂-e = million tonnes of carbon dioxide equivalent.

Figure 5.8: Projected net LULUCF removals under ‘with existing measures’, lower removals and upper removals scenarios, 1990–2035 (Mt CO₂-e)



Note: Removals are expressed as negatives (–) and represent net CO₂ removed from the atmosphere, while emissions are expressed as positives (+) and represent net CO₂ emissions to the atmosphere. GHG = greenhouse gas; LULUCF = land use, land-use change and forestry; Mt CO₂-e = million tonnes of carbon dioxide equivalent; WEM = with existing measures.

5.5.6 Waste

From 2020, emissions from waste are projected to decrease to 2982 kt CO₂-e by 2030 (24.4 per cent below 1990 levels, or 8.8 per cent below 2020 levels) and to 2884 kt CO₂-e by 2035 (26.9 per cent below 1990 levels, or 11.8 per cent below 2020 levels). Table 5.25 presents historical greenhouse gas emissions from 1990 to 2020, and projected greenhouse gas emissions from 2021 to 2035 for the waste sector.

Around 82.2 per cent of waste emissions are CH₄ emissions resulting from disposal of solid waste to land during 1990–2035. Due to the increasing use of landfill gas capture, particularly since this became mandatory for certain landfills under the National Environmental Standard for Air Quality, net emissions from landfills and the waste sector as a whole peaked around 2002. Changing composition of waste, notably a reduction in the proportion of food and paper waste to landfill offsets projected increases in waste volumes, which results in a slightly decreasing trend to 2035.

The remaining 17.8 per cent of emissions in the waste sector are composed of several gases from the following sources in decreasing order of size: domestic wastewater, open burning, industrial wastewater, composting, incineration and anaerobic digestion. Carbon dioxide emissions mainly from open burning remain at steady levels from 2021 to 2035, whereas CH₄ emissions are expected to decrease during this period. Nitrous oxide emissions increase during the same timeframe, largely due to the increased wastewater emissions from an increasing population and also a contribution from increased composting.

Table 5.25: Historical and projected greenhouse gas emissions from waste by gas, under a ‘with existing measures’ scenario, 1990–2035 (kt CO₂-e)

Gas	Historical						Projected			
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
CO ₂	159	136	150	119	109	100	90	96	94	92
CH ₄	3,671	3,981	4,156	4,133	3,632	3,240	3,012	2,862	2,698	2,596
N ₂ O	113	117	129	126	131	147	167	180	191	196
Total	3,943	4,235	4,435	4,378	3,872	3,488	3,269	3,138	2,982	2,884

Note: CH₄ = methane; CO₂ = carbon dioxide; kt CO₂-e = kilotonnes of carbon dioxide equivalent; N₂O = nitrous oxide.

Methodology

All categories in the waste sector use a bottom-up approach, estimating emissions at the category level as reported in the Inventory. This is done by projecting activity data and applying the national greenhouse gas inventory models to estimate emissions.

Some methods for projecting activity data have been revised for the *Fifth Biennial Report*. Several policies and measures have been quantified in the waste sector and use a variant of the model used for existing measures that incorporates the alternative activity data and/or emission factors. Table 5.26 provides details on the methods used for projecting each category in the waste sector.

Table 5.26: Methods for projecting activity data and or emissions in the waste sector, 2021–35

Category in the waste sector	Gas(es)	Method for projecting activity data or emissions	Strengths	Weaknesses
Managed landfills	CH ₄	Waste tonnage is projected by correlating historical GDP with total waste disposed and extending the correlation into the future. Other parameters are held constant Variants of this model using modified activity data and/or parameters are used to estimate the effects of some existing and additional measures	Models projected waste amounts using a robust mathematical model drawing mainly on recent historical trends, the impact of an increasing waste levy and current policy direction	Projection of activity data is sensitive to the latest historical waste tonnages which have been impacted by COVID-19 and could distort the longer-term projection
Unmanaged farm fills	CH ₄	Logarithmic extrapolation of farm counts from 2002 to 2017, which in turn drives overall waste tonnages on farms as per the greenhouse gas inventory	Based on plausible long-term trend in farm counts	Assumes that waste volume per farm is constant

Category in the waste sector	Gas(es)	Method for projecting activity data or emissions	Strengths	Weaknesses
Unmanaged non-municipal fills	CH ₄	Waste tonnages are held constant into the future at 2015 levels, which is based on the available historical data	Plausible projection based on limited available data	Does not account for potential changes in industry activity into the future
Uncategorised landfills	CH ₄	Activity data ended in 2010, however, emissions continue to occur and are projected using the first order decay model in the greenhouse gas inventory	Uses first order decay model from the inventory	Relies on historical activity data being accurate
Composting	CH ₄ , N ₂ O	The activity data are modelled from 1990 based on an assumed growth curve, consistent with limited actual data where available and assumed changes into the future Variants of this model using modified activity data and or parameters are used to estimate the effects of some existing and additional measures	Assumptions are tied to actual data	Limited actual data results in heavy reliance on assumed growth curve
Anaerobic digestion	CH ₄	A model based on inventory tier 1 methods is used to estimate projected emissions for anaerobic digestion based on assumed waste tonnages A variant of this model using modified activity data is used to estimate the effects of additional measures	Applies inventory methods	No activity data are available as this is solely a future activity as at the time of reporting
Incineration	CO ₂ , CH ₄ , N ₂ O	Constant activity assumed since 2007	Simple, consistent with the inventory	Assumes the incineration rate is constant
Open burning	CO ₂ , CH ₄ , N ₂ O	Uses activity data modelled for farm fills, noting that half of the activity data are landfilled and half are burned	Simple, consistent with the inventory	Assumes the same amounts of waste are burned and buried
Domestic wastewater	CH ₄ , N ₂ O	The quantity of domestic wastewater is dependent on the national population, using the latest emission factor as calculated in the greenhouse gas inventory, which is held constant for projections	Uses inventory methods and reflects projected population changes	Assumes no changes in wastewater treatment processes
Industrial wastewater	CH ₄ , N ₂ O	The quantity of industrial wastewater is dependent on industrial production. Projected production for meat and dairy industries is based on projected industry data. The remaining industries are held constant at 2020 levels	Tracks known changes in activity in accordance with the inventory	Assumes emission factors and some activity data are constant

Note: CH₄ = methane; CO₂ = carbon dioxide; GDP = gross domestic product; N₂O = nitrous oxide; NZ ETS = New Zealand Emissions Trading Scheme.

Sensitivity analysis for waste emissions

The projected emissions in the waste sector are predominantly driven by volumes of managed and unmanaged solid waste. Table 5.27 describes the key drivers and sensitivities for the main categories in the waste sector. No quantitative sensitivities were produced for the waste sector for the *Eighth National Communication* or *Fifth Biennial Report*.

Table 5.27: Qualitative analysis of key drivers of projected emissions in the waste sector

Major category in the waste sector	Key drivers of emissions and sensitivities
Managed landfills	Key driver: projected waste volumes Emissions are most sensitive to landfill gas capture rates and historical activity data
Farm waste (both open burning and unmanaged landfills)	Key driver: projected farm counts Emissions are most sensitive to composition and quantity of waste per farm, as well as the degree of aerobic versus anaerobic decomposition
Unmanaged non-municipal fills	Key driver: assumption that waste tonnages remain constant since 2015 Emissions are most sensitive to historical waste tonnages and assumed composition of waste, as well as the degree of aerobic versus anaerobic decomposition
Domestic wastewater	Key driver: population Emissions are most sensitive to emission factors
Industrial wastewater	Key driver: industry production Emissions are most sensitive to emission factors

Differences from the *Fourth Biennial Report*

The most significant changes to the methodologies for calculating emissions from the waste sector since the *Fourth Biennial Report*²⁶⁷ are in the methods for projecting solid waste volumes. Managed solid waste projections are revised using the latest historical data, resulting in a decrease for that category due to the slowing in growth of waste disposal. Farm waste is now divided in half between open burning and landfilling, whereas previous projections assumed the overwhelming majority was buried. Further, non-municipal landfills (a type of unmanaged landfill) are now estimated from projected activity data rather than extrapolated emissions.

Because the waste sector projections use the same models as *New Zealand's Greenhouse Gas Inventory 1990–2020*,²⁶⁸ other improvements that have occurred in the Inventory since the *Fourth Biennial Report* are included in the models used for projections in the *Eighth National Communication* and *Fifth Biennial Report*. The most significant of these improvements are the changes to farm waste disposal (mentioned above) and also the revisions to composting activity data based on evidence.

²⁶⁷ Ministry for the Environment. 2019. *New Zealand's Fourth Biennial Report Under the United Nations Framework Convention on Climate Change*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/assets/Publications/Files/fourth-biennial-report.pdf (6 October 2022).

²⁶⁸ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020/ (6 October 2022).

More details on these improvements can be found in chapter 10 of the following three versions of *New Zealand's Greenhouse Gas Inventory* for 1990–2018,²⁶⁹ 1990–2019²⁷⁰ and 1990–2020.²⁷¹

5.5.7 Tokelau

This is the second biennial report to include emission projections for Tokelau. On 13 November 2017 New Zealand extended its ratification of the UNFCCC and the Paris Agreement to include Tokelau. Emissions estimates for Tokelau have been included in *New Zealand's Greenhouse Gas Inventory* since 2019.

Including and refining Tokelau's emissions calculations for New Zealand's biennial reporting is a gradual process. As with inventory reporting, this requires building expert capacity in the various small government departments and organisations in Tokelau that participate in decision-making, data collection and processing.

Between 1990 and 2020, Tokelau's total emissions increased by 31.9 per cent, from 3.17 kt CO₂-e to 4.18 kt CO₂-e. The main contributors to this increase were domestic navigation and electricity generation. The changes in domestic navigation are a result of Tokelau gaining ownership and use of the ferry *Mataliki* in 2016, cargo vessel *Kalopaga* in 2018 and *Fetu o te Moana* in 2019, leading to an increasing number of sea voyages between the atolls, which increased transport emissions.

Further changes in Tokelau's energy sector emissions are a significant rise and then drop (by nearly 400 per cent and 82.5 per cent respectively) in consumption of imported petroleum products used for electricity production in Tokelau. The main driver underpinning this reported change was switching to a 100 per cent solar photovoltaics energy system by the end of 2012; a significant drop (nearly 82 per cent) in consumption of imported petroleum products for electricity production resulted.

Emissions of perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride are not occurring in Tokelau.

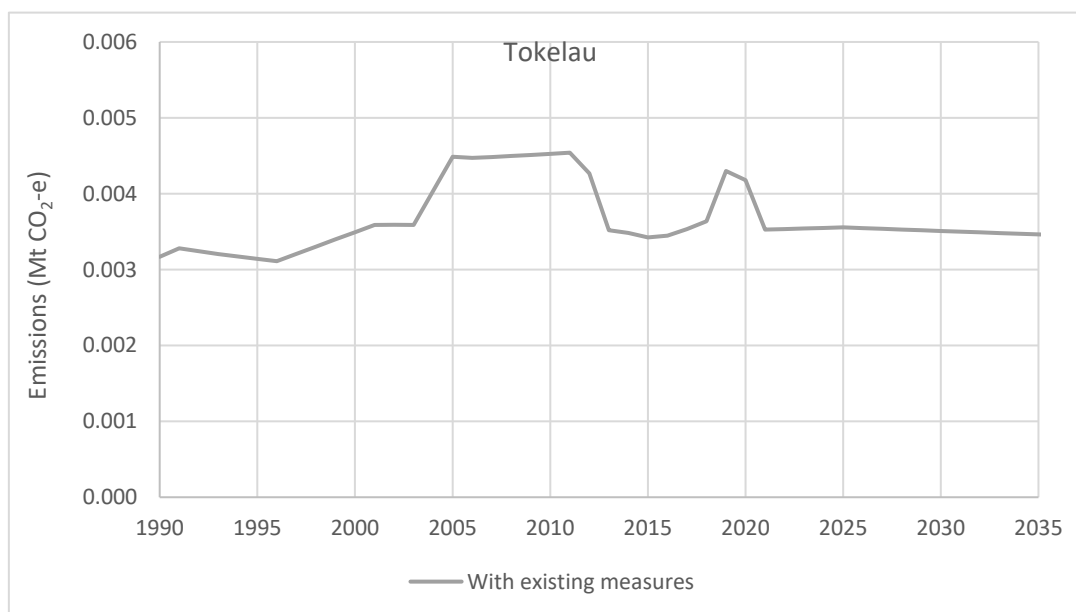
In 2030 total emissions from Tokelau are projected to be 3.51 kt CO₂-e, and in 2035, 3.46 kt CO₂-e. Table 5.28 and figure 5.9 present historical and projected emissions for Tokelau.

²⁶⁹ Ministry for the Environment. 2020. *New Zealand's Greenhouse Gas Inventory 1990–2018*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2018/ (6 October 2022).

²⁷⁰ Ministry for the Environment. 2021. *New Zealand's Greenhouse Gas Inventory 1990–2019*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2019/ (6 October 2022).

²⁷¹ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020/ (6 October 2022).

Figure 5.9: Tokelau’s greenhouse gas emissions for the ‘with existing measures’ scenario, 1990–2035



Note: Mt CO₂-e = megatonnes of carbon dioxide equivalent. Tokelau does not have WOM and WAM scenarios.

Table 5.28: Tokelau’s gross greenhouse gas emissions by gas, 1990–2035 (kt CO₂-e)

Gas	Historical							Projected		
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
CO ₂	1.30	1.38	1.45	2.45	2.52	1.63	2.42	2.42	2.00	2.17
CH ₄	1.78	1.69	1.95	1.93	1.81	1.53	1.48	1.28	1.15	1.01
N ₂ O	0.09	0.07	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.04
HFCs	0.00	0.01	0.03	0.08	0.15	0.22	0.23	0.23	0.23	0.23
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF ₆	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	3.17	3.14	3.49	4.49	4.52	3.42	4.18	3.56	3.51	3.46

Note: CH₄ = methane; CO₂ = carbon dioxide; HFCs = hydrofluorocarbons; kt CO₂-e = kilotonnes of carbon dioxide equivalent; N₂O = nitrous oxide; NO = not occurring; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride. Gross emissions exclude net removals from the land use, land-use change and forestry sector, which, however, are minimal in Tokelau.

Methodology

Tokelau’s emissions were projected using a hybrid of a top-down and bottom-up approach. The emissions estimates for Tokelau are as prepared for the October 2020 projections round. This includes no change to the assumptions used since October 2020, and the projections are based off the 2020 Inventory (data 1990–2018). There has been an update to reflect the 2022 Inventory (data 1990–2020); however, the update only changes years 2019 and 2020.

Differences from the *Fourth Biennial Report*

The most significant change to the projections methodologies for calculating emissions from Tokelau since the *Fourth Biennial Report* has been the shift from a purely top-down approach to a hybrid of a top-down and bottom-up approach. The projections methodology now includes the use of time series activity data and sector-specific assumptions, rather than the previous solely linear interpolation based on Tokelau’s historical greenhouse gas emissions.

6 Vulnerability assessment, climate change impacts and adaptation measures

Key developments since the *Seventh National Communication*

- The Climate Change Adaptation Technical Working Group completed a stocktake on adaptation action and provided recommendations for adapting to climate change in New Zealand.
- The Government amended New Zealand’s primary climate change legislation by adding adaptation to the purpose of the Climate Change Response Act 2002. The 2019 Amendment also set out in the legislation the process for assessing climate risk, developing action plans, and monitoring the implementation and effectiveness of those plans.
- The Government committed to reforming the Resource Management Act 1991, which includes an objective to better prepare for adapting to climate change and risks from natural hazards.
- New Zealand published the first National Climate Change Risk Assessment in 2020. This identifies the most urgent risks New Zealand faces from climate change to 2026.
- New Zealand’s first national adaptation plan was published in 2022. This sets out New Zealand’s long-term adaptation strategy and the actions that will be taken up to 2028 to address climate risks.
- This chapter also serves as New Zealand’s second Adaptation Communication under the Paris Agreement. The chapter has been prepared using the national communication guidelines, drawing on section IV of the biennial transparency report guidelines, where appropriate.

6.1 Introduction

A low population density, long coastline, varied landscape and an economy reliant on the natural environment make Aotearoa New Zealand vulnerable to risks associated with extreme weather, sea-level rise and shifts in climatic conditions.

Climate change will increase the severity and frequency of hazards such as flooding, heatwaves, drought and wildfire. The country will also face new risks because of slow-onset, gradual changes such as sea-level rise, ocean warming, more hot days, and more rainfall in some parts of the country and less in others.

This chapter outlines the expected impacts of climate change on New Zealand and the extent of adaptation action being taken. It provides updated information on the impacts of climate change and the resulting risks New Zealand faces. It also discusses adaptation plans, policies and strategies that address the most urgent climate risks.

Since the *Seventh National Communication* was published in 2017, New Zealand has taken significant steps to build climate resilience. This has been the result of including the need to prepare for, and adapt to, the effects of climate change in primary legislation, the Climate Change Response (Zero Carbon) Amendment Act 2019.

6.2 National circumstances, institutional arrangements and legal frameworks

Chapter 1 of this report outlines the national circumstances that may affect the adaptive capacity of Aotearoa New Zealand's natural and human systems. Essential points are repeated here.

- New Zealand is a long, narrow and mountainous country, consisting of two large islands and several smaller islands. It has nearly 15,000 kilometres of coastline, and its Exclusive Economic Zone is the fourth largest in the world.
- New Zealand's population was 5.1 million at 30 June 2021, and 76.6 per cent of people live in the North Island. New Zealand's population density is relatively low, with an average of 19 people per square kilometre.
- New Zealand has a varied climate, with zones ranging from subtropical to subantarctic. The climate is influenced by New Zealand's location in a latitudinal zone with prevailing westerly winds and the surrounding ocean. New Zealand is already experiencing changes in climate due to climate change, with an increase in average annual temperature of 1.1°C over the past 100 years.
- New Zealand is founded on a partnership between the Crown and indigenous New Zealanders, Māori, through Te Tiriti o Waitangi (the Treaty of Waitangi) signed in 1840. Certain Māori groups will be disproportionately affected by climate change as will Māori interests, values, practices and wellbeing. Many Māori communities are located in rural and remote locations, and are particularly vulnerable to the effects of climate change.
- New Zealand has an export-dependent economy operating on free market principles. The primary sector (agricultural, horticultural, forestry, mining and fishing industries) plays a fundamental role in the export sector and in employment. In the year ending March 2022, dairy products were the largest export earner, accounting for 23 per cent of exports at NZ\$18.3 billion.
- Before 2021, international tourism was a significant export earner for New Zealand, compared with other traditional primary sector exports. In 2019, international tourism expenditure was NZ\$17.2 billion. Due to border restrictions put in place in response to the COVID-19 pandemic, this number has dropped significantly. In 2021, the provisional international tourism expenditure was NZ\$1.5 billion.
- Most of New Zealand's electricity generation comes from renewable sources. In 2021, hydro generation provided 55.5 per cent of New Zealand's electricity. A further 18.4 per cent came from geothermal, 6.0 per cent from wind, 1.1 per cent from wood, 0.6 per cent from biogas and 0.5 per cent from solar. The remaining 17.9 per cent was provided by fossil fuel thermal generation plants using gas, coal and oil.
- International aviation and shipping are critical, due to New Zealand's isolated location in the Pacific Ocean and the importance of primary industry exports and tourism to the economy. Domestically, road transport is the central element of New Zealand's transport system, reflecting the country's small but widely distributed population and long, narrow geography.

6.2.1 Main legal and policy frameworks for adaptation

Climate adaptation legislation

The most adaptation-relevant domestic legislation in Aotearoa New Zealand is the Climate Change Response Act 2002. The 2019 Climate Change Response (Zero Carbon) Amendment Act includes the need to prepare for, and adapt to, the effects of climate change in its purpose.

New provisions in the Climate Change Response Act outline the process for regularly assessing the risks from climate change, taking action to manage those risks, assessing implementation and evaluating the effectiveness of the actions in reducing risk. This included provision for a climate change commission (the Commission) to:

- provide independent, expert advice to the Government on reducing emissions and adapting to the impacts of climate change
- monitor and review the Government's progress towards its emissions reduction and adaptation goals.

The Commission was established in 2019.

National climate change risk assessments

The Climate Change Response Act 2002 requires the preparation of national climate change risk assessments (the risk assessment) every six years. Each risk assessment must:

- assess climate risks to the economy and financial system, society, and the natural and built environments
- identify the most significant risks to New Zealand, based on their nature, severity and the need for a coordinated response.

The first risk assessment was published in 2020 and was produced by the Government because the Commission was yet to be formally established. Subsequent risk assessments will be produced by the Commission. The next is due by August 2026.

National adaptation plan

A national adaptation plan must be prepared in response to the latest risk assessment. The plan must set out:

- the Government's objectives for adapting to the effects of climate change
- the strategies, policies and proposals for meeting those objectives and timeframes for implementing them
- how the objectives, strategies, policies and proposals will address the most significant risks
- measures and indicators to enable regular monitoring on implementation.

The first national adaptation plan was published in August 2022, and the second is due by August 2028.

Progress reports

For each national adaptation plan, the Commission must report every two years on its implementation and effectiveness in reducing the risks. The first report is due August 2024. The Government must respond to the Commission's report within six months of receiving it.

Power to request information on adaptation preparedness

The Climate Change Response Act 2002 also allows the Government and the Commission to request information on how prepared policy and service delivery organisations are for the impacts of climate change. Results from the first request, sent in 2020, established a baseline against which future results may give an indication of the effectiveness of the national adaptation plan in supporting organisations to reduce risks from climate change.

Other legislation and instruments

Local government, comprising of local and regional councils, has statutory responsibilities to avoid or mitigate natural hazards and to have regard to the effects of climate change when making certain decisions. It is also responsible for civil defence and emergency management and improving community resilience through public education and local planning. Local government functions and duties relating to natural hazards include:

- land-use planning under the Resource Management Act 1991, including national direction
- civil defence, as outlined in the Civil Defence Emergency Management Act 2002 and civil defence emergency management group plans
- asset management based on the Soil Conservation and Rivers Control Act 1941 and councils' long-term plans and infrastructure strategies developed under the Local Government Act 2002
- building regulation based on the Building Act 2004
- disclosure of hazard information, as required by the Local Government Official Information and Meetings Act 1987.

Examples of institutional arrangements for adaptation

All New Zealanders have a role to play in adapting to the impacts of climate change:

- Central government establishes regulatory and institutional settings that support effective adaptation. They also facilitate the availability of information and data for good risk-informed decision-making.
- Local government is at the centre of risk management planning and response because most hazard events occur at the local or regional scale. Māori play a unique role in adaptation as Tiriti partners, tangata whenua (people of the land) and kaitiaki (guardians).
- Businesses need to strengthen their resilience to climate risks, including risks to their assets.
- The research and scientific community can also contribute to adaptation because adaptation decisions must be based on the best available science.

Table 6.1 outlines key examples of institutional arrangements in Aotearoa New Zealand that support adaptation.

Table 6.1: Key institutional arrangements for adaptation in Aotearoa New Zealand

Role	Institutional arrangement
Assessing climate impacts	National Institute of Water and Atmospheric Research (NIWA) monitors water and weather patterns. It provides climate services, resources for understanding climate and climate change, and conducts research on a range of climate variables.
Climate change at sector level	One of the four priorities of the legislatively mandated national adaptation plan is to embed climate resilience in all government strategies and policies. Chapters 6–10 of the plan set out actions and future work programmes across five sectors, to support climate resilience across the natural environment (chapter 6), the built environment (chapters 7 and 8), the economy and primary industries (chapter 10) and health and communities (chapter 9).
Decision-making	Aotearoa New Zealand has a Minister of Climate Change. The Minister’s responsibilities include overall climate change policy direction and New Zealand’s climate change adaptation response. The Ministry for the Environment provides the administrative support for this portfolio.
Coordination, addressing cross-cutting issues, adjusting priorities and activities	Climate change is a cross-cutting issue of relevance to almost all government agencies. This is reflected in the recent set up of the Climate Change Chief Executives Board (the Board) that oversees both the emissions reduction plan and national adaptation plan. The Climate Response Ministerial Group oversees the national adaptation plan and its progress. The Board is responsible for overseeing overall implementation of the national adaptation plan, periodically assessing its sufficiency, and advising where course corrections are needed. This includes adjustment of priorities and activities.
Planning and coordination	The New Zealand Government directs adaptation work at the local and regional level through the Resource Management Act 1991 and Local Government Act 2002. As of November 2022, councils will be required to have regard to the national adaptation plan when making or changing policy statements or plans.
Data governance	Statistics about Aotearoa New Zealand’s atmosphere and climate come from the Environmental Reporting Series, which is produced by Stats NZ and the Ministry for the Environment. Twenty atmosphere and climate indicators support the reports with technical information and interactive maps and graphs. ²⁷²

6.3 Climate modelling, projections and scenarios

6.3.1 Current climate

In the past 100 years, Aotearoa New Zealand’s climate has warmed by 1.1°C. New Zealand is experiencing more hot days and fewer cold days: 2021 was the warmest year on record, surpassing the previous record set in 2016.²⁷³ Higher temperatures change the physical environment and weather patterns, presenting new and greater risks to the wellbeing of people and communities and their ways of life, buildings and infrastructure, the natural environment and economy. Globally, sea-level rise is accelerating, with an average rise rate

²⁷² See www.stats.govt.nz/topics/atmosphere-and-climate for more information.

²⁷³ National Institute of Water and Atmospheric Research. 2022. *Aotearoa New Zealand Climate Summary: 2021*. Wellington: National Institute of Water and Atmospheric Research.

of 3.7 millimetres per year between 2006 and 2018.²⁷⁴ By 2100, median sea level in New Zealand is projected to increase by a further 0.44 metres on average under a low-emissions scenario and 0.83 metres on average under a high-emissions scenario. Under the highest emission scenario, sea level in New Zealand is projected to increase by 1.09 metres on average.²⁷⁵ Since 1960, rainfall has mostly increased in the south and decreased in the north, while changes in extreme rainfall are mixed.²⁷⁶

Other major climate impacts are already occurring throughout New Zealand. These were detailed in the Intergovernmental Panel on Climate Change (IPCC) report *Climate Change 2022: Impacts, Adaptation and Vulnerability*:²⁷⁷

- the frequency, severity and duration of extreme wildfire weather conditions is mixed but has increased in the north-east. An increase has occurred in fire impacts, including lost, damaged, threatened and evacuated homes between 1988–2018
- sea surface temperatures increased by 0.2°C per decade from 1981–2018, with Tasman sea surface temperatures the warmest on record during the summer of 2017/18
- the number of frost days decreased at 12 of 30 sites monitored across New Zealand, while the number of warm days increased at 19 of the 30 sites between 1972–2019, while the number of heatwave days increased at 18 of the 30 sites
- glacier volume has decreased 33 per cent since 1977. In the Southern Alps, from 1978–2016, the area of 14 glaciers declined 21 per cent, and extreme glacier mass loss was at least six times more likely in 2011, and ten times more likely in 2018, due to climate change. The end-of-summer snowline elevation for 50 glaciers rose 300 metres from 1949–2019
- marine species abundance and distributions have shifted poleward, and extensive coral bleaching events and loss of temperate kelp forests have occurred, due to ocean warming and marine heatwaves across the region
- while no clear change is evident in storminess, an overall decrease has occurred in wind speed. Between 1980–2019, the annual maximum wind speed gusts decreased at 11 of the 14 sites that had enough data to calculate a trend and increased at 2 of the sites.

This poses a complex adaptation challenge. People must adapt to both slow-onset changes (such as rising sea levels that threaten coastal ecosystems and infrastructure) and increased frequency and magnitude of extreme events. This includes coastal inundation and flooding that can damage homes, roads and other infrastructure, and affect access to coastal areas.

²⁷⁴ Intergovernmental Panel on Climate Change. 2021. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Intergovernmental Panel on Climate Change.

²⁷⁵ Ministry for the Environment. 2022. *Interim guidance on the use of new sea-level rise projections*. Wellington: Ministry for the Environment.

²⁷⁶ Intergovernmental Panel on Climate Change. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Intergovernmental Panel on Climate Change.

²⁷⁷ Unless otherwise stated, all references for this section come from: The Intergovernmental Panel on Climate Change. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Intergovernmental Panel on Climate Change.

6.3.2 Future climate change

Information on future climate change scenarios for Aotearoa New Zealand is contained in the Ministry for the Environment's 2018 report *Climate Change Projections for New Zealand*.²⁷⁸ These projections are based on the IPCC's *Fifth Assessment Report* (AR5). A further interim report provides information on how the IPCC's *Sixth Assessment Report* (AR6) affects regional projections for New Zealand, however, there is *very high confidence* that projected climate changes for the region have not altered substantially since AR5.²⁷⁹ Work is under way to update NIWA's downscaled climate projections for New Zealand, based on the IPCC's *Sixth Assessment Report*. Specific guidance on how to adapt to coastal hazards is contained in the Ministry for the Environment's 2017 report *Coastal Hazards and Climate Change*,²⁸⁰ with updates to this guidance outlined in the 2022 *Interim guidance on the use of new sea-level rise projections*.²⁸¹

Three main sources of uncertainty exist for projected climate change: emission scenarios, regional climate responses, and random climate variability, highlighting the importance of future adaptation. Several observed impacts in New Zealand have already been directly attributed to climate change, with further climate change and the associated impacts inevitable.²⁸² Preliminary projections based on CMIP6 models are described in the IPCC Working Group I (WGI) contribution to AR6. For New Zealand, the CMIP6 projections are broadly similar to CMIP5, as reported in AR5. In general, the CMIP6 models indicate greater warming, a smaller increase in summer precipitation, and a larger increase in winter precipitation. Other significant differences are reported in the Aotearoa New Zealand climate change projections guidance.²⁸³

For more information about projected changes in climate, see chapter 2, section 2.3.2. Figure 6.1 summarises the projected impacts of climate change in New Zealand. Essential points are:

- By 2040, projected warming in New Zealand is 0.2°C to 1.3°C (low emissions: Representative Concentration Pathway (RCP)2.6) to 0.5°C to 1.7°C (high emissions: RCP8.5) in relation to the 1995 baseline, with more extremely high temperatures and fewer extremely low temperatures.

²⁷⁸ Ministry for the Environment. 2018. *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment, 2nd Edition*. Wellington: Ministry for the Environment.

²⁷⁹ Bodeker G, Cullen N, Katurji M, McDonald A, Morgenstern O, Noone D, Renwick J, Revell L, Tait A. 2022. *Aotearoa New Zealand climate change projections guidance: Interpreting the latest IPCC WG1 report findings*. Report number CR 501. Prepared for the Ministry for the Environment by Bodeker Scientific Ltd, National Institute for Water and Atmospheric Research, University of Auckland, University of Canterbury, University of Otago and Victoria University of Wellington. Wellington: Ministry for the Environment.

²⁸⁰ Ministry for the Environment. 2017. *Coastal Hazards and Climate Change: Guidance for Local Government*. Wellington: Ministry for the Environment.

²⁸¹ Ministry for the Environment. 2022. *Interim guidance on the use of new sea-level rise projections*. Wellington: Ministry for the Environment.

²⁸² Lawrence J, Mackey B, Chiew F, Costello MJ, Hennessy K, Lansbury N, Nidumolu UB, Pecl G, Rickards L, Tapper N, Woodward A, Wreford A. 2022: Australasia. In: Intergovernmental Panel on Climate Change. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Intergovernmental Panel on Climate Change.

²⁸³ Bodeker G, Cullen N, Katurji M, McDonald A, Morgenstern O, Noone D, Renwick J, Revell L, Tait A. 2022. *Aotearoa New Zealand climate change projections guidance: Interpreting the latest IPCC WG1 report findings*. Report number CR 501. Prepared for the Ministry for the Environment by Bodeker Scientific Ltd, National Institute for Water and Atmospheric Research, University of Auckland, University of Canterbury, University of Otago and Victoria University of Wellington. Wellington: Ministry for the Environment.

- Spring and winter rainfall is projected to increase in the west of the North Island and South Island and decrease in the east and north. Summer rainfall is projected to increase in the east of the North Island and South Island and decrease in the west and central North Island.
- Overall, more droughts and extreme fire weather are projected over most of New Zealand.
- By 2090, a decrease in cold nights (minimum temperature of 0°C or lower) of 30 per cent (RCP2.6) to 90 per cent (RCP8.5) is projected for New Zealand. In contrast, the number of hot days (maximum temperature of 25°C or higher) is projected to increase by 40 per cent (RCP2.6) to 300 per cent (RCP8.5).²⁸⁴
- The number of snow days is projected to decrease. Under RCP8.5, snow days per year are projected to decrease by 30 days or more by 2090.²⁸⁵
- Relative to 2015, New Zealand glaciers are projected to lose 36 per cent, 53 per cent and 77 per cent of their mass by 2100 under RCP2.6, RCP4.5 and RCP8.5, respectively.
- On average, sea level in New Zealand is projected to rise between 23 centimetres (2050, RCP2.6) to 67 centimetres (RCP8.5).²⁸⁶ In many parts of New Zealand (eg, Auckland, Hawke's Bay, Wairarapa, Wellington, Nelson and Marlborough) rates of subsidence are between 2 millimetres to 6 millimetres per year, which is up to two times the global rate of sea-level rise, increasing the impacts of local sea-level rise.

The IPCC report *Climate Change 2022: Impacts, Adaptation and Vulnerability* identified key climate risks that have the potential to be severe, such as:

- Loss of natural ecosystems and species due to invasive species. A reduction of indigenous species' dominance in ecosystems, increase in vulnerable species from predation, competition and mortality could lead to endangerment and extinction. See table 11.5 in chapter 11, section 11.3.1.
- Coastal flooding, affecting built and natural environments, is projected to become more frequent before mid-century with only modest rises in sea level. This will especially affect Māori communities, where many Māori-owned lands and cultural assets are located on coastal lowlands vulnerable to the impacts of sea-level rise. See box 11.4 and box 11.5 in chapter 11, section 11.3.5.
- Estimates suggest 3°C global warming could reduce gross domestic product by 0.8 per cent per year in New Zealand.
- Reduced snow storage over the winter period will influence the seasonality of snow melt and river flow.²⁸⁷

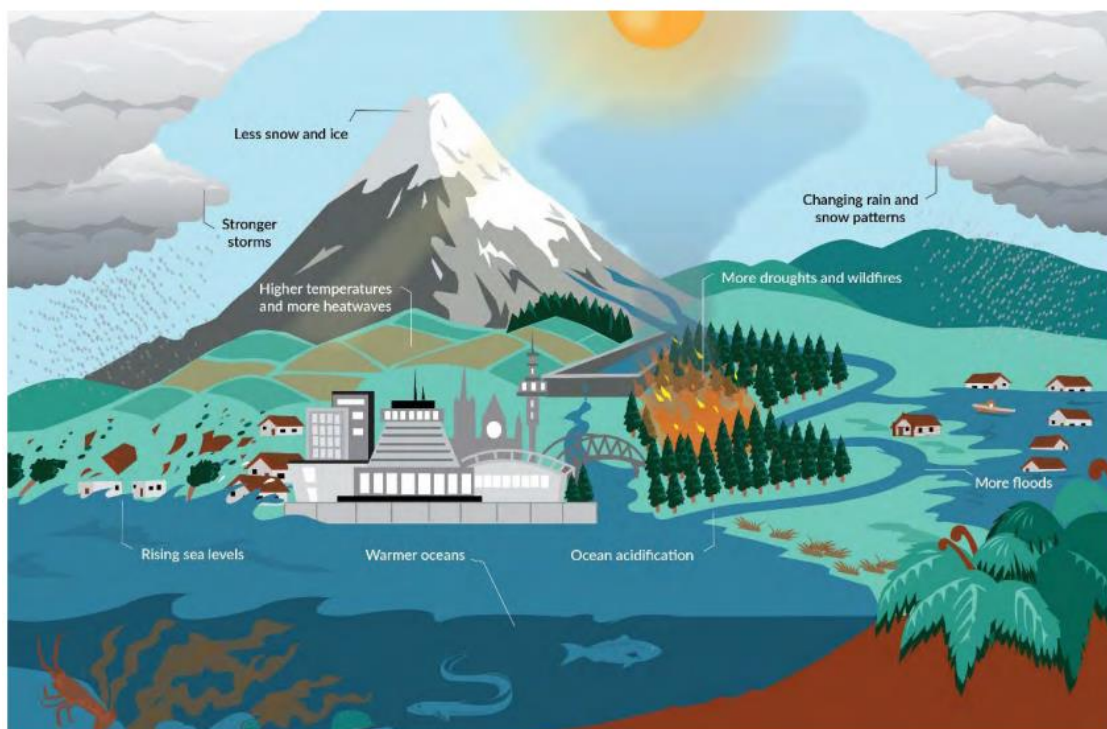
²⁸⁴ Ministry for the Environment. 2018. *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment, 2nd Edition*. Wellington: Ministry for the Environment.

²⁸⁵ Ibid.

²⁸⁶ Intergovernmental Panel on Climate Change. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Intergovernmental Panel on Climate Change.

²⁸⁷ Ministry for the Environment. 2018. *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment, 2nd Edition*. Wellington: Ministry for the Environment.

Figure 6.1: Summary of projected impacts of climate change on Aotearoa New Zealand²⁸⁸



NZ SeaRise released updated downscaled projections for sea-level rise in New Zealand at 2-kilometre resolution.²⁸⁹ These projections take into account vertical land movement, which has a direct impact on local sea level variability on New Zealand’s coastlines. New Zealand lies on a dynamic plate boundary, and so it is vital to provide projections that combine subsidence and uplift rates at the coast with the climatic drivers of sea-level rise, to either amplify or reduce its rate and magnitude.

6.4 Climate change impacts

This section summarises the observed and potential future impacts of climate change in Aotearoa New Zealand (see figure 6.1). The information is sourced from the document *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (WGII) and references therein, unless otherwise stated.²⁹⁰

²⁸⁸ Ministry for the Environment. 2022. *Urutau, ka taurikura: kia tū pakari a Aotearoa I ngā huringa āhuarangi. Adapt and thrive: Building a climate-resilient New Zealand*. Page 22.

²⁸⁹ See [NZ SeaRise Programme](#) for further information.

²⁹⁰ Intergovernmental Panel on Climate Change. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Intergovernmental Panel on Climate Change.

6.4.1 Natural environment

Observed impacts

Changes to the structure, composition and services of terrestrial ecosystems have been observed. Introduced mammalian predators have experienced population irruptions due to increased food availability, related to increasing temperatures. Invasive predators are placing increasing pressure on native forest species and habitat reduction is occurring due to erosion from rising sea levels and storms.

The distribution of various coastal species has changed due to warming, and alterations in life history characteristics have been observed in some fish species. Subantarctic ocean acidity has increased 8.6 per cent over the past 20 years.²⁹¹

Rainfall patterns have changed across temporal and spatial scales, with a general decrease in the northern part of Aotearoa New Zealand but an increase in the southwest. The intensity of extreme rainfall events has increased. Southern glaciers have reduced in size by one-third since 1977.

Projected impacts

Due to warming, terrestrial invasive species are expected to increase in numbers, expand their geographic range, and increase predation on native species. Changes will occur to carbon storage in native forests, improving short term but decreasing in the medium term due to drought. Wildfires are predicted to result in introduced fire-resistant plants replacing non-fire resistant native species.

Increased rainfall, drought and temperatures will likely negatively affect freshwater wetlands and species, and saltwater may intrude into coastal wetlands. River flows are projected to be reduced in the north and east of the North Island, but to increase in the west and south of the South Island. Extreme floods may enable increased movement of invasive species, sediments and nutrients, and toxic chemicals in rivers.

Rising sea levels, continued warming and extreme weather events are expected to further change marine species' distribution, abundance and ecosystem services. Intertidal zones will shrink due to sea-level rise. The future productivity and sustainability of fisheries is dependent on how marine ecosystems are affected. Net primary productivity in New Zealand waters is predicted to decline, with subantarctic waters most affected.

6.4.2 Primary industries

Observed impacts

Droughts have had negative impacts across agricultural sectors. For example, extreme heat is detrimental to livestock welfare, and can reduce growth and reproduction rates, as well as causing death. Pasture production is changing in response to climate-related factors.

Evidence of climate change impacts on crops and forest growth patterns is still limited. For example, a decreased winter chill has contributed to both an early harvest for the kiwifruit industry and elevated energy (refrigeration) demands.

²⁹¹ www.stats.govt.nz/indicators/ocean-acidification/

Climate change has resulted in habitat loss and distribution shifts for fisheries species. Aquaculture (eg, farmed salmon) experienced significant losses during a heatwave.

Projected impacts

Warmer temperatures and extreme weather events will have negative impacts on livestock productivity and welfare. Pasture growth rates may be affected more in terms of seasonality than yield. Land may suffer increased erosion due to heavy precipitation events.

Changing temperature and rainfall patterns may increase winter yields of some crops but reduce the yield of others reliant on winter chill. An overall decline in crop yield and quality is expected with rising temperatures. Higher carbon dioxide is anticipated to contribute to increased productivity of pine (*Pinus radiata*) plantations, though with accompanying increased wind damage. Risks to New Zealand's carbon offsetting and removal strategies are posed by drought, fire, heavy rainfall, soil erosion and pests. Changes will occur to distributions and new incursions of invasive pests and diseases. Beneficial insects may be negatively affected by climate change.

Shellfish are expected to be the fishery most vulnerable to climate change stressors because they are sessile and shell formation is vulnerable to ocean acidification. For other species, those living in temperate and demersal zones are likely to be more affected by climate change, compared with those living in pelagic systems. The aquaculture industry will likely be able to reduce exposure to changing climatic conditions more easily than wild fisheries.

6.4.3 Built environment

Observed impacts

Gradual changes to the climate and extreme weather events are having increasing effects on human settlements and critical infrastructure. For example, sea-level rise poses a risk to many urban services, such as roads, railways, seaports, airports and water infrastructure.

Existing vulnerabilities to disruption and disaster (eg, poor infrastructure quality, social disadvantage, poor health and social support) are intensified by the impacts of climate change. Climate change-related flood damage was almost 30 per cent (NZ\$140.48 million) of the total insured losses in the 12 costliest floods in the decade to 2017.

Energy assets are exposed to sea-level rise and extreme weather events (eg, storms, floods, droughts, fire), and outages can result. Hydro-electricity generation is vulnerable to low rainfall; and high temperatures place other strains on these systems.

Projected impacts

Cities, other settlements, and infrastructure are expected to experience increasing detrimental effects due to climate change, including events such as heavy rainfall, storms, heat waves, fires and droughts. An estimated NZ\$25.5 billion of assets will be exposed to a 1 metre sea-level rise. By 2050, infrastructure (eg, transport, water, electricity, landfills) close to the coast or rivers will be at increased risk. Flow-on effects to community wellbeing may then emerge, with the impacts not experienced equitably across groups of people.

Electricity heating demands are predicted to decrease slightly, due to higher temperatures and improved energy efficiency. Hydro-electricity vulnerability may decrease due to increased hydro lake inflows but this will be countered by more supply disruptions as reliance on electricity grows. Inequity exists in household vulnerability to energy sector risks. This is attributed to differing health needs and housing quality.

6.4.4 Economic sectors

Observed impacts

The reliance of the tourism sector on natural attractions and outdoor activities means climate change is already affecting tourism. For example, the Fox Glacier and Franz Josef Glacier have retreated (around 700 metres since 2008), and heavy rainfall caused damage to the Great Walks closing some.²⁹² Further, travellers are likely to be increasingly reluctant to undertake long-haul flights due to 'flygskam' or 'flight shame'.

Climate change poses significant risks to the financial sector, for example, insured losses due to extreme weather events (almost NZ\$1 billion between 2013 and 2020, 0.4 per cent of gross domestic product).

Projected impacts

Climate change is likely to have widespread negative effects on tourism. For example, a further decrease is anticipated in the volume of the South Island glaciers, and snow skiing will be negatively affected.

The finance sector will also be exposed to increased risks. Factors such as flooding, fire and soil damage will contribute to decreases in property values, increases in insurance costs and challenges in servicing loans. The value of buildings exposed to coastal inundation could increase by NZ\$2.55 billion for every 0.1 metre increment in sea level. Greater understanding is required of distributional impacts, the rate of change of costs over time, and the economic implications of delayed action.

6.4.5 Health and communities

Observed impacts

Severe weather events are linked to negative health impacts. For example, reduced mental health is associated with high temperatures. An increase in the incidence of diseases, such as dengue fever, arriving in Aotearoa New Zealand has been observed (although without local transmission).

Rural communities, including many Māori communities located in rural and remote locations, are particularly vulnerable to the impacts of climate change due to road closures and power cuts. Sites of cultural significance, including marae²⁹³ and urupā (burial grounds), are also vulnerable. These communities may experience cumulative impacts of climate change,

²⁹² Great Walks are premier walking tracks in Aotearoa New Zealand that traverse a range of landscapes. For more information, see www.doc.govt.nz/great-walks.

²⁹³ Courtyard: the open area in front of the wharenuī (meeting house) where formal greetings and discussions take place. Often also used to include the complex of buildings around the marae.

particularly those relying on one sector, for example, tourism or agriculture, as the primary economic generator. The mental health of members of farming and rural communities can be affected by the disruptions to livelihoods and loss of social cohesion.

Droughts, flooding events and extreme wind conditions can cause animal welfare, financial and emotional stress for rural communities and households. The increasing occurrence of adverse weather events affects the financial and social resilience of primary producers and the welfare and wellbeing of their families and broader communities, which depend on a strong and robust primary sector.

Health inequities are already present in the Māori population. Māori are invested in many sectors vulnerable to climate change, such as fishing, forestry, agriculture, renewable energy and tourism. A large amount of Māori-owned land suffers from erosion.

Projected impacts

Negative effects on human health are expected to result from altered rainfall, floods, heat stress, air pollution and diseases. For example, increases may occur in allergies, drinking water contamination and toxic freshwater blooms. Socio-economic status will influence the vulnerability of people to these effects.

Health inequities are projected to increase due to climate change. Further risks to Māori wellbeing and cultural identity are posed by negative impacts to culturally significant fauna and flora. Sea-level rise will affect coastal and low-lying Māori land, posing risks to marae and urupā. Climate change may jeopardise the ability of governments to uphold Māori interests under Te Tiriti o Waitangi.

6.5 Assessment of risks and vulnerability to climate change

This section provides updated information on and methods to identify significant economic, social and/or environmental vulnerabilities or risks related to current and expected climate change impacts.

6.5.1 Arotakenga Huringa Āhuarangi: A Framework for the National Climate Change Risk Assessment for Aotearoa New Zealand

In 2019, the Government published a framework to support a consistent approach to defining and assessing risks from climate change at local, regional and national levels.²⁹⁴

The framework provides the means to evaluate risks and opportunities from climate change in terms of their nature, severity and urgency using a variety of information sources. It includes:

- a three-stage approach to assessing and comparing risks
- templates to be used in completing the various steps of the assessment
- guidance materials to help users in following the methodology.

²⁹⁴ Ministry for the Environment. 2019. *Arotakenga Huringa Āhuarangi: A Framework for the National Climate Change Risk Assessment for Aotearoa New Zealand*. Wellington: Ministry for the Environment.

The framework is consistent with internationally applied risk assessment elements. It also places greater emphasis on engagement (including co-produced elicitation processes, eg, ‘risk workshops’) and the framework’s principles. Processes for engagement and evaluation are considered at every step.

6.5.2 National Climate Change Risk Assessment

The National Climate Change Risk Assessment 2020 (NCCRA) provides a national overview of how Aotearoa New Zealand may be affected by climate-related hazards.²⁹⁵ The risk assessment:

- identifies main climate risks and opportunities that New Zealand can expect to face to 2026
- highlights information gaps
- helps identify where the Government needs to focus its action.

The risk assessment was undertaken over three stages and is summarised in table 6.2.

Table 6.2: Three stages of the National Climate Change Risk Assessment 2020

Stage	Objectives	Output
Stage 1: First-pass risk screen	High-level consideration of climate change risks to Aotearoa New Zealand. Determine national risks to consider in Stage 2.	A set of priority national climate change risks (rated extreme and major in the Stage 1 risk screen) for detailed assessment in Stage 2. Documented in an interim report.
Stage 2: Detailed risk assessment	Examine risks rated extreme and major. Prioritise risks to consider in a national adaptation plan (NAP).	More detailed assessment of risks to inform the NAP. Identify the 10 most urgent risks, documented in this main report.
Stage 3: Adaptation and decision urgency	Assess current and planned adaptation to identify risks needing the most urgent action.	Contribute to prioritising the 10 most urgent risks to consider in the NAP. Documented in this main report.

Forty-three priority risks across five domains

Based on stage 1 (first-pass risk screen), the risk assessment identified 43 priority risks New Zealand will face from climate change to 2026. For each risk, the consequence, urgency ratings and research priorities were defined. The urgency ratings were determined based on exposure to climate impacts, the capacity to adapt and sensitivity to climate change.

The 43 risks were grouped according to five value domains: human, natural environment, economy, built environment and governance. The two most urgent risks in each domain are defined as the 10 most significant risks (see figure 6.2).

²⁹⁵ Ministry for the Environment. 2020. *National Climate Change Risk Assessment for Aotearoa New Zealand: Main report – Arotakenga Tūraru mō te Huringa Āhuarangi o Āotearoa: Pūrongo whakatōpū*. Wellington: Ministry for the Environment.

Stage 2 (detailed risk assessment) and stage 3 (adaptation and decision urgency assessment) of the risk assessment involved a qualitative analysis of exposure and vulnerability, to inform the urgency scores for risks. Descriptions of exposure, vulnerability, consequence, adaptation and strength of evidence for each risk are provided in a supplementary technical report, which provides the evidence base for the assessment findings.²⁹⁶

Risk to Māori

The 43 risks disproportionately affect certain Māori groups and interests, values, practices and wellbeing. Mātauranga Māori²⁹⁷ will be critical for a greater understanding of the risks and for future planning.

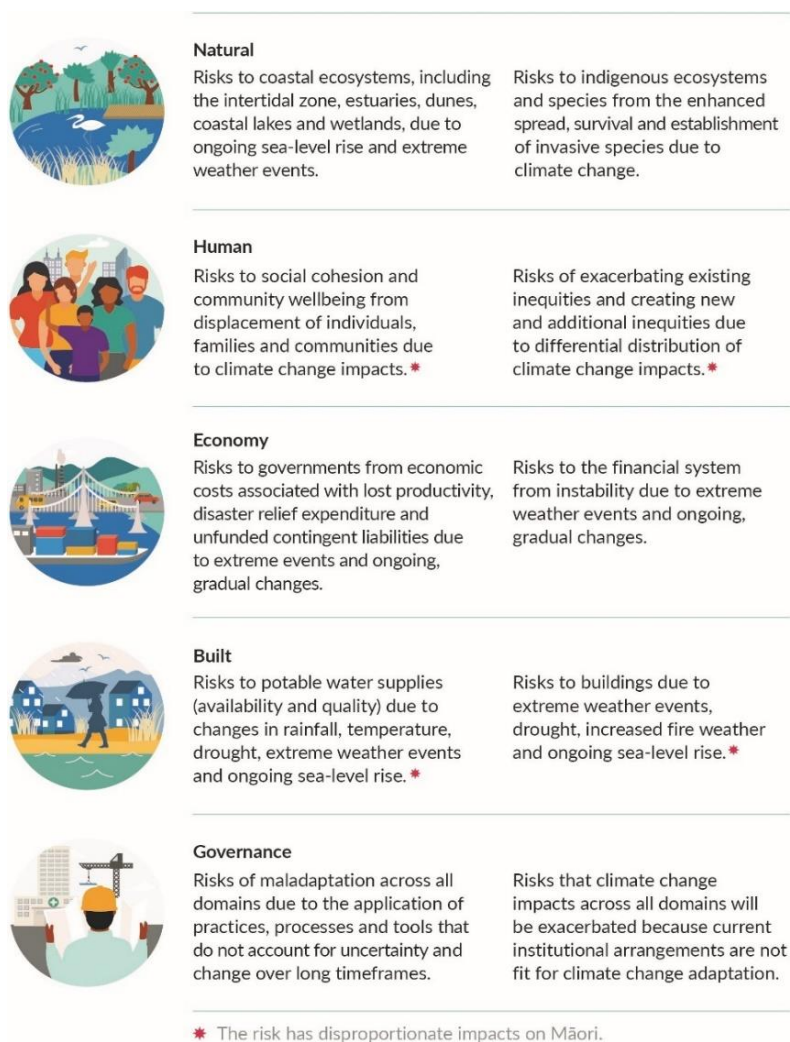
Of particular significance to Māori are risks to social, cultural, spiritual and economic wellbeing from loss and degradation of lands and waters, and from loss of species and biodiversity. Other risks include those to social cohesion and community wellbeing from displacement of individuals, families and communities and risks of exacerbating and creating inequities due to the unequal impacts of climate change.

Māori consulted as part of the risk assessment emphasised that recognising interdependencies is fundamental to exploring climate risks from a Māori point of view. Adaptation actions developed in response to the risks will need to recognise the interconnections and be coordinated across risks.

²⁹⁶ Ministry for the Environment. 2020. *National Climate Change Risk Assessment for New Zealand – Arotakenga Tūraru mō te Huringa Āhuarangi o Aotearoa: Technical report – Pūrongo whaihanga*. Wellington: Ministry for the Environment.

²⁹⁷ Māori knowledge systems and worldviews, including traditional concepts.

Figure 6.2: Ten most significant risks Aotearoa New Zealand will face from climate change, 2020–26, by domain²⁹⁸



6.5.3 Local government risk assessments

Alongside the risk assessment, the Government produced guidance for local government organisations to follow when conducting their own local climate risk assessments.²⁹⁹ The guidance is broadly consistent with the risk assessment. It sets out a step-by-step process to carry out local risk assessments and provides resources and sample templates for practical use.

This guidance complements additional guidance for local government on managing coastal hazards and climate change.³⁰⁰ To reflect the latest science, this coastal hazard guidance was updated in 2022.³⁰¹ The update includes the IPCC’s latest sea-level rise scenarios and accounts for localised vertical land movement from tectonic uplift.

²⁹⁸ This figure is taken from the national adaptation plan, figure 6, page 37.

²⁹⁹ Ministry for the Environment. 2021. *He kupu ārahi mō te aromatawai tūraru huringa āhuarangi ā-rohe / A guide to local climate change risk assessments*. Wellington: Ministry for the Environment.

³⁰⁰ Bell R, Lawrence J, Allan S, Blackett P, Stephens S. 2017. *Coastal Hazards and Climate Change: Guidance for Local Government*. Wellington: Ministry for the Environment.

³⁰¹ Ministry for the Environment. 2022. *Interim guidance on the use of new sea-level rise projections*. Wellington: Ministry for the Environment.

6.5.4 Sector-level risk assessments

An information request made under the Climate Change Response Act 2002 identified that 58 per cent of organisations with policy or service delivery functions have carried out some form of climate vulnerability assessment. Of these organisations, 14 per cent consider that vulnerability is well understood and integrated into decision-making processes.³⁰²

Climate vulnerability assessments are more frequent amongst lifeline utilities than other types of reporting organisations. Eighty-two per cent of lifeline utilities have carried out some form of vulnerability assessment. State services assess their climate vulnerability the least. Fifty-nine per cent of state services indicated limited or no assessment or understanding of vulnerability. Five per cent of these entities indicated they understand climate vulnerability well.

6.5.5 Climate-related disclosures

The Government has passed legislation making climate-related disclosures mandatory for some organisations. From 1 January 2023, around 200 financial institutions in Aotearoa New Zealand will be legally required to annually analyse and publicly disclose their climate-related risks and opportunities. The requirement will apply to large publicly listed companies, insurers, banks, credit unions, building societies, and investment managers. New Zealand is the first in the world to implement such legislation, and by improving transparency and revealing climate-related information within financial markets, the country's financial system will become more resilient.

Gaps in knowledge needed to manage climate change risks and opportunities

The risk assessment identified gaps in understanding of climate risks, which reduce Aotearoa New Zealand's ability to assess and manage climate change. They include:

- a lack of coordinated and readily accessible biological inventories and data sets describing the distribution and status of ecosystems and species
- the relationship between social vulnerabilities, cultural heritage and climate change, along with impacts on Māori social, cultural, spiritual and economic wellbeing
- how climate change will affect the banking and insurance sectors, and the flow-on effects on the financial system
- consistent hazard information for assessing the exposure of the built environment at a national scale
- the interdependencies and shared risks between infrastructure sectors
- a coordinated, comprehensive research platform, to ensure research is available to inform effective adaptation
- the current and future barriers to adaptation
- the full range of opportunities and better understanding of those already identified.

³⁰² Responses were received from around half (220) of the total number of organisations that were sent the information request. As such, the percentages outlined here are only representative of organisations that responded.

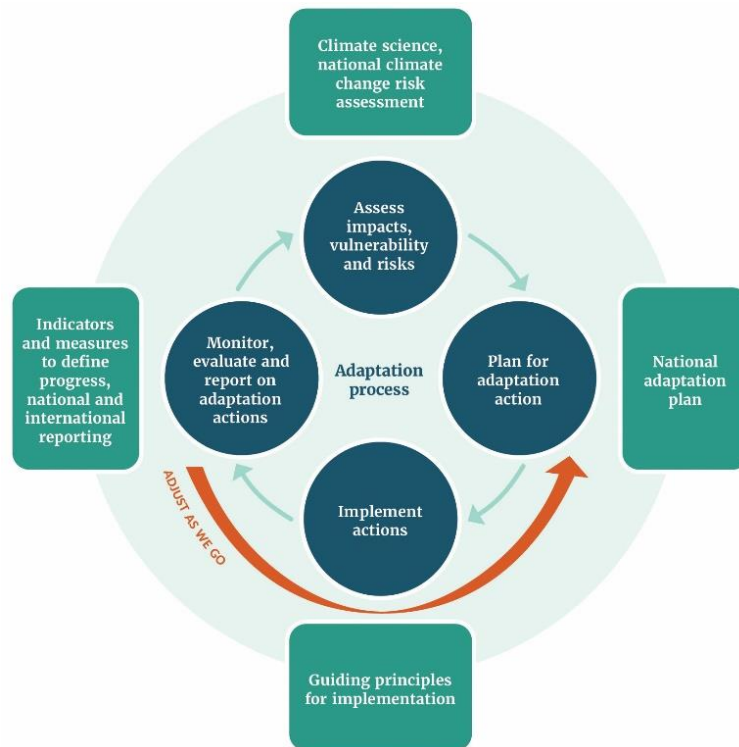
6.6 Aotearoa New Zealand’s adaptation strategy, policies and proposals

6.6.1 Long-term adaptation strategy

Aotearoa New Zealand’s adaptation strategy encourages all New Zealanders to work together now to understand climate risks and take action to manage them. It also acknowledges adaptation will bring new opportunities that must be seized. Its vision is that our people, places and systems are resilient and able to adapt to the effects of unavoidable climate change in a fair, low-cost and ordered manner. Central government, local government, the private sector, iwi, hapū, whānau, communities and individuals all have different but complementary roles to play to build a climate-resilient New Zealand.

The strategy recognises adaptation as a continuous planning process to assess risks, implement the plan, monitor and evaluate how effective the plan is, and adjust it as necessary (see figure 6.3).

Figure 6.3: Aotearoa New Zealand’s legislated adaptation process³⁰³



Upholding the principles of Te Tiriti o Waitangi is a central aspect of the strategy. This means developing adaptation responses in partnership with Māori, elevating te ao Māori (the Māori world) and mātauranga Māori in the adaptation process and empowering Māori in adaptation planning for Māori, by Māori.

No two communities will experience climate change in the same way. Inequality arises through multiple domains, including income, housing, employment and accessibility. Climate change can also increase existing inequities. Some groups may be more susceptible to harm due to where they live. Others may be disproportionately affected by financial impacts or lack the

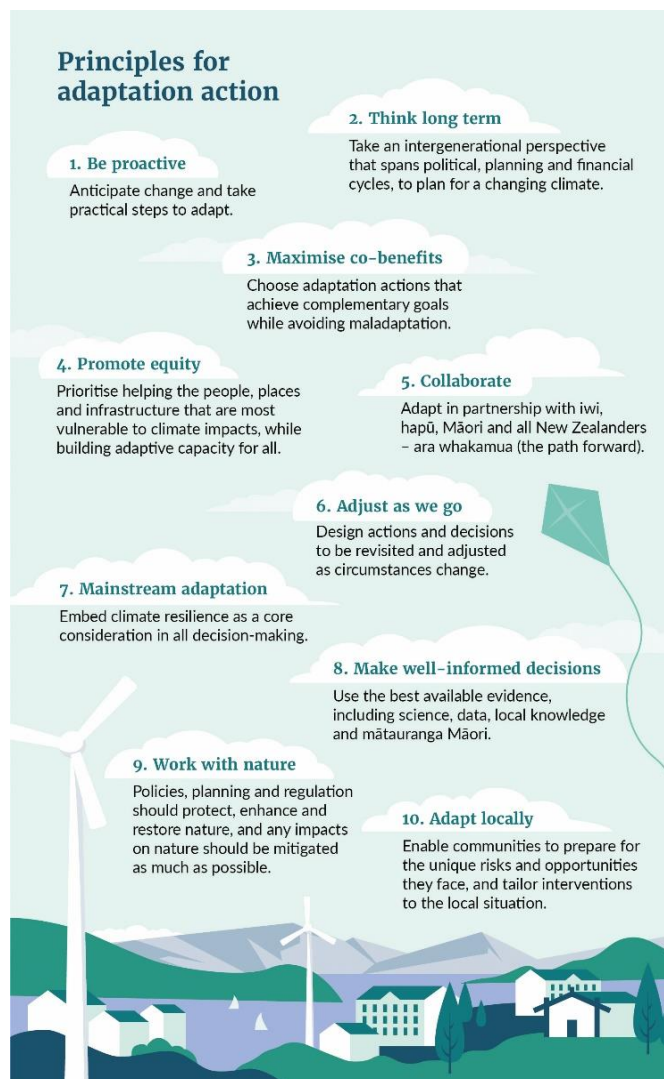
³⁰³ This figure is taken from the national adaptation plan (figure 3, page 24).

resources to adapt and have specific adaptation needs. An equitable transition is core to the strategy and national adaptation plans must support New Zealanders in ways that recognise their unique needs, values and circumstances.

Three goals and 10 principles underpin the long-term adaptation strategy. The principles are shown in figure 6.4. The goals are consistent with the global goal on adaptation under the Paris Agreement and should be implemented in an interlinked and systematic way.

- *Goal 1: Reduce vulnerability to the impacts of climate change* – this means reducing the sensitivity and susceptibility of people and systems to climate impacts.
- *Goal 2: Enhance adaptive capacity and consider climate change in decisions at all levels* – this means helping people, institutions and systems to adjust to climate change by building their capacity to respond, and embedding climate resilience across and through all levels of government.
- *Goal 3: Strengthen resilience* – this means taking action that strengthens the way people and systems cope with immediate climate impacts, along with building capacity for learning and transformational adaptation.

Figure 6.4: Principles guiding Aotearoa New Zealand’s adaptation strategy³⁰⁴



³⁰⁴ This figure is taken from the national adaptation plan (figure 5, page 34).

Adapting in partnership with Māori

It is crucial to reach an equitable transition for Māori, led by Māori, to uphold Māori rights and interests under Te Tiriti o Waitangi (the Treaty of Waitangi). Achieving an equitable transition means building Māori–Crown relationships and capability, so climate response work can progress in partnership.

The Government recognises that Māori have a worldview that sits outside Western interpretations. The Rauora framework is a Māori-led climate-change initiative that brings together Māori values and principles into an indigenous worldview of climate change. The framework was published alongside the national adaptation plan. Reflecting the principle of interconnectedness, which is at the heart of the Rauora framework, both the national adaptation plan and the emissions reduction plan establish a pathway for Māori and government to work together to:

- develop a new platform for Māori climate action that will enable tangata whenua³⁰⁵ to actively participate in the climate response
- develop a Māori climate strategy and action plan that will elevate te ao Māori and mātauranga Māori³⁰⁶ within the overall climate response
- ensure the right funding and resourcing for community action, kaupapa Māori,³⁰⁷ and tangata Māori³⁰⁸ actions and solutions.

6.6.2 National adaptation plan

Aotearoa New Zealand’s first national adaptation plan was published in 2022. This plan is the first step towards meeting the Government’s long-term vision and goals for a climate-resilient New Zealand.

The national adaptation plan responds to the risks identified in the risk assessment. The plan was built on recommendations of the Climate Change Adaptation Technical Working Group recommendations report³⁰⁹ from 2018 and drew on the latest science from the IPCC (AR6 WGI and WGII reports).

Actions in the plan are identified as either critical, supporting or proposed. Critical actions are prioritised. Supporting actions are either less urgent or dependent on the critical actions. Proposed actions are future work programmes that reflect current thinking about what will be needed in the future. These proposed actions may change, because this is a six-year plan.

Four priority areas underpin the plan.

³⁰⁵ ‘Tangata whenua’ – people of the land.

³⁰⁶ ‘Te ao Māori’ – the Māori world; ‘mātauranga Māori’ – Māori knowledge systems and worldviews, including traditional concepts.

³⁰⁷ ‘Kaupapa Māori’ – Māori approach, topic, customary practice, institution, agenda, principles, ideology – a philosophical doctrine incorporating the knowledge, skills, attitudes and values of Māori society.

³⁰⁸ ‘Tangata Māori’ in this context is a term used to describe actions and solutions delivered by Māori for Māori.

³⁰⁹ Climate Change Adaptation Technical Working Group. 2018. *Adapting to Climate Change in New Zealand: Recommendations from the Climate Change Adaptation Technical Working Group*.

Priority 1: Enabling better risk-informed decisions

Information, guidance, tools and methodologies are needed to enable good decisions. All New Zealanders need to be making decisions that take into account climate change across all aspects of our lives. This priority area is focused on actions to provide information, scenarios and guidance to help New Zealanders assess the exposure and vulnerability of their homes, businesses and communities to current and future climate hazards. Some actions apply to all New Zealanders while others are targeted at specific sectors and groups.

Actions to enable better risk-informed decisions will address all risks in the risk assessment, in particular:

- risk of maladaptation across all domains due to the application of practices, processes and tools that do not account for uncertainty and change over long timeframes.

Six objectives enable better risk-informed decisions:

- legislation and institutional arrangements are fit for purpose and provide clear roles and responsibilities
- robust information about climate risks and adaptation solutions are accessible to all
- tools, guidance and methodologies enhance our ability to adapt
- enable communities to adapt
- reduce the vulnerability of assets exposed to climate change
- a resilient financial system underpins economic stability and growth. Participants can identify, disclose and manage climate risks.

Critical actions being taken to enable better risk-informed decisions are:

- Establish a platform for Māori climate action.
- Provide access to the latest climate projections data.
- Design and develop risk and resilience and climate adaptation information portals.
- Deliver a rolling programme of targeted adaptation guidance.
- Develop guidance for assessing risk and impact on physical assets and the services they provide.
- Raise awareness of climate hazards and how to prepare.
- Support high-quality implementation of climate-related disclosures and explore expansion.
- Improve natural hazard information on Land Information Memoranda.

Priority 2: Driving climate-resilient development in the right locations

Actions in this priority area are focused on ensuring decision-making frameworks for planning and infrastructure investment guide climate-resilient development in the right locations and account for changing risks.

During the transition to these new systems local government need to avoid locking in appropriate land use or closing off adaptation pathways before the new resource management system takes full effect.

Councils have existing functions and powers that can be used to avoid, mitigate or manage the impacts of natural hazards. These functions can support climate-resilient development in the right locations. Statutory and non-statutory guidance provide direction for this, including the use of recommended climate change scenarios.³¹⁰

Actions to drive climate-resilient development in the right locations will address:

- risk to potable water supplies (availability and quality)
- risks to buildings
- risk of maladaptation across all domains due to the application of practices, processes and tools that do not account for uncertainty and change over long timeframes
- risk that climate change impacts across all domains will be exacerbated because current institutional arrangements are not fit for climate change adaptation.

Six objectives to drive climate-resilient development in the right locations are:

- legislation and institutional arrangements are fit for purpose and provide clear roles and responsibilities
- ecosystems that are healthy and connected, and where biodiversity is thriving
- homes and buildings are climate resilient, and meet social and cultural needs
- new and existing places are planned and managed to minimise risks to communities from climate change
- ensure all new infrastructure is fit for a changing climate
- use renewal programmes to improve adaptive capacity.

Critical actions being taken to drive climate-resilient development in the right locations are:

- Reform the resource management system.
- Reform institutional arrangements for water services.
- Integrate adaptation into Waka Kotahi NZ Transport Agency decision-making.
- Integrate adaptation into Treasury decisions on infrastructure.
- Embed adaptation in funding models for housing and urban development, including Māori housing.
- Set national direction on natural hazard risk management and climate adaptation through the National Planning Framework.
- Establish an initiative for resilient public housing.

³¹⁰ Ministry for the Environment. 2022. *Aotearoa New Zealand's first national adaptation plan*. Wellington: Ministry for the Environment. Page 68.

Priority 3: Adaptation options including managed retreat

Many communities are already under threat from natural hazard events in New Zealand, and this will increase over time due to climate change. Ideally, councils and communities can work together to reduce risk through social networks, nature-based and hard-engineering solutions, through upgrades to existing buildings and infrastructure to withstand more extreme climatic conditions, and by being better prepared.

Actions focused on adaptation options including managed retreat will address:

- risks to social cohesion and community wellbeing from displacement of individuals, families and communities due to climate change impacts
- risk to potable water supplies (availability and quality) due to changes in rainfall, temperature, drought, extreme weather events and ongoing sea-level rise
- risks to buildings due to extreme weather events, drought, increased fire weather and ongoing sea-level rise in the governance domain
- risk of maladaptation across all domains due to the application of practices, processes and tools that do not account for uncertainty and change over long timeframes
- risks that climate change impacts across all domains will be exacerbated because current institutional arrangements are not fit for climate change adaptation.

Ten objectives enable adaptation options, including managed retreat:

- legislation and institutional arrangements are fit for purpose and provide clear roles and responsibilities
- robust information about climate risks and adaptation solutions is accessible to all
- unlocking investment in climate resilience
- homes and buildings are climate resilient and meet social and cultural needs
- Māori connections to whenua and places of cultural value are strengthened through partnerships
- support working with nature to build resilience
- threats to cultural heritage arising from climate change are understood and impacts minimised
- reduce the vulnerability of assets exposed to climate change
- use renewal programmes to improve adaptive capacity
- a resilient financial system underpins economic stability and growth. Participants can identify, disclose and manage climate risks.

Critical actions being taken to enable adaptation including managed retreat are:

- Pass legislation to support managed retreat.
- Complete case study to explore co-investment for flood resilience.
- Publish the programme of work on how Aotearoa New Zealand meets the costs of climate change and invests in resilience.
- Prioritise nature-based solutions.
- Reduce and manage the impacts of climate hazards on homes and buildings.
- Develop options for home flood insurance.
- Scope a resilience standard or code for infrastructure.
- Support kaitiaki communities to adapt and conserve taonga and cultural assets.³¹¹

Managed retreat legislation

An action to pass legislation to support managed retreat will help to implement decisions to retreat once these have been made. This legislation will be developed in collaboration with a range of stakeholders who will use it, and in partnership with hapū, iwi and Māori, who have particular considerations in relation to whenua Māori and Te Tiriti o Waitangi.³¹²

Legislation for managed retreat will need to consider how to minimise risks to social cohesion, which can be worsened when communities need to relocate. It must consider unique challenges for low-income groups and mobility-compromised and disabled people when faced with having to shift. One way of doing this is to provide certainty about the process and opportunities for people and communities to engage.

Priority 4: Embedding climate resilience across government

To embed climate resilience in all government strategies, actions are focused on five outcome areas. These areas are broadly consistent with those identified in the risk assessment and are described in the following sections.

Natural environment

When ecosystems are healthy and diverse, they can adjust more effectively to climate threats.

Actions focused on the natural environment will address:

- risks to coastal ecosystems, including the intertidal zone, estuaries, dunes, coastal lakes and wetlands, due to ongoing sea-level rise and extreme weather events
- risks to indigenous ecosystems and species from the enhanced spread, survival and establishment of invasive species due to climate change.

³¹¹ 'Kaitiaki' – guardian, caretaker, manager, trustee; 'taonga' – treasure, anything prized – applied to anything considered to be of value, including socially or culturally valuable objects, resources, phenomena, ideas and techniques.

³¹² 'Iwi' – tribe, large group descended from a common ancestor; 'hapū' – kinship group, clan, subtribe; Whenua (Māori) Māori land. There are three types of whenua Māori: Māori freehold land, Māori customary land and general land owned by Māori; 'Tiriti o Waitangi' – Treaty of Waitangi.

New Zealand's objectives are:

- Ecosystems that are healthy and connected, and where biodiversity is thriving.
- Robust biosecurity reduces the risk of new pests and diseases spreading.
- Support working with nature to build resilience.

The critical actions being taken to meet these objectives are:

- Implement the *Department of Conservation Climate Adaptation Action Plan*.
- Implement *Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy*.
- Implement essential freshwater management programmes.
- Engage with councils to implement the *New Zealand Coastal Policy Statement*.
- Deliver climate, biodiversity and wider environmental outcomes.
- Deliver biosecurity actions to protect Aotearoa New Zealand's indigenous ecosystems and economy from invasive species.
- Implement the National Policy Statement on Freshwater Management 2020.
- Implement the proposed National Policy Statement on Indigenous Biodiversity.

Working with nature to adapt to climate change

Safeguarding biodiversity and ecosystems is fundamental to an effective climate response. Valuable native ecosystems can buffer human and natural systems from the impacts of climate change, store carbon, support biodiversity and improve community wellbeing.

To address the climate and biodiversity crises together, the Government is:

- prioritising nature-based solutions to adapt to climate change and deliver other socio-economic and environmental benefits, embedding nature-based solutions in transport policies and identifying options to increase their integration into urban form
- establishing an integrated work programme to deliver climate, biodiversity and wider environmental outcomes.

Homes, buildings and places

Homes, buildings and places play a vital role in the health, wellbeing and quality of life of all New Zealanders. Many homes and buildings are in areas at risk of flooding and/or sea-level rise, and the impacts of climate change can reduce their durability.

The homes, buildings and places actions address the significant risk to buildings due to extreme weather events, drought, increased fire weather and ongoing sea-level rise.

New Zealand's objectives are:

- Homes and buildings are climate resilient and meet social and cultural needs.
- New and existing places are planned and managed to minimise risks to communities from climate change.
- Māori connections to whenua (country, land, nation, state) and places of cultural value are strengthened through partnerships.
- Threats to cultural heritage arising from climate change are understood and impacts minimised.

The critical actions being taken to meet these objectives are:

- Reduce and manage the impacts of climate hazards on homes and buildings.
- Support kaitiaki communities to adapt and conserve taonga and cultural assets.³¹³
- Reduce the exposure of public housing tenants to climate hazards.
- Embed adaptation in funding models for housing and urban development, including Māori housing.

Climate resilience in the building sector

Work is in progress to initiate and support adaptation for the building and construction sector. For example, the *Building for Climate Change work programme* will support actions in the national adaptation plan to increase adaptation and resilience. It is also connected to the work on emissions reduction and seismic resilience.

Infrastructure

Infrastructure provides the services New Zealanders depend on to live, work, learn and play. Resilient infrastructure supports adaptation in communities and businesses and protects the wellbeing of future generations.

The infrastructure actions address the significant risk to potable water supplies (availability and quality) due to changes in rainfall, temperature, drought, extreme weather events and ongoing sea-level rise).

New Zealand's objectives are:

- Reduce the vulnerability of assets exposed to climate change.
- Ensure all new infrastructure is fit for a changing climate.
- Use renewal programmes to improve adaptive capacity.

The critical actions being taken to meet these objectives are:

- Develop guidance to support asset owners to evaluate, understand and manage the impacts and risks of climate change on their physical assets.
- Develop and implement the Waka Kotahi NZ Transport Agency Climate Adaptation Plan.
- Scope a resilience standard or code for infrastructure.
- Integrate adaptation into Treasury decisions on infrastructure.

³¹³ 'Kaitiaki' – guardian, caretaker, manager, trustee; 'taonga' – treasure, anything prized – applied to anything considered to be of value, including socially or culturally valuable objects, resources, phenomena, ideas and techniques.

Building climate resilience into the land transport system

In 2022, Waka Kotahi NZ Transport Agency will publish and begin applying an adaptation plan. This will outline how it will adapt to climate change through the design, delivery, operation and use of the land transport system. The plan will address exposed existing assets and new investment in infrastructure. It will also explore adaptation in maintenance programmes of the roading network, including renewals.

Waka Kotahi will consider multiple risks to the land transport system from climate hazards, including sea-level rise, flooding and landslides. It will lead, collaborate on and support land transport adaptation to enable climate-resilient transport networks and journeys, connecting people, products and services for a thriving Aotearoa New Zealand.

Communities

Communities are diverse and experience the impacts of climate change in various ways. Building and maintaining strong communities will equip New Zealanders with the right tools to adapt.

The relevant actions address the significant risks to social cohesion and community wellbeing from the displacement of individuals, families and communities due to climate change impacts and risks of exacerbating existing inequities and creating new and additional inequities due to differential distribution of climate change impacts.

New Zealand's objectives are:

- Legislation and institutions are fit for purpose and provide clear roles and responsibilities.
- Enable communities to adapt.
- Support vulnerable people and communities.
- Support communities when they are disrupted or displaced.
- The health sector is prepared and can support vulnerable communities affected by climate change.

Critical actions being taken to meet these objectives are:

- Raise awareness of climate-related hazards and how to prepare.
- Develop the Health National Adaptation Plan.
- Modernise the emergency management system.

Updating the emergency management system

The National Emergency Management Agency 'plans to modernise emergency management', including through legislative reforms, working with communities and organisations, clearer roles and responsibilities, and a strengthened partnership with Māori. This work seeks to improve the regulatory framework that underpins emergency management in Aotearoa New Zealand. It will also sharpen the focus on disproportionately affected groups by strengthening community resilience.

Economy and finance

Climate change impacts, such as increased floods, droughts and sea-level rise, are already affecting the Aotearoa New Zealand economy. The contribution of climate change to flood and drought from 2007 to 2017 cost \$840 million in insured damages and economic losses.³¹⁴

The economy and finance actions address risks to government from economic costs associated with lost productivity, disaster relief expenditure and unfunded contingent liabilities and risks to the financial system from instability.

New Zealand's objectives are:

- Sectors, businesses and regional economies can adapt. Participants can identify risks and take action.
- A resilient financial system underpins economic stability and growth. Participants can identify, disclose and manage climate risks.

Critical actions being taken to meet these objectives are:

- Deliver the *New Zealand Freight and Supply Chain Strategy*.
- Develop options for home flood insurance.
- Help financial entities to better identify and manage their climate risks and support financial stability.
- Support high-quality implementation of climate-related disclosures and explore expansion.
- Strengthen the fisheries management system and support the aquaculture sector to sustainably grow.

6.6.3 Regional and local plans, policies and strategies

Regional and local adaptation policy frameworks

As of October 2022, 17 councils across Aotearoa New Zealand have declared climate emergencies, covering 75.3 per cent of the New Zealand population. The 2021 Ministry for the Environment adaptation preparedness report shows that 18 per cent of councils (11 of 61 surveyed) have some sort of plan or strategy to increase resilience to climate impacts.³¹⁵ Out of New Zealand's 15 regional and unitary councils, two have climate adaptation strategies in place.

³¹⁴ Frame D, Rosier S, Carey-Smith T, Harrington L, Dean S, Noy I. 2018. *Estimating Financial Costs of Climate Change in New Zealand: An Estimate of Climate Change-Related Weather Event Costs*. New Zealand Climate Change Institute and NIWA. Wellington.

³¹⁵ Ministry for the Environment. 2021. *Adaptation preparedness: 2020/21 baseline – A summary of reporting organisation responses from the first information request under the Climate Change Response Act 2002*. Wellington: Ministry for the Environment.

6.7 Use of science, mātauranga Māori and local knowledge in adaptation

Use of best available knowledge and science is integrated into adaptation

To date, much effort has been made to base adaptation policy on best available knowledge and science. Both the risk assessment and Climate Change Adaptation Technical Working Group reports were written by leading experts in the adaptation field. Guidance relevant to adaptation produced by the Government is based on the latest findings from the IPCC's AR6 WGI (Physical Science Basis) and WGII (Impacts, Adaptation and Vulnerability) reports.

Further adaptation progress will be supported by science and mātauranga Māori because the national adaptation plan enables the development and use of science and knowledge for adaptation through many different actions, which are described below.

Mātauranga Māori

Mātauranga Māori is the modern term for traditional Māori knowledge. It provides a valuable lens for identifying current and future climate impacts on natural and human systems, as well as for planning and developing solutions. Several proposed actions will progress the development of iwi/Māori climate data and information. These include actions that focus on mātauranga Māori environmental indicators, iwi/Māori socio-economic risk and vulnerability assessment, mapping of taonga, and the extension of mapping the cultural footprint against high-impact weather.

Science and local knowledge

The national adaptation plan incorporates the use of science through actions that deliver scientific information to people, along with actions that use and develop science and knowledge to deliver adaptation. For example, the plan details the research needed to close the adaptation knowledge gaps noted in the risk assessment, over the short and long term. Up to 2025, research priorities are:

- consolidate existing data and make them open access
- complete priority datasets
- start national networks of long-term monitoring of natural environments
- start and complete vulnerability studies.

To deliver scientific information to all New Zealanders, the national adaptation plan will provide access to the latest global climate projections data from the IPCC AR6 report, which will have been scaled down to the Aotearoa New Zealand region, and guidance based on the earlier AR5 report. Information on natural hazards will be provided through land reports procured when people purchase property.

An example of science and local knowledge being used together is a programme called Jobs for Nature, which provides capacity to local communities to restore indigenous ecosystems.

Adaptation in New Zealand is also prioritised through actions in the national adaptation plan that develop and fund science and knowledge through programmes that support innovative adaptation. The work programme Te Ara Paerangi – Future Pathways for the research, science

and innovation system is a considerable shift in how New Zealand funds science.³¹⁶ It includes focusing resources on national goals, such as climate change, and addressing other issues facing the research, science and innovation system, such as how best to honour Tiriti obligations, system funding and incentives, workforce and institutional design.

Innovative work is also funded through programmes such as the Sustainable Land Management and Climate Change and the Greenhouse Gas Inventory research programmes.³¹⁷

National Science Challenges

The National Science Challenges conclude in 2024. The projects with climate adaptation research are the: Deep South Challenge, Resilience to Nature’s Challenges, Our Land and Water, New Zealand’s Biological Heritage, Sustainable Seas, and Building Better Homes, Towns and Cities. The results will likely be ready in time to inform the second national climate change risk assessment and ongoing national adaptation plan work.

Working together to adapt

New Zealand’s long-term adaptation strategy outlines the roles different stakeholders play in adaptation. Central and local government, Māori, the private sector, the research and scientific community and communities and individuals all have roles and responsibilities for managing risk and taking action (for examples, see table 6.3).

Engaging in adaptation action with local government will be essential because local government organisations are on the front line in managing climate impacts. Inclusive engagement, particularly with those disproportionately affected by climate change, will help to ensure adaptation actions lead to the intended outcomes.

Table 6.3: Stakeholder roles and examples for adaptation in Aotearoa New Zealand

Adaptation stakeholder	Role	Example
Central government	Plays a leadership role and establishes policy and institutional settings that support effective adaptation.	Recently published a national adaptation plan: <i>Urutau, ka taurikura: Kia tū pakari a Aotearoa I ngā huringa āhuarangi/Adapt and thrive: building a climate-resilient New Zealand</i> . ³¹⁸
Local government	On the front line in managing climate impacts and risks. Councils have functions and duties in relation to natural hazards, civil defence and emergency management, and improving community resilience.	Develops adaptation options for a vulnerable suburb of Dunedin through a joint initiative between councils called the South Dunedin Future Programme. ³¹⁹ Also, an example of how councils are responding to coastal erosion is Clifton to Tangoio Coastal Hazards Strategy 2120. ³²⁰

³¹⁶ More information on Te Ara Paerangi – Future Pathways can be found in chapter 8.

³¹⁷ More information on these significant research programmes can be found in chapter 8.

³¹⁸ Ministry for the Environment. 2022. *Aotearoa New Zealand’s first national adaptation plan*. Wellington. Ministry for the Environment.

³¹⁹ Dunedin City Council. 2022. *The South Dunedin Future Programme*. Retrieved from www.dunedin.govt.nz/council/council-projects/south-dunedin-future/the-south-dunedin-future-programme (3 November 2022).

³²⁰ Ministry for the Environment. 2022. *Clifton to Tangoio Coastal Hazards Strategy 2120*. Retrieved from environment.govt.nz/what-you-can-do/stories/clifton-to-tangoio-coastal-hazards-strategy-2120/ (3 November 2022).

Adaptation stakeholder	Role	Example
Māori	Have a unique role to play as Tiriti o Waitangi (Treaty of Waitangi) partners, tangata whenua (people of the land, local indigenous people) and kaitiaki (guardians, caretakers, managers, trustees) of their ancestral and cultural landscape. The long-term adaptation strategy sets out how the Government will adapt in partnership with Māori, including elevating te ao Māori (the Māori world) and mātauranga Māori (Māori knowledge systems and worldviews, including traditional concepts) in the adaptation process and empower Māori in planning for Māori, by Māori.	Climate action for Ngaa Rauru Kiitahi, a small iwi in south Taranaki, is encapsulated in their recent climate change strategy. ³²¹ The strategy challenges the iwi to reharvest their own tikanga (custom), kawa (protocol) and mātauranga-a-iwi (knowledge with an iwi-specific base) to advance climate action.
Communities and individuals	Prepares for and manages the impacts of climate change on daily life, primary sector land management and farming systems, and the risks to public and private assets.	Examples of non-governmental organisation group Forest and Bird member-led projects include: <ul style="list-style-type: none"> the Lower Hutt Branch building resilience through building an ecological corridor linking the forests of the eastern and western hills of the Hutt Valley and by propagating native plants in a nursery the Hastings–Havelock and Napier branches increasing carbon sequestration, improving water quality, and increasing resilience of native species to climate change by restoring wetlands and estuaries.
Private sector	Invests in reducing risks to businesses and assets. Businesses can take advantage of new economic opportunities such as access to new technologies and markets.	In many areas, the private sector is already taking action to manage risks from climate change. For example, the Climate Leaders Coalition brings together more than 100 chief executives from various industries. The coalition’s mission is to respond through collective, transparent and meaningful action, and one of its focus areas is adaptation. This means understanding the risks businesses will face and planning for these to help build resilience.

6.8 Cooperation

The national adaptation plan encourages groups affected by climate change to work together to reach effective adaptation outcomes. For example, in response to climate risks to homes and buildings, the Government will work with community housing providers to develop an effective adaptation response. An action will also work to build community resilience through improving inclusion and participation in society. It will build community resilience, to lessen instability and isolation caused by climate change. The aim is to support the understanding of

³²¹ Ministry for the Environment. 2022. *An iwi shows how we can adjust and thrive in a changing climate*. Retrieved from environment.govt.nz/what-you-can-do/stories/an-iwi-shows-how-we-can-adjust-and-thrive-in-a-changing-climate/ (3 November 2022).

diversity within and across communities to allow everyone to feel safe and belong, and to access opportunities.

The Government has plans to partner with Māori landowners to increase the resilience of Māori-owned land, homes and cultural sites, as well as partnering with Māori to support Māori-led approaches to adaptation planning. The Government will also act to pool knowledge and resources to develop sector responses to climate change through industry partnerships.

The private sector recognises the need for cooperative processes to develop adaptation responses. The Aotearoa Circle *Seafood Sector Adaptation Strategy* is a collaboration between the major seafood sector leaders, Government, environmental non-governmental organisations, iwi representatives and the research community.³²² This diversity is reflected in the strategy's actions to ensure adaptation information is more integrated and accessible, and to promote ecologically and economically efficient fishing and aquaculture. Te ao Māori is incorporated throughout the strategy, and specific implementation actions reflect this (eg, piloting and monitoring a te ao Māori approach to coastal management).

The infrastructure sector also recognises the importance of collaboration and sharing. An action in the national adaptation plan is to convene regular events with government and private sector asset owners to share information on the implementation of actions in the plan. This will support alignment across the sector and knowledge sharing for asset owners.

6.9 Finance

The national adaptation plan sets out several actions that support and encourage funding and investment in programmes for adaptation. Public investment will be made in climate change initiatives, innovation grants established, and work done to unlock greater investment in climate-resilient projects.

Sector-specific investment is also visible. Adaptation will be embedded in funding models for housing and urban development, including Māori housing. Investment is planned in strengthening border biosecurity and in public transport and active transport. For the primary sector, the Sustainable Food and Fibre Futures Fund will be continued to be delivered.

Climate change and the agricultural sector

Climate change is increasing the frequency and severity of drought in Aotearoa New Zealand. From 2007 to 2017, drought cost the country around NZ\$720 million. The primary sector is particularly vulnerable and can expect conditions to get drier.

To reduce the economic risks of drought and build climate resilience for farmers and growers, a national long-term adaptation strategy was developed. Online webinars and a one-day symposium were held with stakeholders in 2021. The resulting findings were captured in the *Growing Kai Under Increasing Dry* report.³²³

The report emphasises it is vital for the primary sector to adapt and protect its viability, and to collaborate widely. Solutions include:

³²² The Aotearoa Circle. 2021. *Seafood Sector Adaptation Strategy: Climate Adaptation Strategy 2021–2030*.

³²³ Summary of joint National Science Challenge rolling symposium. 2021. *Growing Kai Under Increasing Dry: How does the primary sector in Aotearoa adapt to a changing climate with a changing drought profile?*

- connecting policy, research and on-farm practice
- introducing long-term rather than short-term planning to respond to events
- enabling behaviour change and diversifying farming activities.

The report notes that, although incremental adaptation has been happening for a decade, transformational change is now required. In contrast to incremental adaptation, which involves actions such as changing seed-sowing dates, transformational adaptation involves identifying novel land use opportunities. The report sets out important roles: farmers and growers are the land use decision-makers, industry bodies work as knowledge brokers for adaptation, researchers contribute new possibilities for adaptation and co-develop solutions, and the Government has a significant role in enabling innovation, investment and flexibility.

6.9.1 Monitoring, reporting and evaluation

Reporting on the national adaptation plan

The Climate Change Response Act 2002 sets out how the implementation and effectiveness of the national adaptation plan will be monitored and evaluated. He Pou a Rangi – Climate Change Commission is required to report every two years to the Minister of Climate Change on the implementation of the plan and its effectiveness in reducing the priority risks in the most recent risk assessment. The Minister of Climate Change must respond to the Commission’s reports within six months of receiving them.

Monitoring the progress of the national adaptation plan and reporting on its effectiveness will enable the Government to identify whether it is appropriate to adjust the actions in the plan.

Governance and oversight

Successfully implementing the national adaptation plan will require action across government. Strong governance and accountability mechanisms are needed to make continuous progress. The Climate Change Chief Executives Board (the Board) has been established to oversee both the national adaptation plan and the emissions reduction plan. The Board will monitor and report on progress each year (annual Board report). The Climate Response Ministerial Group will oversee the plan and drive progress.

Regulatory stewardship (monitoring the Government’s regulatory systems) is a further opportunity to consider climate change and improve how the national adaptation plan is implemented.

7 Financial, technological and capacity-building support

Key developments since the *Seventh National Communication*

- Aotearoa New Zealand has contributed approximately NZ\$285.78 million in climate-specific support for developing countries during 2019 and 2020.
- In 2018 New Zealand increased its climate finance for the period 2019–22 to NZ\$300 million. It met this commitment early, in July 2021. Of this commitment, two-thirds was for the Pacific and half to adaptation (although these were not mutually exclusive targets). New Zealand continues to increase its provision of international climate finance to developing countries.
- New Zealand delivers its international climate finance primarily through activities in its International Development Cooperation programme, focusing on agriculture, food security, disaster prevention and preparedness, ecosystem strengthening, renewable energy, infrastructure and water security.
- New Zealand has continued to support multilateral climate funds, providing NZ\$22.16 million in total. This included an NZ\$15 million contribution to the first replenishment of the Green Climate Fund and an NZ\$3 million contribution to the Adaptation Fund.
- New Zealand has also undertaken dedicated capacity-building and technology-transfer activities. This is aimed at strengthening the capability and capacity of Pacific Island countries to respond to the impacts of climate change.
- This reporting period includes the first year of the COVID-19 pandemic. The impacts of the pandemic on New Zealand’s financial, technology transfer and capacity-building support will be more evident in the next report.

7.1 Introduction

Aotearoa New Zealand is committed to delivering its international obligations, and to providing information about how we will do this, including for our climate finance obligations. New Zealand’s policy is to share indicative finance flows with partner countries at least two years ahead of time, in an effort to enhance transparency and predictability.

In line with the revised United Nations Framework Convention on Climate Change (UNFCCC) guidelines on reporting national communications for Parties included in Annex I to the convention (FCCC/CP/2019/13/Add.1), this chapter reports on the financial, capacity building and technological support New Zealand has provided to developing countries for climate change action for the previous two calendar years, 2019 and 2020. It covers support provided through multilateral, regional and bilateral channels, as well as specific resources provided for mitigation, adaptation, technology transfer and capacity building.³²⁴

In 2018, New Zealand made a new high-level, multi-year climate finance commitment of NZ\$300 million for the period 2019–22. This commitment demonstrated the importance

³²⁴ For clarity, this chapter uses the definition of capacity building from the Organisation for Economic Co-operation and Development’s Development Assistance Committee.

New Zealand placed on supporting developing countries to reduce emissions and adapt to the impacts of climate change. This commitment included a dedicated NZ\$150 million for a Pacific- and adaptation-focused Climate Change Programme.

Over 2019–20, New Zealand’s climate-related support focused on:

- strengthening capacity for effective low-emissions, climate-resilient planning
- supporting low-carbon economic growth, including through a significant contribution to improving access to renewable energy
- supporting Pacific countries to access the climate-related support they need from regional and multilateral agencies
- ensuring decision-makers have access to the science and information they need and use it to make informed decisions
- supporting greater global action to reduce greenhouse gas emissions
- strengthening disaster prevention and preparedness
- improving Pacific resilience through on-the-ground adaptation activities, including in areas such as agriculture, ecosystem strengthening, infrastructure and water security.

New Zealand also supported low-emissions agricultural development, primarily through support for, and participation in, the Global Research Alliance on Agricultural Greenhouse Gases (GRA), which was founded in late 2009.

During the reporting period, New Zealand contributed approximately NZ\$285.78 million in total financial assistance (NZ\$217.12 million in climate-specific support³²⁵) for climate change outcomes across:

- multilateral climate change funds, such as the Global Environment Facility,³²⁶ the Green Climate Fund and the Adaptation Fund – total funding of NZ\$22.16 million (climate-specific NZ\$21.48 million) (table 7.4)
- a range of specialised United Nations bodies – total funding of NZ\$40.94 million (climate-specific NZ\$13.84 million) (table 7.4)
- a range of multilateral financial institutions including regional development banks – total funding NZ\$68.46 million (climate-specific NZ\$27.58 million) (table 7.4)
- bilateral, regional and other channels – total funding of NZ\$154.22 million (table 7.5).

Looking ahead

New Zealand remains committed to the global goal of jointly mobilising US\$100 billion per year from a variety of sources through to 2025. This is in the context of developing countries taking meaningful mitigation actions and providing transparency on implementation.

³²⁵ Climate-specific support represents the total of the climate-related support in table 7.3 (NZ\$285.78 million) minus the amount that is tagged as ‘core/general’ (NZ\$68.66 million). Due to the availability of the relevant imputed shares, the climate-specific figure is more accurate for 2019–20 than for previous reporting periods.

³²⁶ Multilateral contributions represent the total amounts provided to the organisations for the full range of activities covered by their programmes, which include climate change mitigation and adaptation, unless imputed shares are available.

In October 2021, New Zealand committed to spend NZ\$1.3 billion in grant-based climate finance between 2022 and 2025. The allocation of this funding will be guided by the *Aotearoa New Zealand International Climate Finance Strategy – Tuia te Waka a Kiwa*.³²⁷ The strategy will ensure that New Zealand’s climate finance supports developing countries and communities to build resilience in a world on a pathway to keeping global warming within 1.5°C. To do this, the strategy will work towards four key goals:

1. enhance resilience and adaptation
2. promote quicker action on mitigation
3. improve information to allow evidence-based decisions
4. leverage our investments to make greater impact.

7.1.1 New and additional support

New Zealand’s approach to determining new and additional financial resources, for the period 2019–20, has been to report all climate-related assistance provided during the reporting period. This is the most transparent and appropriate way of communicating new resources provided.

This report includes any climate-related support provided over the reporting period that meets agreed Official Development Assistance (ODA) definitions (ie, with a strong concessional element and with economic development and the welfare of developing countries as its main objective). Because climate change is a cross-cutting development issue, this support frequently has co-benefits across a range of development outcomes. This is reflected in the integrated approach to climate change and development in the Pacific region.³²⁸ For the 2019–20 reporting period, it is estimated that approximately 20 per cent of New Zealand’s IDC Programme had a climate-related component.

Overall, New Zealand is committed to increasing its climate-related support. Future growth will be bolstered by:

- the increased IDC Programme budgets for 2021–23
- New Zealand’s increased climate finance commitment of NZ\$1.3 billion for 2022–25
- increased efforts to mobilise private finance
- continued efforts to mainstream climate change across New Zealand’s IDC Programme.

7.1.2 Approach to tracking and reporting provision of support

New Zealand is committed to regular and transparent reporting of its climate-related support, and to improving the tracking of its climate-related financial flows. Tracking and monitoring climate finance enables both donor and recipient countries to direct support to areas or sectors that offer the greatest mitigation and adaptation potential, achieving the most effective outcomes and facilitating further climate finance and investment flows.

³²⁷ Retrieved from www.mfat.govt.nz/en/aid-and-development/climate-change-support.

³²⁸ Pacific Community (SPC). 2017. Framework for Resilient Development in the Pacific: An Integrated Approach to Address Climate Change and Disaster Risk Management (FRDP) 2017–2030. Suva: Pacific Community. Retrieved from <http://gsd.spc.int/frdp/> (30 September 2022).

The IDC Programme uses the Rio markers of the Organisation for Economic Co-operation and Development's (OECD's) Development Assistance Committee for tracking development assistance with climate change adaptation and mitigation outcomes. While the Development Assistance Committee's Rio markers capture the thematic objectives of each activity, they do not quantify expenditure towards these objectives. New Zealand has built on the Rio markers to create a system to quantify the climate-related support provided by the IDC Programme.

In 2018, New Zealand added a marker for capacity building. This marker is a binary indication of whether or not projects support climate change capacity building. New Zealand does not track financial resources towards this marker.

The IDC tracking system allows climate-related expenditure to be quantified and recorded in the IDC Programme's climate change inventory, according to specific classifications and moderation weightings, as table 7.1 shows.

Table 7.1: Classifications and moderation weightings for quantifying and recording climate-related expenditure

Classification	Where addressing climate change is...	Financial information recorded in the climate change inventory
Principal	...one of the main outcomes of the activity Addressing climate change risks or opportunities is fundamental to the design of the activity. The activity includes climate change as an important outcome. Climate change is explicitly addressed through specific outputs	100% of the activity value for the financial year
Significant	...one of the outcomes of the activity Addressing climate change risks or opportunities is an important but not the principal reason for undertaking the activity. Climate change is explicitly addressed as part of outputs in the activity design – these do more than simply avoid a potential negative impact	30% of the activity value for the financial year unless either: 1. a more accurate figure is known or 2. a different default figure is specified for the particular activity type
Not targeted	...not an outcome of the activity Climate change opportunities and risks have been assessed but will not be significantly addressed through any of the outputs in the Results Framework	0% of the activity value for the financial year

In addition to the criteria in table 7.1, some specific types of activities supported by the IDC Programme have specific weightings. Table 7.2 provides further guidance on the application of the climate change markers for those activities.

Table 7.2: Guidance on the application of the climate change markers

Activity	Description	Marker and classification	Weighting
Disaster risk reduction and management	The activity is driven by a prime concern for extreme weather events	Adaptation: Principal	100%
	The activity is driven by a prime concern for seismic events (earthquakes, tsunamis) but where extreme weather events occur	Adaptation: Significant	50%

Activity	Description	Marker and classification	Weighting
Renewable energy and energy efficiency	Any activity dealing with renewable energy and/or energy efficiency, whether the prime concern is energy security, economic growth, climate change or any combination of these	Mitigation: Principal	100%
Energy upgrading	Energy upgrading activities, where the outcome of the activity is safer access to energy supplies during extreme weather events, can potentially be marked significant	Adaptation: Significant	30%

In this *Eighth National Communication*, New Zealand provides information on:

- bilateral financial contributions, including funding from the IDC Programme for activities where addressing climate change is assessed as being the ‘principal’ or ‘significant’ outcome of the activity
- financial contributions to regional organisations with a strategic focus on climate change
- financial contributions to multilateral agencies that have climate change as an integral part of their strategic plans and approaches.

Except for funding to support GRA activities, New Zealand does not monitor its core funding to regional and multilateral organisations to the level of specific climate change allocations and actions. Some of the figures provided in table 7.4 and table 7.5 represent total contributions to multilateral and regional organisations that New Zealand “cannot specify as being climate-specific”. This approach is in keeping with the UNFCCC Biennial Reporting Guidelines for developed country Parties.³²⁹

7.1.3 New Zealand’s IDC Programme principles

New Zealand’s IDC Programme pursues impactful development outcomes through four principles when providing climate-related support, as outlined in *New Zealand’s International Cooperation for Effective Sustainable Development (ICESD)*.³³⁰ These principles are that:

- **effective development** is values driven, partnership focused, adaptive, outcomes focused and evidence based
- **inclusive development** addresses exclusions and inequality created across all dimensions of social identity, while promoting human rights and equitable participation in the benefits of development
- **resilient development** strengthens the environment, economy and societies to withstand shocks and manage crises while protecting future wellbeing
- **sustained development** enables lasting progress and is locally owned to uphold results in the long term.

³²⁹ UNFCCC. 2011. UNFCCC biennial reporting guidelines for developed country Parties, Annex I, Decision 2/CP.17 (pages 31–35). Retrieved from unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf#page=4 (30 September 2022).

³³⁰ Retrieved from www.mfat.govt.nz/assets/Aid-Prog-docs/Policy/Policy-Statement-New-Zealands-International-Cooperation-for-Effective-Sustainable-Development-ICESD.pdf (30 September 2022).

New Zealand aims to, where appropriate, integrate environment and climate change objectives as cross-cutting issues in all activities managed by its IDC Programme. This is in keeping with international best practice and reduces the reporting burden for partner countries. Designing development assistance with environment and climate change co-benefits in mind ensures the development initiatives funded by the IDC Programme support sustainable management of natural assets and address climate change.

7.2 Financial resources

This *Eighth National Communication* reports on all climate-related financial support New Zealand provided during 2019–20, for the purpose of assisting developing countries' climate change mitigation and adaptation efforts.³³¹ This report also highlights some of the key initiatives Aotearoa New Zealand has supported.

New Zealand's reporting period includes two calendar years, 2019 and 2020. Funds are reported in New Zealand dollars (NZ\$). The methodology used for calculating currency exchange is the annual average exchange rates, as used by the OECD. The rates used are:

- 2019: US\$ 1 = NZ\$ 1.518
- 2020: US\$ 1 = NZ\$ 1.542.

This report has adopted the UNFCCC-agreed common tabular format from the revised UNFCCC guidelines on reporting national communications for Parties included in Annex I to the convention (FCCC/CP/2019/13/Add.1). This is to ensure transparency in reporting financial data and to promote consistency across all financial contributors.

For the purposes of this report, 'provided' means funds that have been transferred from the New Zealand Government to a recipient, including any multilateral or regional organisation.

Table 7.3 summarises the public financial support New Zealand has provided in 2019–20. The tables that follow provide more detail on how it provided that support through multilateral channels (table 7.4) and bilateral, regional and other channels (table 7.5) in each of the reporting years.

7.2.1 Multilateral support

New Zealand provides support to multilateral funds with a strategic focus on climate change, including the Adaptation Fund, the Global Environment Facility (GEF) and the Green Climate Fund (GCF).

Adaptation Fund

The Adaptation Fund was established in 2001 to finance concrete adaptation projects and programmes in developing country Parties to the Kyoto Protocol that are particularly vulnerable to the adverse effects of climate change.

In 2019, New Zealand contributed NZ\$3 million to the Adaptation Fund. This contribution responds to the calls from Pacific countries for a greater focus on finance for climate change adaptation.

³³¹ New Zealand respects the choice of countries to differentiate finance given to them for the purposes of loss and damage. However, in this report this support is counted as 'adaptation' finance.

Global Environment Facility

The GEF is an operating entity of the UNFCCC's Financial Mechanism. It distributes financial assistance associated with the major multilateral agreements on climate change, biodiversity, persistent organic pollutants, ozone-depleting substances and desertification. It also supports activities relating to land degradation and international waters.

The reporting period falls within the seventh (2018–22) replenishment period of the GEF Trust Fund. Table 7.4 provides details of New Zealand's total contributions to the GEF Trust Fund for the 2019–20 reporting period, which amounted to NZ\$4.15 million.³³²

New Zealand's contribution recognises the GEF's considerable efforts to increase the support it provides to least developed countries and small island developing states, as well as the GEF Trust Fund's responsiveness to the 2030 Agenda for Sustainable Development.

Green Climate Fund

The GCF is an operating entity of the UNFCCC's Financial Mechanism. The GCF was established in 2010 and became fully operational in 2015. It aims to support a paradigm shift in the global response to climate change, by mobilising funding at scale (including via its Private Sector Facility) to invest in low-emissions and climate-resilient development. The GCF has committed to achieving a 50:50 balance between mitigation and adaptation investments, with at least 50 per cent of adaptation funding to go to the most vulnerable countries, including least developed countries, small island developing states and African states.

In 2019, New Zealand contributed NZ\$15 million to the first replenishment of the GCF. This contribution complements New Zealand's existing support for climate action and supports climate action in areas where it does not have the expertise or scale to make a difference.

Other multilateral support

New Zealand supports a range of multilateral organisations and programmes with a strategic focus on climate change, including those with specific programmes related to the implementation of the UNFCCC (table 7.4). This includes, for instance, the World Bank, the Asian Development Bank and the United Nations Development Programme.

Montreal Protocol implementation

The Montreal Protocol plays an important role in tackling climate change, in particular through the Kigali Amendment, which New Zealand ratified in October 2019. For the 2019–20 reporting period, New Zealand's total contributions to the Montreal Protocol amounted to NZ\$1.92 million.

7.2.2 Regional support

New Zealand is a major funder of the Pacific regional organisations that have a strategic focus on climate change, as detailed in table 7.5. These organisations include:

³³² Annual contributions represent the combined total of New Zealand's payments to the GEF Trust Fund in the financial year (July to June). GEF projects address six global environmental issues, or focal areas, of which climate change is one.

- the Secretariat of the Pacific Regional Environment Programme (SPREP),³³³ which coordinates the region’s response to climate change; it provides policy and technical support to its Pacific Island members to meet their commitments under the UNFCCC and to support climate change adaptation actions
- the Pacific Islands Forum Fisheries Agency (FFA),³³⁴ which provides expertise, technical assistance and other support to its members to assist them with decisions on tuna and other fisheries management, including managing for the impacts of climate change on fisheries
- the Pacific Community (SPC),³³⁵ which assists members in a number of climate-affected sectors, such as health, geoscience, agriculture, forestry, water resources, disaster management and energy
- the Pacific Islands Forum Secretariat (PIFS),³³⁶ which, under the guidance of Forum leaders, ministers and officials, conducts high-level advocacy and develops policy guidance on climate change and access to climate finance.

New Zealand’s core funding to Pacific regional organisations contributes to programmes and projects identified in their strategic plans. However, as core, untagged funding it is not monitored at a level that tracks specific climate change activities. Therefore, the figures for regional agencies provided in table 7.5 are moderated based on the policies outlined in table 7.1.

The IDC Programme also supports climate change efforts in the Pacific through several regional initiatives. The following are examples of these initiatives.

- An SPC-led activity to reduce the risk of water scarcity through improved sustainable water resources will provide at-risk Pacific communities with improvements to their water infrastructure and infrastructure maintenance. It will also provide training and tools to enable these communities to adapt to the impacts of climate change through effectively managing water resources, managing water demand and supply, and mitigating risks.
- An activity started in 2019 to support management of invasive species for climate change adaptation involved SPREP, along with New Zealand’s Department of Conservation and Manaaki Whenua Landcare Research in its delivery. This will support the Pacific to adapt to the increasing impact of invasive species with climate change and to increase its resilience by supporting healthy ecosystems, improving information and management of invasive species, improving food security and reducing disaster risk.
- At the 2019 United Nations Climate Change Conference (COP25), in partnership with the Climate Change Resilience team at SPREP, New Zealand co-hosted the Moana Blue Pacific Pavilion with Fiji, as well as a full programme of side events. The Moana Blue Pacific Pavilion was a place for discussion, debate and knowledge transfer on issues related to the ocean and climate change that are important to the Pacific. New Zealand also supported regional delegates to attend COP25 through this partnership.

New Zealand continues to partner with other development partners, such as the Asian Development Bank and World Bank Group, to mobilise finance at scale for renewable energy across the Pacific region. (See section 7.2.3 under ‘Mitigation’ for more details.)

³³³ www.sprep.org.

³³⁴ www.ffa.int.

³³⁵ www.spc.int.

³³⁶ www.forumsec.org.

7.2.3 Bilateral support

A large proportion of New Zealand's climate-related support is delivered bilaterally through its IDC Programme as grant funding. New Zealand contributed approximately NZ\$138.79 million in climate-related bilateral and multi-country assistance during 2019–20.

Country partnerships are at the heart of New Zealand's approach to bilateral assistance and climate-related support. Bilateral Statements of Partnership and four-year plans are based on partner countries' national plans and self-identified needs and priorities.

New Zealand primarily delivered its climate-related support as part of activities designed to achieve sustainable, inclusive and resilient development outcomes that meet the aspirations and needs that partner countries identified, consistent with international best practice.

New Zealand's climate-related support builds stronger and more resilient infrastructure, strengthens disaster preparedness and supports low-emissions economic growth, including through its significant contribution to improving access to affordable, reliable and clean energy. Examples include:

- New Zealand provided NZ\$1.43 million, over 2019–20, towards the Niue Renewable Energy activity. This activity helped to resolve issues with the current electricity network in Niue, increasing the country's renewable energy supply and reduce its dependence on imported fuels.
- From 2019, New Zealand has been involved in revitalising informal settlements and their environments in Fiji. This activity aims to integrate ecologically and environmentally sustainable water infrastructure into the housing and landscapes of 12 informal settlements in the greater Suva area. The programme combines community engagement with the instalment and monitoring of decentralised water infrastructure to achieve health outcomes and improve climate change and nature disaster resilience.
- In 2019, New Zealand began implementing the Cambodia Climate-smart Commercial Horticulture activity. Building on the successful Commercial Development and Strengthening of Horticulture in Cambodia activity, this new activity introduced climate-smart agricultural techniques and technologies. It will also sustainably increase climate-change resilience, farm and food safety, profitability and market system support for small-scale commercial and semi-commercial horticulture farmers.

The Pacific region has a great need for climate-related assistance. New Zealand has the relationships and experience to make a practical difference, and will strive to be a partner of preference for the Pacific on climate issues.

Climate-related support is also provided bilaterally to partner countries in Africa, Latin America and the Caribbean, and to members of the Association of Southeast Asian Nations (ASEAN) with a particular focus on disaster risk reduction, renewable energy and sustainable agriculture.

The following sections give further details of how New Zealand is supporting mitigation, adaptation, technology transfer and capacity-building actions. Table 7.5 details the country's financial contributions in 2019 and 2020 to these areas.

Adaptation

New Zealand's support for climate change adaptation efforts is primarily designed to reduce the vulnerability of human or natural systems to the impacts of climate change, by increasing community resilience and adaptive capacity. It delivers this support to other countries through

a range of approaches to bilateral, regional and multilateral assistance. Regional, national and community-level resilience and adaptation actions are implemented within the context of national and regional plans, strategies and frameworks. New Zealand works with partner countries, regional agencies and multilateral funds to help shape and deliver these actions in response to the priorities of individual countries.

As already noted, at least 50 per cent of New Zealand's future climate finance will go towards adaptation to the impacts of climate change and building resilience to climate change-related loss and damage (see 'Loss and damage' below). Over 2019–20, 47 per cent of its support for bilateral, regional and other channels was for supporting adaptation actions and 14 per cent was for mitigation. The other 39 per cent is directed to both adaptation and mitigation actions (all percentages are approximate).

As table 7.5 sets out, the IDC Programme supports key initiatives for climate change adaptation, disaster risk management and resilience building such as the following.

- Reduce the risk of water scarcity in atoll countries by enabling water-scarce communities to actively manage resources to improve resilience.
- Mainstream risk-based analysis into government planning by incorporating climate change into governance systems for planning, budgeting and programme management purposes. Interventions are targeted at national and subnational levels in several Pacific Island countries.
- Improve ecosystem resilience, through contributions to the Pacific regional 'Kiwa Initiative: Nature-based Solutions for Climate Resilience'. This initiative aims to strengthen Pacific Island ecosystems, economies and communities to become more resilient to the impacts of climate change. Funding is provided for nature-based solutions to local and national authorities, regional and civil society organisations.

Adaptation and disaster risk reduction are closely related processes in that both aim to reduce vulnerability to short-term acute hazards and longer-term chronic hazards. New Zealand supports the Pacific's approach, as stated in the *Framework for Resilient Development in the Pacific (FRDP)*, of integrating disaster risk reduction and climate adaptation. New Zealand participates in the annual United Nations Office for Disaster Risk Reduction Global Platform on Disaster Risk Reduction, and is an active supporter of the FRDP as a member on the Pacific Resilience Partnership Taskforce, which facilitates the implementation of the FRDP's goals.

Agriculture

The dominance of agriculture in New Zealand's emissions profile and its vulnerability to the impacts of climate change have motivated New Zealand to use its expertise to help address the 10–12 per cent of global emissions that come from the agriculture sector worldwide. New Zealand has invested approximately NZ\$14.95 million in climate-related agriculture initiatives over the 2019–20 reporting period.³³⁷ These initiatives have included a focus on supporting communities to increase their resilience to natural disasters and climate-related weather events, including by introducing new drought-tolerant irrigation technologies. In addition, New Zealand is a leading member of the GRA, which brings countries together to find ways to grow more food without increasing greenhouse gas emissions, and supports these efforts in a range of ways, as outlined elsewhere in this chapter and report.

³³⁷ This includes bilateral and multilateral (International Fund for Agricultural Development and Consultative Group for International Agricultural Research) support but excludes GRA support and Pacific regional agency support.

Climate mobility

Displacement related to climate change is a real and pressing concern in the Pacific. In 2018, New Zealand developed a plan to take early and collaborative action on climate mobility. This plan recognises the importance of the perspectives of Pacific peoples, including their desire to live in their own country, where possible.

As part of that plan, New Zealand is supporting activities to avert and delay climate-related displacement, and preparing people for climate migration where that may be necessary. Its initiatives include:

- conducting a comprehensive scoping study in 2020 to inform the procurement of research to better understand future climate migration trends and the social and economic impacts on New Zealand and Pacific Island countries. Lack of reliable data impedes the ability of New Zealand and Pacific Island countries to adequately prepare for and respond to climate mobility
- supporting a peace-building non-government organisation to help communities in Fiji to prevent and manage conflicts that may result from displacement and relocations related to climate change
- supporting the Government of Fiji to establish the Fiji Relocation Trust Fund to provide internal relocation assistance to Fijian communities
- funding a consortium of United Nations and international organisations, led by the International Organization for Migration, to strengthen the capacity and coordination of Pacific governments and non-government actors in their approach to climate mobility.

COVID-19

As countries set out their economic recovery strategies from COVID-19, there are opportunities to accelerate climate action. New Zealand is aware of the need to guard against the risk of recovery spending that locks in high-emissions pathways.

COVID-19 has affected most activities that provide financial, technological and capacity-building support to developing countries. The true impact of COVID-19 on the delivery of climate change initiatives will only be realised in future reporting periods.

Long-term low-emissions development strategies

A low-emissions, climate-resilient development approach represents an important opportunity for Pacific Island countries to anticipate, plan for and counter some of the impacts of climate change and to transition their economies to a low-carbon future. This is also an opportunity for sustainable development.

Pacific Island countries rely on imported fossil fuels for energy generation and transport, and a small number of climate-sensitive industries that underpin their economies (mainly tourism, fisheries and agriculture). New Zealand is supporting them to develop low-emissions, climate resilient development strategies, sector roadmaps, and associated policies and legislation to reduce emissions and increase their resilience to the impacts of climate change.

New Zealand supported an NZ\$590,000 project led by the Department of Climate Change in Tonga's Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications. The resulting long-term, low-emissions development strategy articulates a long-term vision and direction for the future of Tonga across all sectors in a low-carbon world and in a changing climate.

In 2020, New Zealand committed NZ\$150,000 to support the Fiji Government to review and update its 2014 Draft National Energy Policy with a view to developing a new policy for 2020–30.

New Zealand is also partnering with the Global Green Growth Institute to deliver a multi-country programme of work. The programme will support Pacific Island countries to develop the policy, legislation, regulations, strategies and roadmaps they need to transition to low-emissions, climate-resilient economies and societies.

Mainstreaming low-carbon, climate-resilient development decision-making into governance is critical for sustainable development and for adapting to climate change.

Loss and damage

New Zealand recognises Pacific Island countries are some of the most exposed in the world to the impacts of climate change. There are indications that some locations have exceeded their adaptation limits already. Economic and non-economic costs are becoming increasingly apparent. New Zealand is currently scoping potential activities that could avert, minimise and address loss and damage.

Most of New Zealand's adaptation work in the Pacific region supports the resilience of communities, livelihoods and ecosystems and helps to minimise the loss and damage associated with climate change (see 'Adaptation' below). It also supports work on early warning systems to prepare for hazards, and financial preparedness and resilience, as the following examples illustrate.

- The Averting Water-related Emergencies activity will create effective early warning systems by supporting Pacific Island countries to anticipate and prepare for water-related emergencies through understanding their vulnerability.
- In 2020, New Zealand provided funding to SPC to establish the Pacific Community Centre for Ocean Science. The centre brings together scientific data and expertise and makes them more readily available to decision-makers in the region. It also provides a platform to coordinate and integrate ocean science activities with international and regional partners.
- New Zealand supports the Pacific Insurance and Climate Adaptation Programme, which will improve the financial preparedness and resilience of Pacific peoples in the face of climate change and natural hazards.

Mitigation

New Zealand's main areas of engagement for mitigation support have been in the energy and agriculture sectors. A priority has been to support renewable energy initiatives through the IDC Programme.

Through its support for affordable, reliable and clean energy sources, New Zealand continues to help partner countries reduce their carbon emissions, improve energy efficiency and pursue low-carbon development pathways. These measures have co-benefits such as increasing energy security, reducing reliance on costly diesel imports and encouraging emerging green industries to grow.

As the cost of renewable energy generation has decreased, New Zealand has worked with other development partners to encourage the private sector to fund and develop commercially viable renewable energy generation projects, particularly in the Pacific region (see 'Private sector' below for more details).

New Zealand continues to champion a coordinated approach among development partners, particularly in the Pacific region. It is a key funder and member of the Pacific Regional Infrastructure Facility (PRIF),³³⁸ which coordinates the Pacific efforts of eight large development partners. The PRIF has an active and effective Energy Sector Working Group, in which development partners coordinate their work and share opportunities for working together in the energy sector. By taking a coordinated, regional approach to renewable energy and energy efficiency projects, PRIF partners will accelerate progress towards achieving Pacific Island countries' renewable energy targets, which form an important part of their Nationally Determined Contributions (NDCs) submitted under the Paris Agreement.

Private sector

New Zealand continues to value private sector expertise and actively seek to crowd in private sector climate finance. The private sector plays an important role in contributing to positive climate change outcomes through knowledge and innovation, investment and responsible business conduct.

New Zealand's IDC Programme supports the private sector to transition to a green economy by strengthening the enabling policy environment, catalysing investment and providing technical assistance across industry sectors.

New Zealand's support for the Asian Development Bank's Pacific Private Sector Development Initiative has enabled the development of policy recommendations for sustainable tourism in the Pacific as part of a post-COVID recovery strategy. New Zealand and the Private Sector Development Initiative also cooperate closely on sustainable tourism programme delivery through the lead regional tourism body, the Pacific Tourism Organisation.

Investment in initiatives to catalyse greater private investment in the green economy is important. In 2020, New Zealand completed the design for InvestPacific, an NZ\$50 million impact investment fund based in New Zealand that will mobilise private investment in the Pacific for inclusive and climate-resilient development. The fund is expected to launch in 2023.

In 2019, New Zealand committed NZ\$4 million to the Pacific Infrastructure Technical Assistance Fund, which provides technical assistance grants to support Pacific Island countries to attract high-quality infrastructure finance. The fund has helped to progress a number of renewable energy and resilient infrastructure projects across the region.

New Zealand supports the Pacific private sector to build more sustainable, climate-resilient businesses through access to business advisory services and concessional finance. In 2020, it committed NZ\$6.94 million to the Pacific Small and Medium Enterprise Finance Facility pilot to enable Pacific small and medium enterprises to adapt to the economic impacts of COVID-19 and build back better by investing in climate mitigation and adaptation, education and green technology.

Special initiatives

New Zealand's Climate Change Development Fund provides NZ\$300,000 each year to help developing countries to deal with climate change challenges. In 2019–20, the fund:

- helped developing country experts to participate in informal workshops relevant to the international negotiations agenda, including on international carbon markets

³³⁸ theprif.org.

- provided supplementary funding to some UNFCCC work programmes, including the Warsaw International Mechanism on Loss and Damage, and for enhancing the capacity of developing countries to participate in the transparency arrangements under the Paris Agreement and the UNFCCC.

Global Research Alliance on Agricultural Greenhouse Gases

New Zealand has provided NZ\$73.5 million to support the GRA's work since it began in 2009. New funding has been agreed to support further international collaboration, build developing countries' capacity through training and awards, and continue New Zealand's leadership in the GRA. The GRA is a major initiative involving the collaboration of 66 developed and developing country members, working with 27 partner organisations to reduce agricultural greenhouse gas (GHG) emissions, enhance soil organic carbon and improve food security.

The following are some of the GRA's projects that have benefited developing countries.

- **Climate, Food and Farming Research Network – Global Research Alliance Development Scholarship (CLIFF-GRADS).** CLIFF-GRADS is a joint initiative of the GRA and the Consultative Group for International Agricultural Research (CGIAR). It aims to build the capability of early-career agriculture students from developing countries to conduct applied research on climate change mitigation in agriculture. The New Zealand Government, the United States Agency for International Development and CGIAR fund CLIFF-GRADS. Since it began in 2017, CLIFF-GRADS has offered more than 120 scholarships to PhD students from developing countries.
- **Agricultural GHG inventory development.** In support of the GRA, New Zealand has delivered capability-building activities to improve livestock GHG measurement and reporting by developing countries. Effective measurement and reporting in this area are prerequisites for enhanced action on mitigation in the livestock sector in NDCs and enable robust domestic policy action. Regional inventory improvement programmes are under way in Latin America, South East Asia and East Africa, building local networks of experts who employ similar systems and can learn from each other. Participants have built their capacity and understanding of improving inventories for livestock systems and the steps needed for developing them in line with national circumstances and priorities.
- **Supporting developing country participation in research.** This work includes participation in European Union funding calls and region-specific projects such as the sustainable intensification of legume-based livestock systems. New Zealand is supporting a Latin American regional project to establish a regional platform of cooperation to strengthen livestock systems based on the use of forage legumes. This work benefits more than 2,500 farmers, technicians, researchers and students in eight countries. It will reduce fertiliser requirements, lead to more resilient and climate-friendly beef production, and develop human resources in a regionally supportive manner.

Table 7.3: Provision of public financial support – summary information, 2019 and 2020 (CTF Table 7)

Table 7.3a: Provision of public financial support – summary information, 2019

Allocation channel	New Zealand dollars (millions) Climate-specific						US dollars (millions) Climate-specific					
	Core/ general	Mitigation	Adaptation	Cross- cutting	Other	Total	Core/ general	Mitigation	Adaptation	Cross- cutting	Other	Total
Total contributions through multilateral channels	30.65	0.94	3.75	34.35		69.69	20.19	0.62	2.47	22.64		45.92
Multilateral climate change funds	0.28		3.00	16.38		19.66	0.19		1.98	10.79		12.96
Multilateral financial institutions, including regional development banks	17.87			13.21		31.08	11.77			8.71		20.48
Specialised United Nations bodies	12.50	0.94	0.75	4.76		18.95	8.23	0.62	0.49	3.14		12.48
Total contributions through bilateral, regional and other channels		11.58	32.39	32.84		76.81		7.63	21.37	21.65		50.65
TOTAL	30.65	12.52	36.14	67.19		146.50	20.19	8.25	23.84	44.29		96.57

Table 7.3b: Provision of public financial support – summary information, 2020

Allocation channel	New Zealand dollars (millions) Climate-specific						US dollars (millions) Climate-specific					
	Core/ general	Mitigation	Adaptation	Cross- cutting	Other	Total	Core/ general	Mitigation	Adaptation	Cross- cutting	Other	Total
Total contributions through multilateral channels	38.01	0.98	1.65	21.23		61.87	24.66	0.64	1.07	13.77		40.14
Multilateral climate change funds	0.40			2.10		2.50	0.26			1.36		1.62
Multilateral financial institutions, including regional development banks	23.01			14.37		37.38	14.93			9.32		24.25
Specialised United Nations bodies	14.60	0.98	1.65	4.76		21.99	9.47	0.64	1.07	3.09		14.27
Total contributions through bilateral, regional and other channels		9.09	41.36	26.96		77.41		5.90	26.87	17.48		50.25
TOTAL	38.01	10.07	43.01	48.19		139.28	24.66	6.54	27.94	31.25		90.39

Table 7.4: Provision of public financial support – contributions through multilateral channels, 2019 and 2020 (CTF Table 7a)

Table 7.4a: Provision of public financial support – contributions through multilateral channels, 2019

Donor funding	Core/general		Climate-specific*		Status	Funding source	Financial instrument	Type of support	Sector
	NZ\$ million	US\$ million	NZ\$ million	US\$ million					
Multilateral climate change funds									
Global Environment Facility	0.28	0.19	1.38	0.91	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Adaptation Fund	0.00	0.00	3.00	1.98	Disbursed	ODA	Grant	Adaptation	Multi-sector
Green Climate Fund	0.00	0.00	15.00	9.88	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Subtotal	0.28	0.19	19.38	12.77					
Multilateral financial institutions, including regional development banks									
World Bank – IDA 18	11.93	7.86	5.36	3.53	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Asian Development Bank – ADF 12	4.79	3.15	1.86	1.23	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Subtotal	16.72	11.01	7.22	4.76					
Specialised United Nations bodies									
United Nations Development Programme	5.60	3.69	2.40	1.58	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
United Nations Environment Programme Montreal Protocol	0.00	0.00	0.94	0.62	Disbursed	ODA	Grant	Mitigation	Multi-sector
United Nations Women	1.75	1.15	0.75	0.49	Disbursed	ODA	Grant	Adaptation	Government and civil society
World Food Programme	4.20	2.77	1.80	1.19	Disbursed	ODA	Grant	Cross-cutting	Humanitarian
International Fund for Agricultural Development	0.95	0.62	0.56	0.37	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Subtotal	12.50	8.23	6.45	4.25					
Other multilateral									
CGIAR – Climate Change, Agriculture and Food Security Programme	0.00	0.00	5.50	3.62	Disbursed	ODA	Grant	Cross-cutting	Agriculture

Donor funding	Core/general		Climate-specific*		Status	Funding source	Financial instrument	Type of support	Sector
	NZ\$ million	US\$ million	NZ\$ million	US\$ million					
Association of Small Island States	0.10	0.07	0.04	0.03	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Commonwealth Small States Office	1.05	0.69	0.45	0.30	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Subtotal	1.15	0.76	5.99	3.95					
TOTAL	30.65	20.19	39.04	25.73					

Note: * OECD's imputed shares for 2019 have been applied for those organisations on the OECD list (Asian Development Bank, Green Climate Fund, Global Environment Facility, International Fund for Agricultural Development and World Bank). For those multilateral organisations not on the OECD list or where imputed shares are not available, New Zealand has applied its standard weighting of 30% (Rio Marker 1) and 100% (Rio Marker 2). CGIAR = Consultative Group for International Agricultural Research; ODA = Official Development Assistance.

Table 7.4b: Provision of public financial support – contributions through multilateral channels, 2020

Donor funding	Core/general		Climate-specific*		Status	Funding source	Financial instrument	Type of support	Sector
	NZ\$ million	US\$ million	NZ\$ million	US\$ million					
Multilateral climate change funds									
Global Environment Facility	0.40	0.26	2.10	1.36	Disbursed	ODA	Grant	Cross-cutting	
Subtotal	0.40	0.26	2.10	1.36					
Multilateral financial institutions, including regional development banks									
World Bank – IDA 18	5.88	3.82	2.77	1.80	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
World Bank – IDA 19	11.76	7.63	5.53	3.59	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Asian Development Bank – ADF12	2.63	1.71	0.39	0.25	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Subtotal	20.27	13.15	8.69	5.64					
Specialised United Nations bodies									
United Nations Development Programme	5.60	3.63	2.40	1.56	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
United Nations Environment Programme	0.00	0.00	0.98	0.64	Disbursed	ODA	Grant	Mitigation	Multi-sector

Donor funding	Core/general		Climate-specific*		Status	Funding source	Financial instrument	Type of support	Sector
	NZ\$ million	US\$ million	NZ\$ million	US\$ million					
Montreal Protocol									
United Nations Women	1.75	1.14	0.75	0.49	Disbursed	ODA	Grant	Adaptation	Governance and civil society
World Food Programme	4.20	2.73	1.80	1.17	Disbursed	ODA	Grant	Cross-cutting	Humanitarian
International Fund for Agricultural Development	0.95	0.61	0.56	0.36	Disbursed	ODA	Grant	Cross-cutting	Agriculture
United Nations Peacebuilding Fund	2.10	1.36	0.90	0.58	Disbursed	ODA	Grant	Adaptation	Governance and civil society
Subtotal	14.60	9.47	7.39	4.79					
Other multilateral									
CGIAR – Climate Change, Agriculture and Food Security Programme	0.00	0.00	4.50	2.92	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Association of Small Island States	0.11	0.07	0.05	0.03	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Commonwealth Small States Office	0.53	0.34	0.23	0.15	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Commonwealth Fund for Technical Cooperation	2.10	1.36	0.90	0.58	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Subtotal	2.74	1.77	5.68	3.68					
TOTAL	38.01	24.66	23.85	15.47					

Note: * OECD's imputed shares for 2020 have been applied for those organisations on the OECD list (Asian Development Bank, Global Environment Facility, International Fund for Agricultural Development and World Bank). For those multilateral organisations not on the OECD list or where imputed shares are not available, New Zealand has applied its standard weighting of 30% (Rio Marker 1) and 100% (Rio Marker 2). CGIAR = Consultative Group for International Agricultural Research; ODA = Official Development Assistance.

Table 7.5: Provision of public financial support – contributions through bilateral, regional and other channels, 2019 and 2020 (CTF Table 7b)

Table 7.5a: Provision of public financial support – contributions through bilateral, regional and other channels, 2019

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Pacific Regional / Climate and Oceans Support Program in the Pacific (COSPPAC)	3.00	1.98	Disbursed	ODA	Grant	Adaptation	Multi-sector
Pacific Regional / World Bank Pacific Facility Trust Fund	1.50	0.99	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Asian Development Bank Pacific Partnership Facility	3.15	2.08	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Cook Islands / Core Sector Support: Bridging Funding 2018–19	2.73	1.80	Disbursed	ODA	Grant	Adaptation	Multi-sector
Cook Islands / Infrastructure Trust Fund	3.60	2.37	Disbursed	ODA	Grant	Adaptation	Multi-sector
Cook Islands / Wastewater Activity	0.33	0.22	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Pacific Regional / Information for Decision-making	0.27	0.18	Disbursed	ODA	Grant	Adaptation	Multi-sector
Pacific Regional / Strengthening Water Security in Selected Pacific Island Countries	0.51	0.34	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Fiji / Social Housing	0.34	0.22	Disbursed	ODA	Grant	Adaptation	Other social infrastructure and services
Fiji / Ease of Doing Business – International Finance Corporation contribution	0.60	0.40	Disbursed	ODA	Grant	Adaptation	Business and other services
Fiji / Dairy Industry Development Initiative	0.45	0.30	Disbursed	ODA	Grant	Adaptation	Agriculture
Fiji / Child-focused Disaster Risk Reduction	0.34	0.23	Disbursed	ODA	Grant	Adaptation	Humanitarian
Fiji / Disaster Risk Management – Tropical Cyclone Winston: Recovery Package	0.20	0.13	Disbursed	ODA	Grant	Adaptation	Humanitarian
Fiji / Ministry for Primary Industries – Biosecurity Authority of Fiji Biosecurity Activity	0.13	0.09	Disbursed	ODA	Grant	Mitigation	Agriculture
Fiji / Tuna Longline Fisheries	0.14	0.09	Disbursed	ODA	Grant	Mitigation	Fishing

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Fiji / Habitat Training for Disaster Risk Reduction in Fiji	0.19	0.12	Disbursed	ODA	Grant	Adaptation	Humanitarian
Pacific Regional / Ocean Acidification Partnership	0.26	0.17	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Pacific Islands Emergency Management Alliance	0.31	0.21	Disbursed	ODA	Grant	Adaptation	Humanitarian
Worldwide / New Zealand Red Cross Partnership 2018–23	0.64	0.42	Disbursed	ODA	Grant	Cross-cutting	Humanitarian
Kiribati / Energy and Public Utility Reform	0.13	0.08	Disbursed	ODA	Grant	Mitigation	Energy
Kiribati / Improved Sanitation	0.22	0.15	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Kiribati / Energy Project (Kiritimati)	0.16	0.10	Disbursed	ODA	Grant	Mitigation	Energy
Kiribati / Water	0.18	0.12	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Caribbean / Caribbean Geothermal Technical Assistance Phase II	2.33	1.54	Disbursed	ODA	Grant	Mitigation	Energy
Colombia / Dairy Value Chain Project	0.10	0.07	Disbursed	ODA	Grant	Adaptation	Agriculture
Peru / Dairy Initiative	0.26	0.17	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Pacific Regional / Strengthening Pacific Monitoring, Evaluation and Learning (MEL) Capacity	0.11	0.07	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Nauru / Energy Efficiency	0.34	0.23	Disbursed	ODA	Grant	Cross-cutting	Energy
Nauru / Renewable Energy Initiative	1.95	1.29	Disbursed	ODA	Grant	Mitigation	Energy
Pacific Regional / Energy: North West Pacific Design	0.26	0.17	Disbursed	ODA	Grant	Mitigation	Energy
Niue / Strengthen Governance: Infrastructure	0.90	0.59	Disbursed	ODA	Grant	Adaptation	Government and civil society
Niue / Niue Renewable Energy Activity	1.21	0.80	Disbursed	ODA	Grant	Cross-cutting	Energy
Federated States of Micronesia / Energy Initiative	0.92	0.61	Disbursed	ODA	Grant	Mitigation	Energy
Republic of Marshall Islands / Energy Initiative	0.64	0.42	Disbursed	ODA	Grant	Mitigation	Energy
Palau / Energy Initiatives	0.17	0.11	Disbursed	ODA	Grant	Mitigation	Energy
Sri Lanka / Dairy Excellence Training	0.17	0.11	Disbursed	ODA	Grant	Adaptation	Agriculture

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Sri Lanka / Dairy Expansion in Dry Zone	0.28	0.19	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Pacific Regional / Support: Office of the Pacific Ocean Commissioner	0.43	0.28	Disbursed	ODA	Grant	Adaptation	Multi-sector
Pacific Regional / Pacific Islands Forum Secretariat 2018–20	2.02	1.33	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Climate Change Programme Design	0.67	0.44	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Support to the Pacific Climate Change Centre	1.17	0.77	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Asian Development Bank Pacific Renewable Energy Program	4.52	2.98	Disbursed	ODA	Grant	Cross-cutting	Energy
Pacific Regional / Pacific Regional Infrastructure Facility – Phase Four	1.35	0.89	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Improve Decision-making through Ocean Knowledge	1.23	0.81	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Pacific Voice	0.77	0.51	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Forum Fisheries Agency 2015–21 core funding	1.62	1.07	Disbursed	ODA	Grant	Adaptation	Fishing
Pacific Regional / Secretariat of the Pacific Regional Environment Programme (SPREP) Programme Support 2016–19	1.53	1.01	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Recognised Seasonal Employer Worker Training Programme II (RSE WTP II)	0.32	0.21	Disbursed	ODA	Grant	Adaptation	Education
Pacific Regional / Pacific Community (SPC) 2017–19	0.69	0.45	Disbursed	ODA	Grant	Adaptation	Multi-sector
Pacific Regional / Local Government Technical Assistance Facility 2017–22	0.24	0.16	Disbursed	ODA	Grant	Adaptation	Government and civil society
Pacific Regional / Improving Pacific Access to Climate Finance	0.89	0.59	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Papua New Guinea / Private Sector Development: PNG Partnership (International Finance Corporation)	2.25	1.48	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Papua New Guinea / Water, Sanitation and Hygiene	0.20	0.13	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Pacific Regional / Pacific Response to Coconut Rhinoceros Beetle	0.73	0.48	Disbursed	ODA	Grant	Adaptation	Agriculture

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Pacific Regional / Rhinoceros Beetle Biocontrol	0.12	0.08	Disbursed	ODA	Grant	Adaptation	Agriculture
Worldwide / Volunteer Service Abroad 2018–23	2.74	1.81	Disbursed	ODA	Grant	Adaptation	Multi-sector
Worldwide / Negotiated Partnerships: Design and Due Diligence	0.19	0.12	Disbursed	ODA	Grant	Adaptation	Multi-sector
Samoa / Habitat Disaster Risk Reduction	0.60	0.39	Disbursed	ODA	Grant	Adaptation	Humanitarian
Samoa / Renewable Energy Partnership	0.88	0.58	Disbursed	ODA	Grant	Cross-cutting	Energy
Samoa / Tourism Infrastructure – Apia Waterfront Development	0.51	0.34	Disbursed	ODA	Grant	Adaptation	Multi-sector
Samoa / Cocoa Industry Development Initiative	0.45	0.30	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Solomon Islands / Provincial Airfield Upgrades	0.15	0.10	Disbursed	ODA	Grant	Adaptation	Transport and storage
Solomon Islands / Coconut Rhinoceros Beetle Response	0.15	0.10	Disbursed	ODA	Grant	Adaptation	Agriculture
Solomon Islands / Building Ecotourism in the Arnavons	0.30	0.20	Disbursed	ODA	Grant	Adaptation	Multi-sector
Solomon Islands / Fisheries Development	0.63	0.42	Disbursed	ODA	Grant	Adaptation	Fishing
Solomon Islands / Renewable Energy Scoping Study	1.83	1.20	Disbursed	ODA	Grant	Cross-cutting	Energy
Tokelau / Coastal Risk Mitigation	0.45	0.30	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Tokelau / Renewable Energy Expansion and Renewal	2.50	1.65	Disbursed	ODA	Grant	Mitigation	Energy
Tokelau / Wharf and Reef Channel Rehabilitation	0.38	0.25	Disbursed	ODA	Grant	Adaptation	Transport and storage
Tonga / Energy: Nuku'alofa Network Upgrade Project	1.05	0.69	Disbursed	ODA	Grant	Cross-cutting	Energy
Tuvalu / Tuvalu Trust Fund Contributions	0.90	0.59	Disbursed	ODA	Grant	Adaptation	Government and civil society
Tuvalu / Budget Support (Policy Reform Matrix)	0.30	0.20	Disbursed	ODA	Grant	Adaptation	Government and civil society
Vanuatu / Growing Market Opportunities for Tanna Farmers	0.13	0.09	Disbursed	ODA	Grant	Adaptation	Agriculture
Vanuatu / Inter-island Shipping Support Project Additional Support – South Paray	0.14	0.09	Disbursed	ODA	Grant	Adaptation	Transport and storage
Vanuatu / Support to Wan Smolbag 2015–19	0.28	0.19	Disbursed	ODA	Grant	Adaptation	Government and civil society

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Vanuatu / Water Sector Partnership 2017–21	0.62	0.41	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Myanmar / Renewable Energy Programme	0.41	0.27	Disbursed	ODA	Grant	Mitigation	Energy
Indonesia / Livelihood Support in Eastern Indonesia	0.38	0.25	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Myanmar / Dairy Inclusive Growth and Investment	0.20	0.13	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Cambodia / Climate-smart Commercial Horticulture	0.56	0.37	Disbursed	ODA	Grant	Adaptation	Agriculture
Indonesia / Strengthening Disaster Resilience	0.29	0.19	Disbursed	ODA	Grant	Adaptation	Multi-sector
Myanmar / Rakhine Winter Cropping Activity	0.84	0.55	Disbursed	ODA	Grant	Adaptation	Agriculture
Indonesia / Innovative Agribusiness	0.21	0.14	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Viet Nam / Dam Safety Project	0.44	0.29	Disbursed	ODA	Grant	Adaptation	Humanitarian
Indonesia / Accelerating Geothermal Development	0.41	0.27	Disbursed	ODA	Grant	Mitigation	Energy
Indonesia / Improving Energy Access in Maluku	0.42	0.28	Disbursed	ODA	Grant	Mitigation	Energy
Myanmar / Matupi Sustainable Rural Economic Development (SURE)	0.19	0.12	Disbursed	ODA	Grant	Adaptation	Multi-sector
Indonesia / Supporting Geothermal Sector Training	0.69	0.46	Disbursed	ODA	Grant	Mitigation	Energy
Indonesia / Better Warehousing	0.39	0.26	Disbursed	ODA	Grant	Adaptation	Humanitarian
Myanmar / Dairy Industry and Veterinary Training	0.27	0.18	Disbursed	ODA	Grant	Adaptation	Agriculture
Asia Regional / Lao PDR and Cambodia Renewable Energy Facility	1.58	1.04	Disbursed	ODA	Grant	Cross-cutting	Energy
Lao PDR / Quality Beef Initiative	0.35	0.23	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Cambodia / Quality Horticulture Initiative	0.37	0.24	Disbursed	ODA	Grant	Adaptation	Agriculture
Myanmar / Better Warehousing and Logistics	0.15	0.10	Disbursed	ODA	Grant	Adaptation	Multi-sector
Viet Nam / Dragon Fruit Development	0.21	0.14	Disbursed	ODA	Grant	Adaptation	Agriculture
Kenya / Strengthened Avocado Value Chain	0.20	0.13	Disbursed	ODA	Grant	Adaptation	Agriculture
Comoros / Support for Realisation of Geothermal Potential	0.22	0.14	Disbursed	ODA	Grant	Mitigation	Energy

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Zambia / Dairy Transformation Programme	0.41	0.27	Disbursed	ODA	Grant	Adaptation	Agriculture
Africa Regional / Africa Geothermal Assistance Facility	0.51	0.34	Disbursed	ODA	Grant	Cross-cutting	Energy
Other / Adaptation	1.26	0.83	Disbursed	ODA	Grant	Adaptation	Multi-sector
Other / Mitigation	0.10	0.06	Disbursed	ODA	Grant	Mitigation	Multi-sector
Other / Cross-cutting	0.80	0.52	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
TOTAL	76.81	50.65					

Note: * Bilateral activities with a moderated (climate-specific) value of less than NZ\$100,000 have been grouped together and are listed at the end of this table as 'Other' in the 'Country' column. Lao PDR = Lao People's Democratic Republic; ODA = Official Development Assistance.

Table 7.5b: Provision of public financial support – contributions through bilateral, regional and other channels, 2020

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Pacific Regional / Invasive Species Management	2.09	1.35	Disbursed	ODA	Grant	Adaptation	Multi-sector
Pacific Regional / Climate Mobility	2.00	1.30	Disbursed	ODA	Grant	Adaptation	Multi-sector
Pacific Regional / Averting Water-related Emergencies	0.25	0.16	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Pacific Regional / Reduce Risk of Water Scarcity	3.33	2.16	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Cook Islands / Wastewater Activity	0.24	0.16	Disbursed	OOF	Grant	Adaptation	Water and sanitation
Pacific Regional / Design and Delivery	1.00	0.65	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Low-emissions, Climate-resilient Planning	0.55	0.35	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Fiji / Disaster Risk Management	0.46	0.30	Disbursed	ODA	Grant	Adaptation	Multi-sector
Fiji / Ease of Doing Business – International Finance Corporation contribution	0.60	0.39	Disbursed	ODA	Grant	Adaptation	Business and other services

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Fiji / RISE – Upgrades for Informal Settlements	2.00	1.30	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Fiji / Fiji Relocation Trust Fund	0.50	0.32	Disbursed	ODA	Grant	Adaptation	Other social infrastructure and services
Fiji / Dairy Industry Development Initiative	0.40	0.26	Disbursed	ODA	Grant	Adaptation	Agriculture
Fiji / Habitat Training for Disaster Risk Reduction in Fiji	0.21	0.13	Disbursed	ODA	Grant	Adaptation	Humanitarian
Pacific Regional / Mainstreaming Climate Change in Governance	3.75	2.43	Disbursed	ODA	Grant	Cross-cutting	Governance and civil society
Pacific Regional / Pacific Islands Emergency Management Alliance	0.30	0.19	Disbursed	ODA	Grant	Adaptation	Humanitarian
Worldwide / Disability-inclusive Humanitarian Action	0.13	0.09	Disbursed	ODA	Grant	Adaptation	Humanitarian
Pacific Regional / New Zealand Red Cross Partnership	0.64	0.42	Disbursed	ODA	Grant	Cross-cutting	Humanitarian
Caribbean Regional / Agriculture and Tourism Support	0.17	0.11	Disbursed	ODA	Grant	Adaptation	Agriculture
Caribbean Regional / Caribbean Geothermal Technical Assistance Phase II	1.31	0.85	Disbursed	ODA	Grant	Mitigation	Energy
Peru / Dairy Initiative	0.13	0.08	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Pacific Regional / Strengthening Pacific Monitoring, Evaluation and Learning (MEL) Capacity	0.14	0.09	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Pacific Climate Change Mobility Scoping Study	0.13	0.09	Disbursed	ODA	Grant	Adaptation	Multi-sector
Nauru / Energy Efficiency	0.15	0.10	Disbursed	ODA	Grant	Cross-cutting	Energy
Nauru / Renewable Energy Initiative	0.77	0.50	Disbursed	ODA	Grant	Mitigation	Energy
Niue / Strengthen Governance: Infrastructure	0.61	0.40	Disbursed	ODA	Grant	Adaptation	Government and civil society
Niue / Renewable Energy Activity	0.22	0.15	Disbursed	ODA	Grant	Cross-cutting	Energy
Federated States of Micronesia / Energy Initiative	0.20	0.13	Disbursed	ODA	Grant	Mitigation	Energy
Republic of Marshall Islands / Energy Initiative	0.15	0.10	Disbursed	ODA	Grant	Mitigation	Energy
Palau / Energy Initiatives	0.31	0.20	Disbursed	ODA	Grant	Mitigation	Energy
Palau / Support to Our Ocean 2020	0.20	0.13	Disbursed	ODA	Grant	Cross-cutting	Multi-sector

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Palestine / Renewable Energy (Office of the Quartet)	0.19	0.12	Disbursed	ODA	Grant	Cross-cutting	Energy
Sri Lanka / Dairy Excellence Training	0.14	0.09	Disbursed	ODA	Grant	Adaptation	Agriculture
Sri Lanka / Dairy Expansion in Dry Zone	0.19	0.12	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Pacific Regional / Support: Office of the Pacific Ocean Commissioner	0.15	0.09	Disbursed	ODA	Grant	Adaptation	Multi-sector
Pacific Regional / Climate Change Programme Design	0.30	0.19	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Pacific Community (SPC) Core Funding 2020–24	5.39	3.50	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / University of the South Pacific Partnership	1.50	0.97	Disbursed	ODA	Grant	Cross-cutting	Education
Pacific Regional / Improving Ecosystem Resilience: Kiwa Initiative	1.00	0.65	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / InvestPacific	0.13	0.09	Disbursed	ODA	Grant	Cross-cutting	Financial services
Pacific Regional / Pacific Public Sector Strengthening	1.43	0.93	Disbursed	ODA	Grant	Adaptation	Governance and civil society
Pacific Regional / Pacific Regional Nationally Determined Contribution (NDC) Hub	0.55	0.36	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Pacific Infrastructure Technical Assistance Facility	0.17	0.11	Disbursed	ODA	Grant	Cross-cutting	Construction
Pacific Regional / Pacific Voice	0.11	0.07	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Secretariat of the Pacific Regional Environment Programme (SPREP) 2020–25	2.08	1.35	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Pacific Regional / Forum Fisheries Agency 2015–21 core funding	1.38	0.90	Disbursed	ODA	Grant	Adaptation	Fishing
Pacific Regional / Recognised Seasonal Employer Worker Training Programme II (RSE WTP II)	0.23	0.15	Disbursed	ODA	Grant	Adaptation	Education
Pacific Regional / Local Government Technical Assistance Facility 2017–22	0.27	0.17	Disbursed	ODA	Grant	Adaptation	Government and civil society
Papua New Guinea / Private Sector Development: PNG Partnership (International Finance Corporation)	1.05	0.68	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Papua New Guinea / Farming Livelihoods (HARVEST)	0.10	0.07	Disbursed	ODA	Grant	Adaptation	Agriculture
Pacific Regional / Pacific Response to Coconut Rhinoceros Beetle	0.51	0.33	Disbursed	ODA	Grant	Adaptation	Agriculture

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Worldwide / Volunteer Service Abroad 2018–23	2.07	1.34	Disbursed	ODA	Grant	Adaptation	Multi-sector
Pacific Regional / Pacific Seeds for Life (PS4L)	0.39	0.25	Disbursed	ODA	Grant	Adaptation	Agriculture
Worldwide / Negotiated Partnerships: Design and Due Diligence	0.11	0.07	Disbursed	ODA	Grant	Adaptation	Multi-sector
Samoa / Habitat Disaster Risk Reduction	0.39	0.25	Disbursed	ODA	Grant	Adaptation	Humanitarian
Samoa / Improved Livelihoods Cocoa	0.14	0.09	Disbursed	ODA	Grant	Adaptation	Agriculture
Samoa / Incentivising Economic Reform 2018–21	2.50	1.62	Disbursed	ODA	Grant	Cross-cutting	General programme assistance
Samoa / Tourism Infrastructure – Apia Waterfront Development	0.30	0.20	Disbursed	ODA	Grant	Adaptation	Tourism
Samoa / Cocoa Industry Development Initiative	0.24	0.15	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Solomon Islands / Forest Conservation	0.21	0.14	Disbursed	ODA	Grant	Adaptation	Multi-sector
Solomon Islands / Building Ecotourism in the Arnavons	0.26	0.17	Disbursed	ODA	Grant	Adaptation	Multi-sector
Solomon Islands / Fisheries New Phase 2020–24	0.88	0.57	Disbursed	ODA	Grant	Adaptation	Fishing
Timor Leste / Crop Diversification	1.43	0.93	Disbursed	ODA	Grant	Mitigation	Agriculture
Tokelau / Coastal Risk Mitigation	0.14	0.09	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Tokelau / Budget Support 2020/21	2.25	1.46	Disbursed	ODA	Grant	Adaptation	General programme assistance
Tokelau / Renewable Energy Expansion and Renewal	2.50	1.62	Disbursed	ODA	Grant	Mitigation	Energy
Tonga / Energy: Nuku’alofa Network Upgrade Project	0.75	0.49	Disbursed	ODA	Grant	Cross-cutting	Energy
Tonga / Parliament Buildings Project	0.22	0.15	Disbursed	ODA	Grant	Adaptation	Multi-sector
Tonga / Incentivising Public Sector Reform 2019–21	2.50	1.62	Disbursed	ODA	Grant	Adaptation	General programme assistance
Tonga / Community Shelter Resilience	1.16	0.76	Disbursed	ODA	Grant	Adaptation	Multi-sector
Tuvalu / Vaitupu Water Security	0.30	0.19	Disbursed	ODA	Grant	Adaptation	Multi-sector
Tuvalu / Budget Support (Policy Reform Matrix)	0.60	0.39	Disbursed	ODA	Grant	Adaptation	Governance and civil society
Tuvalu / Fisheries Support Programme 2020–25	0.44	0.29	Disbursed	ODA	Grant	Adaptation	Multi-sector

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Vanuatu / Inter-island Shipping Support Project Additional Support – South Paray	0.38	0.25	Disbursed	ODA	Grant	Adaptation	Transport and storage
Vanuatu / Santo WASH Project in Vanuatu	0.11	0.07	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Vanuatu / Support to Wan Smolbag 2015–19	0.34	0.22	Disbursed	ODA	Grant	Adaptation	Government and civil society
Vanuatu / Water Sector Partnership 2017–21	1.10	0.71	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Myanmar / Renewable Energy Programme	–0.18	–0.12	Disbursed	ODA	Grant	Mitigation	Energy
Indonesia / Palu Earthquake Recovery	0.12	0.08	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Myanmar / Dairy Inclusive Growth and Investment	0.14	0.09	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Cambodia / Climate-smart Commercial Horticulture	0.48	0.31	Disbursed	ODA	Grant	Adaptation	Agriculture
Asia Regional / ASEAN Climate-smart Agriculture Initiative	1.25	0.81	Disbursed	ODA	Grant	Mitigation	Agriculture
Asia Regional / Support to the Mekong River Commission	0.30	0.19	Disbursed	ODA	Grant	Adaptation	Water and sanitation
Myanmar / Promoting Rural Electrification	1.38	0.90	Disbursed	ODA	Grant	Mitigation	Energy
Myanmar / Livelihoods and Food Security Fund	0.75	0.49	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
Cambodia / Angkor Governance Support	0.12	0.08	Disbursed	ODA	Grant	Mitigation	Government and civil society
Indonesia / Strengthening Disaster Resilience	0.15	0.10	Disbursed	ODA	Grant	Adaptation	Multi-sector
Myanmar / Rakhine Winter Cropping Activity	0.21	0.14	Disbursed	ODA	Grant	Adaptation	Agriculture
Indonesia / Innovative Agribusiness	0.16	0.10	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Viet Nam / Dam Safety Project	0.33	0.22	Disbursed	ODA	Grant	Adaptation	Humanitarian
Indonesia / Accelerating Geothermal Development	0.17	0.11	Disbursed	ODA	Grant	Mitigation	Energy
Indonesia / Improving Energy Access in Maluku	0.35	0.22	Disbursed	ODA	Grant	Mitigation	Energy
Myanmar / Matupi Sustainable Rural Economic Development (SURE)	0.17	0.11	Disbursed	ODA	Grant	Adaptation	Multi-sector
Indonesia / Supporting Geothermal Sector Training	0.26	0.17	Disbursed	ODA	Grant	Mitigation	Energy
Indonesia / Better Warehousing	0.28	0.18	Disbursed	ODA	Grant	Adaptation	Humanitarian

Recipient country/programme/activity*	Total amount climate-specific NZ\$ million	Total amount climate-specific US\$ million	Status	Funding source	Financial instrument	Type of support	Sector
Myanmar / Dairy Industry and Veterinary Training	0.21	0.14	Disbursed	ODA	Grant	Adaptation	Agriculture
ASEAN / Lao PDR and Cambodia Renewable Energy Facility	1.39	0.90	Disbursed	ODA	Grant	Cross-cutting	Energy
Lao PDR / Quality Beef Initiative	0.20	0.13	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Cambodia / Quality Horticulture Initiative	0.22	0.14	Disbursed	ODA	Grant	Adaptation	Agriculture
Myanmar / Better Warehousing and Logistics	0.32	0.22	Disbursed	ODA	Grant	Adaptation	Multi-sector
Myanmar / Resilient Horticulture	0.21	0.14	Disbursed	ODA	Grant	Adaptation	Agriculture
Viet Nam / Dragon Fruit Development	0.20	0.13	Disbursed	ODA	Grant	Adaptation	Agriculture
Worldwide / Save the Children New Zealand Implementation	0.74	0.48	Disbursed	ODA	Grant	Adaptation	Multi-sector
Worldwide / World Vision New Zealand Implementation	1.31	0.85	Disbursed	ODA	Grant	Adaptation	Multi-sector
Worldwide / ChildFund New Zealand Implementation	0.75	0.49	Disbursed	ODA	Grant	Adaptation	Multi-sector
Africa Regional / African Climate-smart Agriculture Initiative	0.40	0.26	Disbursed	ODA	Grant	Mitigation	Agriculture
Africa Regional / East Africa: Farm to Market Alliance	0.42	0.27	Disbursed	ODA	Grant	Adaptation	Agriculture
Zambia / Dairy Transformation Programme	0.42	0.27	Disbursed	ODA	Grant	Adaptation	Agriculture
Africa Geothermal / Africa Geothermal Assistance Facility	0.57	0.37	Disbursed	ODA	Grant	Cross-cutting	Energy
Other / Adaptation	1.43	0.93	Disbursed	ODA	Grant	Adaptation	Multi-sector
Other / Mitigation	0.10	0.07	Disbursed	ODA	Grant	Mitigation	Multi-sector
Other / Cross-cutting	0.56	0.36	Disbursed	ODA	Grant	Cross-cutting	Multi-sector
TOTAL	77.41	50.25					

Note: * Bilateral activities with a moderated (climate-specific) value of less than NZ\$100,000 have been grouped together and are listed at the end of this table as 'Other' in the 'Country' column. ASEAN = Association of Southeast Asian Nations; Lao PDR = Lao People's Democratic Republic; ODA = Official Development Assistance; RISE = Revitalising Informal Settlements and their Environments.

7.3 Technology development and transfer

The development and transfer of climate-friendly technologies is critical for reducing GHG emissions and adapting to the impacts of climate change, including achieving the goals of the Paris Agreement. Aotearoa New Zealand is committed to promoting, facilitating and financing the transfer of, access to and deployment of climate-friendly technologies for the benefit of developing countries.

Technology transfer helps both developed and developing countries reduce the cost of tackling climate change, while also stimulating opportunities for sustainable development. Practical assistance and cooperative action to accelerate technology development and transfer to help developing country Parties are, therefore, priorities for New Zealand. During the reporting period, New Zealand delivered on these commitments through the New Zealand IDC Programme and the GRA. This section reports on these commitments in text and tables, which also reference other sections of this chapter where relevant.

7.3.1 Technology transfer delivered through the New Zealand IDC Programme

As detailed in section 7.2.3, country partnerships are at the heart of New Zealand's climate-related support, and countries' identified priorities are central to the development support New Zealand provides. Its IDC Programme is committed to supporting climate change action in developing countries. Particular areas of focus are the Pacific region, renewable energy and agriculture; these areas are reflected in the sectors most strongly represented in table 7.6. In addition, New Zealand has supported a number of technology transfer activities in South East Asia, Africa, the Caribbean and Latin America, through both the IDC Programme and the GRA, as outlined in table 7.6 and table 77.

As detailed under 'Mitigation' in section 7.2.3, a priority for the IDC Programme has been supporting energy initiatives to enable access to affordable, reliable and clean energy sources, reducing carbon emissions, improving energy efficiency and creating low-carbon development pathways. Table 7.5 in section 7.2.3 gives several examples of energy projects that promoted, facilitated and financed technology transfer for the benefit of developing country Parties, and the majority of mitigation activities listed in table 7.6 are energy activities.

Another priority in the IDC Programme has been supporting adaptation projects that reduce the vulnerability of human and natural systems to the impacts of climate change by increasing community and infrastructure resilience. Many of the activities identified in table 7.6 aim to help communities better meet the challenges of more extreme weather events, the increasing risk of drought, sea-level rise, and changes in fisheries resources. Section 7.2.3, under 'Adaptation', details a number of these projects, including those focused on water and sanitation, agriculture and disaster-resilient infrastructure.

Success stories

Tonga Village Network Upgrade Programme and Nuku'alofa Network Upgrade Project

This activity built and embedded capability in the Tongan electricity utility to undertake all of its own network upgrades and repairs. It involved training a large group of Tongans to New Zealand line mechanic standards, while completely upgrading the electricity network on the main island of Tongatapu.

In 2020, Tropical Cyclone Harold hit Tonga, causing widespread damage. On Tongatapu, where lines had previously been upgraded, damage was relatively minor and power cables were reinstated relatively easily. The Tonga Power team were able to assess damage across all island groups quickly and came up with a plan to rehabilitate damaged lines. They had the necessary materials held in stock on Tongatapu for the network upgrade programmes, meaning they required no materials from overseas. They also had a large number of well-trained and experienced line mechanics to undertake the repairs. Power was restored quickly to all islands without the need to send overseas line crews in to help, as has been the normal practice following cyclone damage in Pacific countries. Being able to complete the repairs independently was particularly beneficial as Tonga had effectively closed its borders to keep out the COVID-19 pandemic.

The extended length of the programme with continued support from New Zealand and more recently other development partners has meant that line mechanics who were first trained have been able to build and maintain their skills, and then pass them on to new groups of line mechanics.

The original approach involved partnering the local utility with a line company and training organisation both based in New Zealand, which built an enduring partnership. A crucial element of the programme's success was that Tongan line mechanics spent considerable time in New Zealand working with line mechanics there and undertaking training. Some line mechanics have chosen to stay in New Zealand or move to Australia, which has resulted in high remittances back to Tonga from well-paid, skilled work. Because the programme trained twice the number of line mechanics needed for the work in Tonga, the choice of some line mechanics to work in other countries has not disrupted the upgrading work on Tonga.

This activity had a life span of 10 years, 2012–21, and a total funding package of NZ\$42.1 million.

Lessons learnt

Nauru Energy Efficiency

The activity's aim is to increase Nauru's economic resilience by increasing energy efficiency and therefore reducing the amount of imported fossil fuel. It involves scoping all potential energy efficiency opportunities and then implementing the most impactful and cost-effective. This is the first project in Nauru to address energy efficiency and uses New Zealand's wealth of experience and capability in this often overlooked energy subsector.

Within this activity, the transferred technologies include:

- monitoring equipment for disaggregating electricity use in buildings
- energy-efficient appliances, lighting and equipment.

The lesson learnt in this activity is that the energy sector has a lot of interconnected parts and, for best results, a holistic approach that covers the entire energy sector is needed. While energy efficiency is often overlooked, work to improve it is much cheaper than building more renewable energy generation. Within this holistic approach, the activity includes scoping the potential efficiencies by reducing transport energy and associated emissions.

This activity has a life span of five years, 2019–24, and a total funding package of NZ\$4.9 million.

Activity Evaluations for the International Development Cooperation Programme

Evaluations are critical to running a successful and credible IDC Programme. Any completed activity that was high risk or had high strategic value is independently evaluated. These evaluations identify what worked, how it worked, for who, what did not work, why it did not work and ways to make sure it works in the future. Evaluations of IDC Programme activities are carried out by external evaluators and they complement our internal monitoring and review processes. These evaluations are publicly available at www.mfat.govt.nz/en/aid-and-development/our-approach-to-aid/evaluation-and-research.

Global Research Alliance on Agricultural Greenhouse Gases

In addition to delivering technology transfer through its IDC Programme, through its support of the GRA New Zealand promotes and facilitates the development of agriculture-specific endogenous and non-endogenous capacities and technologies of developing country Parties. New Zealand's support enables developing countries to implement their commitments, in particular by:

- developing national agricultural GHG inventories
- developing, applying and diffusing – including transferring – technologies, practices and processes that control, reduce or prevent GHGs in the agriculture sector
- conserving and enhancing GHG sinks and reservoirs in terrestrial ecosystems.

These outcomes are achieved through a range of research, education, training and public awareness activities, focused mainly on mitigation but with some adaptation components. Activities include:

- assisting countries to develop and/or improve their agriculture GHG inventories in ways that are consistent with their national circumstances, priorities and capacities (see table 7.6)
- providing training to South East Asian, African and Latin American countries to improve agricultural development strategies that aim for low GHG emissions and reduce vulnerability or increase resilience to climate change (see table 7.6)
- investing in the establishment of measurement hubs in ASEAN and Africa by providing training on the use of equipment and installing required equipment to measure GHG emissions (see table 7.6).

Explanation of information in tables 7.6 and 7.7

During the reporting period, New Zealand's support for technology transfer included 'hard' technology – tangible components – and 'soft' technology, which includes information and knowledge sharing, training and research. Much of this support is a combination of both hard and soft technology, to help ensure that the management and development of climate-friendly technologies are country relevant, sustainable and long-lasting. Table 7.6 includes examples of both hard- and soft-technology transfer, with many of the activities identified combining both.

Similarly, most of the activities identified in table 7.6 are a combination of endogenous and non-endogenous technology transfer. This helps to ensure that technology transfer is implemented in country-specific ways, building on existing knowledge and practices, and using local governance structures. In recognition of this dual approach, table 7.6 does not differentiate between endogenous and non-endogenous technology transfer unless specified.

As detailed in section 7.2.3, New Zealand follows several development principles when providing climate-related support through its IDC Programme, including ownership, alignment, donor harmonisation, results focus and transparency. Because these principles are applied in the delivery of all development support, the column 'Factors that led to the project's success' in table 7.6 identifies these criteria.

The GRA applies a different funding criterion. Where possible, therefore, table 7.7, which focuses on technology transfer delivered through the GRA, identifies factors that led to a project's success in a different way from table 7.6, with its focus on the New Zealand IDC Programme. These factors are not always recorded for GRA activities, and so some of the activities in table 7.7 do not include factors that led to a project's success.

Table 7.6: Technology transfer delivered through the New Zealand IDC Programme (CTF Table 8)

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Agriculture and Tourism Support	Increasing climate resilience, reducing <i>Sargassum</i> on the beaches of the Caribbean and increasing regional food security	Caribbean	Agriculture	Adaptation	Supporting the Caribbean's goal of addressing <i>Sargassum</i> arrival on local beaches, by investigating potential uses for <i>Sargassum</i> and causes of arrival	2019–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Creating technology or value chains from the floating <i>Sargassum</i>	Public	Refer to table 7.5
Dairy Value Chain Project	Increasing the productivity and incomes of small- to medium-scale dairy farmers in the Colombian high tropics	Colombia	Agriculture	Adaptation	Improving productivity and incomes of small- to medium-scale dairy farmers, by adapting farm management practices and systems, and increasing the capacity of Colombia's training	2018–22	Establishing a coalition of agricultural technology companies that work together to service the demand for dairy technology in Colombia	Adapted New Zealand dairy farming systems and industry knowledge to the Colombian context	Public	Refer to table 7.5a
Dairy Initiative	Increasing the productivity and incomes of small- to medium-scale dairy farmers in the Peruvian Sierra	Peru	Agriculture	Cross-cutting	Increasing the adoption of improved milk and cheese production, handling and processing practices. Supported by effective research and extension systems	2017–21	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Established processing plants to trial and demonstrated best practices in improving raw milk and cheese quality assurance practices	Public	Refer to table 7.5

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Dairy Excellence Training	Improving dairy-related incomes and standard of living in Sri Lanka, and contributing to an increased supply of local milk, through improved knowledge and skills from extension training	Sri Lanka	Agriculture	Adaptation	Supporting Sri Lanka's Ministry of Rural Economic Affairs to develop and roll out in-service training that enables livestock development staff to act as dairy advisors	2017–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Improved knowledge and skills from extension training	Public	Refer to table 7.5
Pacific Response to Coconut Rhinoceros Beetle	Supporting the Pacific to respond to the invasion of a new strain of coconut rhinoceros beetle	Pacific	Agriculture	Adaptation	Providing tools and strategies required to effectively manage the coconut rhinoceros beetle	2019–29	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	An integrated pest management approach that brings together scientifically proven control methods in a single package, allowing effective implantation	Public	Refer to table 7.5
Pacific Seeds for Life	Achieving food-secure and resilient communities across the Pacific	Vanuatu, Fiji, Tonga, Samoa, Tuvalu, Kiribati	Agriculture	Adaptation	Supporting the development of an enabling national-level environment through research, regulations, training, and awareness raising and improving seed and planting material production	2020–24	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Upgrading facilities and equipment for Centre for Pacific Crops and Trees molecular lab, technical support to improve the quality of collection , and sourcing new seeds and planting varieties for the region	Public	Refer to table 7.5b

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Cocoa Industry Development Initiative	Encouraging smallholder cocoa growers to produce larger volumes of cocoa by increasing their capabilities in on-farm and post-harvest practices	Samoa	Agriculture	Cross-cutting	Increasing the value and volume of Samoan cocoa export and financial returns through increased investment and sustainable production and quality management	2017–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	New methods of seedling planting by providing appropriate seedling bags to ensure trees can withstand harsh conditions such as cyclones	Public	Refer to table 7.5
ASEAN Climate-smart Agriculture Initiative	Supporting ASEAN countries to shift to low-emissions agriculture and improving agricultural productivity and returns	Asia	Agriculture	Mitigation	Enabling ASEAN countries to increase their engagement with the GRA in order to develop and implement effective technologies/practices to mitigate agricultural greenhouse gas emissions, and to build regional capability in agricultural emissions measurement	2020–25	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Identifying low-emissions agriculture systems, technologies and practices	Public	Refer to table 7.5b
Rakhine Winter Cropping Activity	Improving food security and generating more sustainable farming systems in Rakhine State	Myanmar	Agriculture	Cross-cutting	Improving agriculture farm systems to be more resilient through better water management and crop diversification	2017–20	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Better water harvesting, storage and irrigation systems. New agriculture techniques, seed varieties and tools	Public	Refer to table 7.5

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Dairy Industry and Veterinary Training	Livestock educational institutions and vocational training systems provide more qualified people	Myanmar	Agriculture	Adaptation	Supporting dairy and beef farmers to increase output and achieve higher income through new knowledge, skills and technologies	2017–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Improved knowledge and skills from new training	Public	Refer to table 7.5
Quality Beef Initiative	An expanded and viable beef industry and value chain producing high-quality, safe meat for consumers	Lao PDR	Agriculture	Cross-cutting	Providing farm demonstrations and training in profitable beef production systems to smallholder farmers, and delivering training that enhances food safety for consumers	2017–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Improved knowledge and skills from new training	Public	Refer to table 7.5
Quality Horticulture Initiative	Sector growth through delivering on market demand for high-quality, safe produce	Cambodia	Agriculture	Adaptation	Working with select vegetable supply chains to improve sustainable production systems for vegetables, post harvest systems, food quality assurance and market linkages	2017–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Improved knowledge and skills from new training	Public	Refer to table 7.5

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Dragon Fruit Development	Improving capability and capacity for the development and commercialisation of new varieties of dragon fruit	Viet Nam	Agriculture	Adaptation	Developing and commercialising new dragon fruit varieties that earn premium prices on international markets and have increased resistance to disease	2017–21	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	New systems and practices in sustainable production and disease control	Public	Refer to table 7.5
African Climate-smart Agriculture Initiative	Supporting eastern and southern African countries to shift to low-emissions agriculture	Africa	Agriculture	Adaptation	Enabling countries to increase their engagement with the GRA in order to develop and implement effective technologies/practices to mitigate agricultural greenhouse gas emissions, and build regional capability in agricultural emissions measurement	2020–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Identified low-emissions agriculture systems, technologies and practices	Public	Refer to table 7.5b
Strengthened Avocado Value Chain	Improving smallholder farmer economic opportunities by strengthening and sharing lessons with the avocado industry in Kenya	Kenya	Agriculture	Adaptation	Improving the quality of services and access to these services, as well as improving the efficiency of the activity by improving the value for money	2018–23	Builds on the previous and successful activity, the Kenya Avocado Programme	Improved knowledge and skills from new training	Public	Refer to table 7.5a

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Dairy Transformation Programme	Improving the productivity and profitability of smallholder dairy farmers by strengthening emerging dairy value chains and improving access to and quality of extension support in Zambia	Zambia	Agriculture	Adaptation	Supporting smallholder farmers to improve their productivity, milk quality and linkage to urban markets	2017–20	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Improved knowledge and skills from new training	Public	Refer to table 7.5
Caribbean Geothermal Technical Assistance Phase II	Supporting the development of geothermal energy in the Caribbean	Caribbean	Energy	Mitigation	A flexible, demand-driven technical assistance facility supporting the development of geothermal energy across eastern Caribbean island states	2018–22	Builds on previous technical assistance towards the development of renewable energy across the region	Assisting with technical studies and applications for funding for a programme of drilling for geothermal energy	Public	Refer to table 7.5
Energy Efficiency	Supporting Nauru's economic resilience	Nauru	Energy	Mitigation	Increasing energy efficiency and therefore reducing the amount of imported fossil fuel	2019–24	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Established a fund to enable the replacement of inefficient household appliances with efficient appliances	Public	Refer to table 7.5

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Renewable Energy Initiative	Increasing renewable energy production, reducing reliance on fossil fuels and increasing equitable access to affordable energy	Nauru	Energy	Mitigation	Assisting the Nauru Utilities Corporation to develop a least-cost plan for increasing Nauru's renewable energy production	2017–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Provided a grid-connected 1-megawatt-peak solar photovoltaic system	Public	Refer to table 7.5
Niue Renewable Energy Activity	Supporting Niue's goal to increase renewable energy production and reduce reliance on fossil fuels	Niue	Energy	Mitigation	Resolving technical issues with the current generation and network distribution, and increasing renewable energy supply	2017–21	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Provided grid-connected photovoltaic panels and battery storage	Public	Refer to table 7.5
Energy Initiative	Expanding access to affordable, reliable and clean energy	Federated States of Micronesia	Energy	Mitigation	Expanding access to affordable, reliable and clean energy	2018–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Provided grid-connected photovoltaic panels	Public	Refer to table 7.5
Energy Initiative	Supporting the goal of the Government of the Republic of Marshall Islands to expand access to affordable, reliable and clean energy	Republic of Marshall Islands	Energy	Mitigation	Supporting the goal of the Government of the Republic of Marshall Islands to expand access to affordable, reliable and clean energy	2018–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Provided grid-connected photovoltaic panels	Public	Refer to table 7.5

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Energy Initiatives	Supporting the Government of Palau's goal to increase renewable energy production, reduce reliance on fossil fuels and increase equitable access to affordable, clean energy	Palau	Energy	Mitigation	Installing and rehabilitating renewable energy generation systems, and delivering technical assistance and training to integrate renewable generation into the grid	2018–21	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Provided grid-connected photovoltaic panels and battery storage	Public	Refer to table 7.5
Renewable Energy Partnership	Supporting efficient, reliable, safe, affordable and sustainable electricity supply for Samoa	Samoa	Energy	Mitigation	Developing large-scale photovoltaics, small hydro power plant rehabilitation (post-cyclone) and construction, and technical assistance to develop a least-cost investment plan and asset management	2017–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Provided grid-connected photovoltaic panels	Public	Refer to table 7.5a
Renewable Energy Expansion and Renewal	Increasing access to reliable clean energy by expanding each village's solar photovoltaic capacity and improving renewable energy asset management processes	Tokelau	Energy	Mitigation	Providing co-financing and technical assistance to expand renewable energy infrastructure and replace components at end of life	2019–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Provided grid-connected photovoltaic panels	Public	Refer to table 7.5

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Nuku'alofa Network Upgrade Project	Facilitating economic and social development through the delivery of reliable, resilient and safe electricity	Tonga	Energy	Mitigation	Improving the performance and management of the network and reducing the diesel consumption in electricity generation through increased network efficiency	2018–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Upgraded electricity network materials, equipment and tools	Public	Refer to table 7.5
Renewable Energy Programme	Increasing beneficial and sustainable use of renewable energy resources to support economic and social development	Myanmar	Energy	Mitigation	Supporting ethnic communities and rural areas to increase renewable energy production and connectivity by undertaking best-practice development of renewable energy resources	2018–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Providing technical assistance and capacity building, as well as assisting with technical studies and applications for funding	Public	Refer to table 7.5
Promoting Rural Electrification	Enhancing living conditions of the population in rural areas by improving access to clean, affordable and reliable electricity	Myanmar	Energy	Mitigation	Promoting and encouraging private sector participation and investment in renewable energy mini-grids in rural Myanmar	2019–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Provided technical assistance and capacity building to support the implantation of mini-grid projects	Public	Refer to table 7.5b

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Accelerating Geothermal Development	Accelerating geothermal development that supports economic and social development, while increasing human capacity and advancing gender, environment and human rights in the sector	Indonesia	Energy	Mitigation	Supporting geothermal energy development and access to energy by providing technical assistance and capacity building to three partner agencies focused on geothermal development	2018–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Enabled geothermal electricity generation by providing technical assistance and capacity building	Public	Refer to table 7.5
Improving Energy Access in Maluku	Supporting the uptake of affordable, reliable and renewable energy	Indonesia	Energy	Mitigation	Supporting the uptake of affordable, reliable and renewable energy in off-grid and grid-connected areas in Seram and surrounding islands in eastern Indonesia	2017–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Enabled electricity mini-grids by providing technical assistance and capacity building	Public	Refer to table 7.5
Supporting Geothermal Sector Training	Increasing workforce skills and capability in geothermal energy	Indonesia	Energy	Mitigation	Increasing workforce skills and capability in geothermal energy through targeted support covering training for geothermal trades, technicians and plant operators	2017–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Enabled geothermal energy generation through capacity building	Public	Refer to table 7.5

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Lao PDR and Cambodia Renewable Energy Facility	Increasing the use of renewable energy resources to support economic and social development	Cambodia, Lao PDR	Energy	Mitigation	Providing technical assistance to increase the use of renewable energy resources to support economic and social development in Lao PDR	2019–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Transferred technology through technical assistance and capacity building	Public	Refer to table 7.5
Support for Realisation of Geothermal Potential	Undertaking technical studies allowing the Government of Comoros to attract funding for the next stages of realising its geothermal potential	Comoros	Energy	Mitigation	Assisting the development of the potential geothermal resource on Comoros for electric power generation	2017–20	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Provided technical assistance and capacity building	Public	Refer to table 7.5a
Africa Geothermal Assistance Facility	Reducing reliance on fossil fuels and expanding access to affordable, reliable and clean energy in East Africa through technical assistance for geothermal energy development and distribution	Africa	Energy	Mitigation	Establishing a Geothermal Facility to support the development of the geothermal sector in 11 East African countries	2017–24	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Assisted with technical studies and applications for funding for a programme of drilling for geothermal energy	Public	Refer to table 7.5
Infrastructure Trust Fund	Supporting the Cook Islands to resource construction of resilient public infrastructure and	Cook Islands	Multi-sector	Adaptation	Financing the construction of high-quality public infrastructure in the Cook Islands and	2019–34	Country ownership, alignment with country strategies and priorities, donor harmonisation,	Assisting with technical studies and the procurement of appliances that will enable slab	Public	Refer to table 7.5a

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
	strengthen infrastructure sector capability				supporting infrastructure sector capacity building, by contributing to an Infrastructure Trust Fund		results focused, transparency	replacement at Rarotonga International Airport		
Strengthening Water Security in Selected Pacific Island Countries	Supporting vulnerable and isolated communities in drought-prone Pacific atolls to gain sustained access to safe and reliable drinking water, including during periods of drought	Pacific	Water and sanitation	Adaptation	Building resilience by helping vulnerable Pacific Island countries to access safe and reliable drinking water supplies, and reduce their risk of water shortage	2017–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Developing practical tools and procedures to improve awareness, build capacity, reduce vulnerability and maximise use of available water resources	Public	Refer to table 7.5a
Tropical Cyclone Winston: Recovery Package	Providing a package of recovery support to Fiji following Tropical Cyclone Winston	Fiji	Humanitarian	Adaptation	Providing a recovery package for Fiji in response to Tropical Cyclone Winston, which destroyed housing and crucial infrastructure	2017–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Delivered training programmes and construction techniques that improve resilience to cyclones	Public	Refer to table 7.5a
Habitat Training for Disaster Risk Reduction in Fiji	Increasing resilience to disasters of vulnerable Fijian communities through shelter-specific training in disaster risk reduction using community-led safe shelter awareness	Fiji	Humanitarian	Adaptation	Building on Habitat for Humanity New Zealand training in resilient building methods for disaster risk reduction and sustainability	2017–22	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Building using and training in resilient building methods for disaster risk reduction and sustainability	Public	Refer to table 7.5

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Local Government Technical Assistance Facility 2017–22	Improving service delivery and infrastructure at the local level	Pacific	Adaptation	Government and civil society	Supporting New Zealand local government employees to work with their equivalents in Pacific Island countries to share technical knowledge and capability	2017–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Sharing technical knowledge and capability focusing on urban planning, asset management and governance	Public	Refer to table 7.5
Wharf and Reef Channel Rehabilitation	Increasing the safety and efficiency of ship-to-shore transfers of passengers and cargo at Tokelau's atolls	Tokelau	Adaptation	Transport and storage	Reconstructing wharfs and reef channels in four locations on Tokelau	2017–20	Engagement of local decision-makers and labourers has increased the sense of local ownership for the rehabilitated wharfs	Upgraded and resilient wharfs and reef channels	Public	Refer to table 7.5a
Water Sector Partnership 2017–21	Increasing sustainable and equitable access to improved, safe water, leading to a healthier and more economically productive and resilient ni-Vanuatu population	Vanuatu	Adaptation	Water and sanitation	Supporting the Department of Water Resources to operationalise its National Implementation Plan	2017–21	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Assisting with technical studies to assess risks to the water system and work with the community to address them	Public	Refer to table 7.5

Project title	Purpose of the project	Recipient country or countries	Sector	Targeted area	Description of the project	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector – was private-sector activity encouraged?	Total funding
Strengthening Disaster Resilience	Improving skills and knowledge for disaster risk reduction planning and implementation	Indonesia	Adaptation	Multi-sector	Providing training and capability building to increase the disaster risk management skills of local governments. Action plans for 10 districts will be developed and effectively implemented	2017–20	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Improved knowledge and skills from training	Public	Refer to table 7.5
Better Warehousing	Improving relief response capabilities of the Indonesian Red Cross National Society, as a result of better warehousing and logistics, resulting in reduced losses from disasters	Indonesia	Adaptation	Humanitarian	Providing funding and technical assistance to improve infrastructure, knowledge and relief response capabilities in an emergency	2017–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Technology was transferred through technical assistance and capacity building	Public	Refer to table 7.5
Myanmar Better Warehousing and Logistics	Increasing the sustainable recovery from emergencies for vulnerable disaster-affected communities through more efficient provision of relief supplies in Myanmar	Myanmar	Adaptation	Multi-sector	Providing funding and technical assistance to improve warehousing infrastructure, knowledge and relief response capabilities in Myanmar	2017–23	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Technology was transferred through technical assistance and capacity building	Public	Refer to table 7.5

Note: Lao PDR = Lao People's Democratic Republic.

Table 7.7: Technology transfer delivered through the Global Research Alliance on Agricultural Greenhouse Gases

Project title	Purpose	Recipient country or countries	Sector	Targeted area	Description	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector	Total funding (NZ\$)
Institutional Strengthening in Indonesia for Mitigating Livestock Methane Emissions	Assisting South East Asian countries to develop higher-tier agricultural inventories	Indonesia, Malaysia	Agriculture	Mitigation	Developing Tier 2 inventories to measure the impacts of mitigation technologies and practices	2018–20	Builds on existing activities in South East Asia to improve livestock GHG inventories	Training in undertaking measurements and understanding how these are linked to higher-tier livestock GHG accounting methodologies. Understanding the impacts of specific mitigation technologies to reduce livestock methane emissions	Public	\$563,220
Database and Inventory Refinement for GHG Emissions Associated with Manure	Consolidating and unifying methane and nitrous oxide emissions datasets associated with manure from several regions of the world	Chile	Agriculture	Mitigation	Establishing a central database. Analysing the data to generate emissions factors and provide a global resource for upgrading national inventories	2018–21	Coordination across responsible agencies, government and researchers	Coordinated and analysed regional data from Latin America; developed understanding of the requirements for GHG inventories and developed regionally specific emissions factors	Public	\$140,000
Bovine Productivity in the South American Chaco Region	Generating socio-economic and environmental benefits for the region by improving the efficiency, stability and resilience of family livestock system	Argentina, Bolivia, Uruguay	Agriculture	Mitigation	Generating an extension network and a virtual collaborative site with specialised livestock technicians that efficiently disseminate and transfer technology to producers	2020–24	Partnership with FONTAGRO	Network of pilot sites (livestock farms) where the proposed technologies are adapted and demonstrated, together with a technical assistance and training plan on livestock innovation for extension agents, advisors and producers	Public	\$310,599

Project title	Purpose	Recipient country or countries	Sector	Targeted area	Description	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector	Total funding (NZ\$)
Agritech for Climate-smart Dairy	Generating digital tools to implement climate-smart dairy in the targeted region	Argentina, Costa Rica, Dominican Republic, Honduras, Uruguay	Agriculture	Mitigation	Creating a digital platform to monitor real-time productive, climate and management aspects that allow the implementation of climate-smart dairy establishments in the region	2020–24	Partnership with FONTAGRO	Creating reliable data for farmers and technicians for the sustainable management of milk establishments	Public	\$279,503
Innovation in Pasture Management	Improving self-sufficiency and sustainability of livestock production	Argentina, Costa Rica, Uruguay	Agriculture	Mitigation	Improving grass harvest produced on family farms, through the use of drones and decision support platform	2020–24	Partnership with FONTAGRO	Developing new technologies to help farmers increase their harvest and facilitate management decisions	Public	\$310,559
Organic-Carbon Sequestration in Latin American and Caribbean (LAC) Soils	Contributing to the design of land uses management with potential for sequestration of soil carbon in the agricultural system	Uruguay, Argentina, Chile, Colombia, Costa Rica	Agriculture	Mitigation	Generating capacities in LAC to quantify and monitor soil carbon stock	2020–24	Partnership with FONTAGRO	Identifying and evaluating strategies for intensification of agricultural production systems in LAC with potential for mitigation and adaptation to climate change	Public	\$397,331
Regional and Technical Engagement in South and East Africa	Improving the livestock GHG inventory of Kenya	Tanzania, Kenya, Botswana, Zambia, Malawi, South Africa	Agriculture	Mitigation	In partnership with FAO and local institutes, a three-day technical workshop to develop a Tier 2 inventory for Kenya's dairy sector	2018–19	Built on existing work with Kenya via the joint GRA–FAO–CCAC project, 'Reducing enteric methane for improving food security and livelihoods'	Developed a higher-tier GHG inventory for the dairy sector to account for mitigation practices and technologies	Public	\$68,856

Project title	Purpose	Recipient country or countries	Sector	Targeted area	Description	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector	Total funding (NZ\$)
Regional and Technical Engagement in South and East Africa	Regional GRA engagement with East African countries	Ethiopia, Ivory Coast, Kenya, Tanzania, Uganda	Agriculture	Mitigation	On behalf of the GRA and working in partnership with CCAFS, FAO, the World Bank and the African Climate Policy Centre, NZAGRC	2018–19	Coordination across responsible agencies, government, researchers and regional organisations	Demonstrated how science underpins this work, including helping to support countries' NDCs. Identified ways to build regional and national capacity through future activities	Public	\$68,856
The Effect of Feed and Nutrition on Methane Emissions from Cattle in South East Asia and South America	Improving the quantification of the effects of feed and nutrition on enteric methane emissions from cattle	Malaysia, Colombia, Argentina, Brazil, Chile, Costa Rica, Mexico, Peru, Uruguay, Indonesia, Thailand, Viet Nam, China, Philippines, Cambodia, Lao PDR	Agriculture	Mitigation	Generating more data for production systems in South East Asia and South America to develop specific methane yield values for the region	2019–21	Expanded animal feed databases to represent production systems in South East Asia and South America	Creating more reliable and precise databases to improve animal feed and reduce methane emissions efficiently	Public	\$328,497
Enteric Fermentation: Rumen Microbiomes to Predict Methane	Sequencing microbiome profiles of ruminant species from multiple countries	Brazil, Peru, Uruguay	Agriculture	Mitigation	Developing a rapid sequencing technology to generate low-cost profiling of rumen microbiome that can be used to predict methane emissions	2018–22	Global collaboration to understand how the rumen adapts to different production system	Generated a method of profiling the rumen microbiome with low cost and in live animals at any stage of production	Public	\$367,024

Project title	Purpose	Recipient country or countries	Sector	Targeted area	Description	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector	Total funding (NZ\$)
MRV of Livestock Emissions at the Provincial Level in China	Developing methods and systems for advanced (Tier 2) measurement, reporting and verification (MRV)	China	Agriculture	Mitigation	Delivering improved guidance for provincial-level implementation of Tier 2 inventories	2018–20	Collaboration with international research centres	Sharing improved guidance for provincial-level implementation of MRV – Tier 2 for compilers, and sharing project's outcomes with policy-makers	Public	\$193,118
Discovery of new nitrification inhibitors: Phase II	Identifying novel compounds to nitrification and mitigate nitrous oxide emissions	China	Agriculture	Mitigation	Identifying novel compounds to nitrification and mitigating nitrous oxide emissions	2017–20	New Zealand's International Research Fund 'Global Partnerships in Livestock Emissions Research' supports the participation of developing country researchers	Involving international partners from China and the United Kingdom. Shared the high-throughput screening mechanisms for novel inhibitors developed in New Zealand	Public	\$50,000
Antibody Binding to Antigenic Targets in the Rumen	Improving the effectiveness of anti-methanogen vaccines	Argentina	Agriculture	Mitigation	Optimise antigen production and improve the effectiveness of anti-methanogen vaccines	2017–20	New Zealand's International Research Fund 'Global Partnerships in Livestock Emissions Research' supports the participation of developing country researchers	Involving international partners from Argentina and Australia	Public	\$120,000
Emissions Avoidance of Soil Carbon from Lands Undergoing Practice Change	Understanding the possible options in soil management that may prevent or reduce the rapid initial loss of soil carbon	Indonesia	Agriculture	Mitigation	Using the latest information in published and grey literature, along with professional expertise to understand how to reduce soil carbon losses	2019–20	Partnership with ACIAR	Identifying ways to build regional and national capacity through future activities	Public	\$100,000

Project title	Purpose	Recipient country or countries	Sector	Targeted area	Description	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector	Total funding (NZ\$)
Evaluation of Climate Risks to Farming Systems in the Pacific	Improving understanding of the risks of the long-term impact of climate change in the Pacific	Solomon Islands	Agriculture	Mitigation	Studying the impact of climate change on agricultural livelihoods and food security in the Pacific	2019–21	Partnership with ACIAR	Delivering key industry report to develop larger programme	Public	\$88,456
UNIQUE – GRA Engagement Activities in Selected Countries in Sub-Saharan Africa and Asia	Supporting countries' capacity to identify concrete mitigation actions and policies, including robust assessment of possible reductions	Sub-Saharan countries	Agriculture	Mitigation	Collaborating with international experts to develop national and regional capacity to advance locally appropriate GHG inventories, NDCs and MRV systems	2019–20	Partnership with UNIQUE and international experts	Developing access to infrastructure and material for developing countries. It will support the targeted countries into reaching their NDCs	Public	\$150,000
Livestock Sector Activity Data Collection- Sub-Saharan Africa	Improving national livestock GHG emissions to Tier 2.	39 countries across Sub-Saharan Africa.	Agriculture	Mitigation	Data collection and analysis of technics to produce a report GHG emission capability for each selected country	2020	Partnership with FANRPAN	Developing higher-tier GHG inventory for livestock	Public	\$179,402
Development of Regional Methane Emissions Factors for Livestock Categories for Sub-Saharan Africa	Improving livestock GHG emissions to higher-tier level and supporting countries in achieving their NDCs	Central, East, West and Southern African countries (39 in total)	Agriculture	Mitigation	Improving livestock GHG emissions to higher-tier level and supporting countries in achieving their NDCs	2020–21	Inventory of measurement results and outcomes comparisons	Resulting data will generate regionally relevant methane emissions factors for livestock in Sub-Saharan Africa	Public	\$71,720
Stocktake of Selected ASEAN Countries' Inventory Capability Needs	Gathering information on livestock GHG inventories to be developed	Cambodia, Lao PDR, Myanmar, Philippines	Agriculture	Mitigation	Collecting information on livestock GHG inventories	2020	Collaboration with regional expert to gather information and report to New Zealand	Sharing knowledge to move to higher-tier inventory	Public	\$16,000

Project title	Purpose	Recipient country or countries	Sector	Targeted area	Description	Year(s)	Factors that led to the project's success	Technology transferred	Activities undertaken by public or private sector	Total funding (NZ\$)
Tier 2 Inventory Development and Implementation in Kenya	Helping targeted country to move to higher-tier inventory	Kenya	Agriculture	Mitigation	Providing technical support and expertise to Kenya to move to Tier 2 inventory for its dairy sector	2018–19	Collaboration with FAO, CCAFS and Kenya's State Department for Livestock	Improved national capability in inventory development	Public	\$100,860

Note: ACIAR = Australian Centre for International Agricultural Research; CCAC = Climate and Clean Air Coalition; CCAFS = Research Program on Climate Change, Agriculture and Food Security; FANRPAN = Food, Agriculture and Natural Resources Policy Analysis Network; FAO = Food and Agriculture Organization; FONTAGRO= Regional Fund for Agricultural Technology of Latin America; GHG = greenhouse gas; GRA = Global Research Alliance on Agricultural Greenhouse Gases; Lao PDR = Lao People's Democratic Republic; MRV = measurement, reporting and verification; NDC = Nationally Determined Contribution; NZAGRC = New Zealand Agricultural Greenhouse Gas Research Centre.

7.4 Capacity building

Aotearoa New Zealand recognises that enhancing the capacity and capability of developing countries to take effective climate change action must play an important role in responding to climate change. It provides capacity-building support that responds to the existing and emerging capacity needs developing country Parties identify in the areas of mitigation, adaptation, and technology development and transfer. This occurs through a number of mechanisms, including the New Zealand IDC Programme, the GRA, the UNFCCC and regional organisations such as SPREP, SPC and the University of the South Pacific.

New Zealand's capacity-building activities are targeted to areas where it has expertise, such as weather and climate data analysis and forecasting, agriculture, renewable energy generation and disaster risk resilience building, and where countries have identified specific needs and capacity gaps. A large portion of this capacity-building activity has been aimed at the Pacific region. This means the capacity-building support is focused on responding to the needs of those with the least capacity – small island developing states, many of which are also the countries most vulnerable to climate change. Other capacity-building activities New Zealand has delivered where it has expertise have been to the benefit of developing countries in Africa, South East Asia, Latin America and the Caribbean.

7.4.1 Capacity building supported through the New Zealand IDC Programme

Capacity building is an integral part of most activities in the New Zealand IDC Programme. As noted in section 7.1.2, we introduced a climate change capacity-building marker into our reporting system in 2018. This is enabling us to better track the support we provide for climate change capacity building and to provide more detailed reporting in the future. Table 7.8 describes New Zealand's capacity-building support in the context of climate change. The following examples illustrate the range of areas to which this support has contributed.

- **Improving climate research, data and analysis to support better evidence-based decision making.** New Zealand provided funding to establish a Pacific Community Centre for Ocean Science (see section 7.2.3).
- **Disaster risk management and resilience building.** The Disaster Risk Management in Fiji activity was designed to increase the capacity of the National Disaster Management Office to manage disaster awareness and response in Fiji. It involves: (a) providing technical assistance to the office; (b) upgrading tsunami and flood protection systems; and (c) constructing warehouses and evacuation centres.
- **Renewable energy.** Alongside the many renewable energy activities that are aimed at technology transfer, New Zealand aims to strengthen these with capacity-building support to ensure countries and communities have the ability to operate and maintain these technologies into the future, especially in the face of the impacts of climate change (see section 7.3.1 under 'Success stories').
- **Ocean acidification.** The New Zealand Pacific Partnership on Ocean Acidification activity has supported communities in Fiji, Kiribati and Tokelau to better adapt to the impacts of ocean acidification through support for research and community-based adaptation and awareness-raising actions.
- **Drought resilience.** The Averting Water-related Emergencies activity builds early warning systems in the Pacific region (see section 7.2.3 under 'Loss and damage').

- **Agriculture.** The Myanmar Dairy Inclusive Growth and Investment activity supports continued development of an inclusive, vibrant and sustainable dairy sector, leading to higher incomes for smallholder farmers and safe food for consumers.
- **Fisheries.** The Solomon Islands fisheries support activity will contribute to sustainable fisheries management, food security and improved government revenue.

Data and information

Having access to climate data and analysis, along with suitable information products and services, is critical for improving the effectiveness of climate action. New Zealand is providing a wide range of support to increase the quality and quantity of weather and climate data and forecasting; improve impact analysis of natural disasters exacerbated by climate change; and undertake an extensive research project into the current and predicted impacts of climate change in the Pacific region. It is also creating information products and services to better respond to the demands of government, business and communities to improve climate-resilient decision-making.

7.4.2 Other capacity-building support

New Zealand has provided support to capacity-building initiatives from other government funding sources. It has channelled some of this support through the GRA, the UNFCCC, other New Zealand government agencies and regional organisations, such as SPREP. As detailed in table 7.9, during the reporting period New Zealand provided:

- NZ\$1,004,009 to the Livestock Emissions Abatement Research Network (LEARN),³³⁹ to support technicians, PhD students and postdoctoral fellows from developing countries to build international capability in livestock emissions research
- NZ\$589,668 for Climate, Food and Farming Network students from developing countries, who are currently enrolled in PhD programmes, to undertake short-term research in association with advanced research institutes on topics related to measurement and mitigation of GHG emissions, or carbon storage in agricultural systems and quantification of GHG emissions
- NZ\$35,126 to support participants to attend advanced online courses hosted by the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) on agricultural GHG assessment of emissions, mitigation options and adaptation strategies
- NZ\$167,580 to support GRA members from developing countries to attend a GRA council meeting and Climate Smart Conference.

³³⁹ See www.livestockemissions.net for further information.

Table 7.8: Activities managed by the New Zealand IDC Programme that address capacity building (CTF Table 9)

Recipient country or countries	Target area	Project title	Description
Pacific Regional	Adaptation	Pacific Islands Emergency Management Alliance	Funds SPC to deliver regional and national training exercises and technical assistance for Pacific Island countries' emergency services
Palestine	Cross-cutting	Palestine Renewable Energy (Office of the Quartet)	Supports the development of renewable energy initiatives in Occupied Palestinian Territories through the funding of a senior energy expert, and contributes to an economic development associate and multiple detailed feasibility studies for proposed solar power generation sites in Gaza
Solomon Islands	Adaptation	Forest Conservation	Supports the protection of forests and the ecosystem services they provide, through delivery of alternative source of revenue for landowners
Philippines	Adaptation	Agricultural Livelihoods in Mindanao	Targets households that are food insecure, many of which are returning home after being displaced by conflict
Pacific Regional	Cross-cutting	Climate and Oceans Support Program in the Pacific	Provides funding for the Climate Data for the Environment component, which will include funding for NIWA-led activities
Pacific Regional	Cross-cutting	PICTicipate (from 2018/19)	Supports the attendance of Pacific Island citizens at regional and international events, which strengthens ownership of regional and international development processes, and provides capacity building and knowledge transfer
Samoa	Adaptation	Habitat Disaster Risk Reduction Samoa	Supports disaster risk reduction in Samoa through training in safer building techniques, disaster preparation and financial literacy
Tuvalu	Cross-cutting	Vaitupu Energy Extension	Scopes the work required on the current renewable energy infrastructure, in order to determine the scale of additional work required
Tuvalu	Adaptation	Vaitupu Water Security	Supports the generation of knowledge for evidence-based decision-making, the establishment of local capacity to manage, operate, maintain and govern the system, and the empowerment of the community to maintain safe drinking water in all conditions
Tokelau	Cross-cutting	Coastal Risk Mitigation	Enhances the resilience of communities by preparing designs and inputs for strengthening coastal defences, constructing emergency shelters and repairing or replacing Nukunonu bridge

Recipient country or countries	Target area	Project title	Description
Fiji	Cross-cutting	Disaster Risk Management in Fiji	Supports improved disaster preparedness and response, and climate resilience by increasing the capacity of the National Disaster Management Office to manage disaster awareness and response in Fiji
Fiji	Adaptation	Fiji Ease of Doing Business – International Finance Corporation contribution	Promotes private sector development and growth by promoting policy and providing tools and opportunities for businesses, investors and government departments
Worldwide	Cross-cutting	Commonwealth Fund for Technical Cooperation 2019–21	Contributes to the Commonwealth Fund for Technical Cooperation, which supports the Commonwealth Secretariat work programme to deliver assistance to developing Commonwealth member countries, mostly in the form of technical assistance
Worldwide	Cross-cutting	CGIAR – Research on Climate Change, Agriculture and Food Security 2018–21	Supports international agricultural research focused specifically on climate change, agriculture and food security programmes
Pacific Regional	Cross-cutting	Improving Ecosystem Resilience: Kiwa Initiative	Supports the implementation of the ‘Kiwa Initiative: Nature-based Solutions for Climate Resilience’, which will increase the resilience of Pacific Islands ecosystems, economies and communities
Pacific Regional	Cross-cutting	Support to the Pacific Climate Change Centre	Supports the Pacific Climate Change Centre and will focus on human resources and capacity development
Pacific Regional	Cross-cutting	Strengthening Pacific Monitoring, Evaluation and Learning (MEL) capacity	Improves governance and decision-making by strengthening capacity for contextually and culturally appropriate monitoring, evaluation and learning
Pacific Regional	Cross-cutting	Pacific Regional Infrastructure Facility (PRIF) Phase Four (November 2019 – November 2023)	Improves the delivery of development assistance to the infrastructure sector in the Pacific. PRIF supports infrastructure development and maintenance in Pacific Island countries through investment coordination, research and technical assistance
Myanmar	Cross-cutting	Myanmar Dairy Inclusive Growth and Investment	Supports continued development of an inclusive, vibrant and sustainable dairy sector in Myanmar, which leads to higher incomes for smallholder farmers and safe food for consumers
Worldwide	Cross-cutting	Alliance of Small Island States, Grant for Assistance	Enhances capacity for advocacy on climate change and oceans issues in international fora
Pacific Regional	Adaptation	Pacific Public Sector Strengthening	Supports public sector reform initiatives, development of Pacific-specific solutions and supports the Pacific Public Service Commissioners’ Conference to share knowledge and experience

Recipient country or countries	Target area	Project title	Description
Kiribati	Mitigation	Energy and Public Utility Reform	Supports the Public Utilities Board to build institutional capability and capacity
Pacific Regional	Cross-cutting	Improve Decision-making through Ocean Knowledge	Supports the establishment of the Pacific Community Centre for Ocean Science, which will support and strengthen regional oceans governance and management for Council of Regional Organisations of the Pacific processes
Pacific Regional	Cross-cutting	Pacific Regional NDC Hub	Supports the Pacific Regional NDC Hub, which has been established to help Pacific Island countries enhance and implement their NDCs under the Paris Agreement
Fiji	Adaptation	RISE – Upgrades for Informal Settlements	Integrates ecologically and environmentally sustainable water infrastructure into the housing and landscapes of 12 informal settlements in the greater Suva area
Niue	Cross-cutting	Strengthen Governance: Capability	Contributes to good governance, management and improved service delivery within Niue's public sector through building the capability of government institutions to deliver their functions effectively and efficiently and adhere to accountability requirements
Pacific	Cross-cutting	Pacific Participation at Global Evaluation Fora	Supports Pacific attendance at Global Evaluation Fora to strengthen Pacific voice and participation on the international stage
Pacific Regional	Cross-cutting	Pacific Voice	Focuses on amplifying the Pacific voice, enabling the Pacific to tell its story and influencing global negotiations with greater impact
Pacific Regional	Adaptation	Climate Mobility	Enhances Pacific resilience to climate change by enabling Pacific peoples to remain in situ and minimise harm from potential climate-related mobility
Tuvalu	Cross-cutting	Integrated Water Resources Management – Tuvalu	Supports a diagnostic of current water collection and storage on the outer atolls that will strengthen drought management plans, water and sanitation policy, and drought modelling
Kiribati	Cross-cutting	Climate Change Resilience	Supports Kiribati to plan for and respond to climate change impacts effectively
Pacific Regional	Cross-cutting	Ecosystems Resilience	Supports Pacific countries to maintain and restore ecosystem services for food security, coastal protection and disaster risk reduction
Pacific Regional	Adaptation	Information for Decision-making	Supports the incorporation of climate change information into all forms of government decision-making and planning
Kiribati	Cross-cutting	Uananginang Ununiki Group	Provides a source of fresh drinking water for home-grown vegetables and root crops to sustain and nourish the community

Recipient country or countries	Target area	Project title	Description
Pacific Regional	Adaptation	Disaster Risk Management in the Pacific 2019–24	Provides a programme of technical and advisory support to the Cook Islands, Niue, Samoa, Tokelau and Tonga to strengthen domestic disaster risk management capabilities
Africa	Adaptation	East Africa: Farm to Market Alliance	Contributes to the Farm to Market Alliance in East Africa, which works to sustainably improve farmer livelihoods while fostering commercial viability of value chain stakeholders
Pacific Regional	Adaptation	Enhanced Pacific Biosecurity Programme	Supports the Cook Islands, Fiji, Niue, Samoa, Tonga and Vanuatu to improve Pacific biosecurity
Pacific Regional	Adaptation	Reduce Risk of Water Scarcity	Provides at-risk communities with improvements to their water infrastructure, infrastructure maintenance, training and tools
Pacific Regional	Adaptation	Averting Water-related Emergencies	Supports Pacific Island countries to understand their vulnerability to water-related hazards and informs vulnerable communities so they can anticipate and respond
Pacific Regional	Adaptation	Building Resilient Water Management Systems	Integrates water resource management approaches into local, national and regional systems to improve water security
Pacific Regional	Cross-cutting	Low-emissions, Climate-resilient Planning	Supports the transition to low-emissions and climate-resilient futures through supporting long-term, climate-responsive planning and decision-making
Cambodia	Mitigation	Angkor Governance Support	Supports the development of the Angkor Park Landscape Management Strategy for this World Heritage site and its indigenous communities
Tuvalu	Mitigation	Maritime Transport – Maintenance and Safety Systems	Improves maritime safety aboard Tuvalu Government vessels by addressing known mechanical faults and establishing maintenance plans and safety systems to keep the vessels up to a minimum international standard
Africa	Cross-cutting	Building Resilience of Smallholder Farmers	Targets food-insecure households in rural areas of Zimbabwe by providing capacity-strengthening activities to build resilience to climate shocks
Kiribati	Adaptation	Activity Capacity Support – Urban Development	Provides funding for the management of urban development initiatives in water and sanitation, solid waste management and urban housing

Recipient country or countries	Target area	Project title	Description
Indonesia	Adaptation	Strengthening Disaster Resilience	Provides training and capability building to increase the disaster risk management skills of local governments, provide specialist advice and technical support to local governments, and increase participation of the private sector, non-government organisations and communities in disaster risk management
Indonesia	Adaptation	National Disaster Response Framework	Supports the development of an all-of-government framework for disaster preparedness and response that clarifies roles, accountabilities and mechanisms for coordinating disaster preparedness and response work
Tuvalu	Mitigation	Tuvalu Renewable Energy Projects	Includes the installation of hybrid photovoltaics on the three outer islands of Nanumea, Nanumanga and Niutao as well as on Vaitupu, and hybrid photovoltaics on selected buildings in Funafuti
Samoa	Cross-cutting	Samoa Renewable Energy Partnership	Includes the development of large-scale photovoltaics, small hydro power plant rehabilitation and construction, and technical assistance to develop a least-cost investment plan and asset management
Kiribati	Adaptation	Kiribati Water	Aims to improve communities' access to reliable, safe water in Kiribati through investing in infrastructure and strengthening capacity and management
Pacific Regional	Adaptation	Strengthening Water Security in Selected Pacific Island Countries	Supports vulnerable Pacific Island countries to access safe and reliable drinking water supplies, and reduce their risk of water shortage
Pacific Regional	Cross-cutting	Ocean Acidification Partnership	Supports communities in Fiji, Kiribati and Tokelau to better adapt to the impacts of climate change-induced ocean acidification through support for research- and community-based adaptation actions
Fiji	Mitigation	MPI-BAF Biosecurity Activity	Supports Pacific capacity development to improve invasive species identification, management and response
Vanuatu	Adaptation	Water Sector Partnership 2017-21	Supports the Department of Water Resources to operationalise its National Implementation Plan
Pacific Regional	Adaptation	Improving Pacific Access to Climate Finance	Involves contracting for technical assistance and providing direct funding to help Pacific Island countries access climate finance

Note: BAF = Biosecurity Authority of Fiji; CGIAR = Consultative Group for International Agricultural Research; MPI = Ministry for Primary Industries; NDC = Nationally Determined Contribution; NIWA = National Institute of Water and Atmospheric Research; RISE = Revitalising Informal Settlements and their Environments; SPC = Pacific Community.

Table 7.9: Capacity-building activities funded from other sources

Recipient countries	Target area	Programme/project title	Description
Argentina, Bangladesh, Brazil, Chile, Costa Rica, Ethiopia, Nigeria, Pakistan, Paraguay, Senegal, Uruguay	Mitigation	Livestock Emissions Abatement Research Network	Supports technicians, doctoral students and postdoctoral fellows from developing countries to build international capability in livestock emissions research
Algeria, Argentina, Benin, Brazil, Burkina Faso, Cameroon, China, Colombia, Cuba, Ecuador, Ethiopia, India, Iran, Kenya, Mexico, Nepal, Nigeria, Pakistan, South Africa, Tanzania, Togo, Uganda, Viet Nam, Zimbabwe	Mitigation	Climate, Food and Farming Network – GRA Development Scholarships (CLIFF-GRADS)	The CLIFF-GRADS programme provides grants for students from developing countries, who are currently enrolled in PhD programmes, to undertake short-term research in association with advanced research institutes. Topics are related to measurement and mitigation of GHG emissions, or carbon storage in agricultural systems and quantification of GHG emissions
Democratic Republic of the Congo, Uganda, Benin, Kenya, South Africa	Mitigation	African Regional Universities Forum for Capability Building in Agriculture (RUFORUM)	Supports capability in Africa by offering grants to students and research from RUFORUM-associated universities, working on innovative responses to support smallholder farmers
CLIFF-GRADS Alumni	Mitigation	Financial Support	Financial support for CLIFF-GRADS alumni to participate in workshops and connect with each other. It also provided a platform for alumni to present their work
Ethiopia, Indonesia, Kenya, South Africa, Uganda	Cross-cutting	World Farmers' Organisation – GRA Study Tours	Young farmer and early-career agricultural scientist study tour to raise awareness between the international farming and science communities of the issue of GHGs from agriculture, to provide a way to share experiences and to be informed of, and inform, the global research agenda
Ghana, Senegal, Uganda, Cameroon, Côte d'Ivoire, Nigeria, Zambia, Zimbabwe, South Africa, Thailand, Tunisia, Costa Rica	Mitigation	Financial Support	Provided financial support for countries to attend a Livestock Research Group meeting and an associated GHG Animal Agriculture Conference
Pacific	Mitigation	Pacific Climate Change Conference	Hosted an interactive session at the Pacific Climate Change Conference. This event offered an occasion to enhance dialogue and cooperation with Pacific countries. Twenty-two delegates from Pacific countries attended thanks to GRA's financial support
Ethiopia, Ghana, Argentina, Eswatini, Senegal, Uruguay, Zimbabwe, Malawi, Tunisia, Paraguay, Mongolia, Sri Lanka, Egypt, Panama, Viet Nam, Ecuador, Cambodia	Mitigation	Financial Support	Provided financial support to GRA members from developing countries to attend a GRA council meeting and Climate Smart Conference

Recipient countries	Target area	Programme/project title	Description
Peru, Namibia, Botswana, Bhutan, Senegal, Rwanda, Ecuador	Mitigation	Training Course Hosted by CIHEAM	Funding for participants to attend an advanced online course in GHG assessment and mitigation in agriculture
Nigeria, Ghana, Egypt, Turkey, Argentina, South Africa	Mitigation	Training Course Hosted by CIHEAM	Funding for participants to attend an advanced online course in livestock and climate change (assessment of emissions, mitigation options and adaptation strategies)
Uganda, Malawi, Mexico, Colombia, Uruguay, Indonesia	Mitigation	Inventory Training	Training workshop for GHG inventory experts in developing countries
Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Gambia, Ghana, Guinea, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Togo	Mitigation	Regional and Technical Engagement in Africa	Developing technical knowledge and engagement in African countries
Kenya, Indonesia, Costa Rica	Mitigation	The Role of Modelling in National Estimation of Livestock Emissions	Training workshop to improve the estimation and reporting of livestock GHG emissions
African and ASEAN countries	Mitigation	Development of Online Resources on Methodological and Emissions Factor Improvements to Countries' Agricultural GHG Inventories	Sharing practices, allowing compilers to improve current methodologies for NDC report

Note: ASEAN = Association of Southeast Asian Nations; CIHEAM = International Centre for Advanced Mediterranean Agronomic Studies; GHG = greenhouse gas; GRA = Global Research Alliance on Agricultural Greenhouse Gases.

8 Research and systematic observations

Key developments since the *Seventh National Communication*

- Aotearoa New Zealand's first emissions reduction plan and national adaptation plan have been released, both identifying key priorities and gaps in mitigation and adaptation research.
- The New Zealand Government announced the establishment of a new Centre for Climate Action on Agricultural Emissions.
- The Government is in the process of considering the future of the research, science and innovation system through the programme Te Ara Paerangi – Future Pathways in areas including climate change.
- Progress continues on climate change research through the National Science Challenges.

8.1 Introduction

Aotearoa New Zealand's climate change research needs are dictated by its geographical situation, unique climatic, biophysical features, population distribution and economic activities. These are described in detail in chapter 2.

The country spans a range of latitudes and altitudes, with climatic zones ranging from subtropical to subantarctic; its east and west coasts also differ significantly. Research therefore has to address a wide set of climate phenomena, ranging from tropical cyclones to the behaviour of Antarctic ice, producing regional climate change projections and determining the likely effects of climate change on diverse ecosystems.

Mitigation and adaptation research must cover equally diverse issues. These include transport in a country with a small population base but long travel distances; substantial agricultural and forestry activities; energy demand and supply; and the sustainable development of growing urban settlements, often at or near coastal areas. The dependence of New Zealand's economy on primary sector exports and international trade also means mitigation options need to be compatible with the commercial and safety requirements and standards of international markets. Just under half of New Zealand's greenhouse gas emissions come from agriculture, particularly pastoral agriculture, which also makes a significant contribution to the New Zealand economy. Consequently, New Zealand has a strong focus on research to mitigate agricultural emissions and understand the climate change impacts and options for agriculture.

The strategic directions and goals for research in New Zealand are outlined by the New Zealand Government in its *National Statement of Science Investment 2015–2025*.³⁴⁰ New Zealand's first emissions reduction plan and national adaptation plan have been released, both identifying key priorities and gaps in mitigation and adaptation research.

³⁴⁰ Ministry of Business, Innovation and Employment. 2015. *National Statement of Science Investment 2015–2025*. Wellington: Ministry of Business, Innovation and Employment.

New Zealand's National Science Challenges have a strong focus on climate research. These are designed to take a strategic approach to the Government's science investment by targeting a series of goals that, if achieved, will have major and enduring benefits for New Zealand.

New Zealand has continued to support and promote collaboration in research and systematic observations on climate change, as required by Article 4 and Article 5 of the United Nations Framework Convention on Climate Change (UNFCCC). This is complemented by substantial expenditure from the private sector, which matches government funding in some research consortia, and from local government, particularly on climate impacts.

New Zealand continues to collaborate internationally on scientific research. It contributes personnel and funding to support the work of the Intergovernmental Panel on Climate Change (IPCC). This includes participating in the production of its reports and updating of methodologies for the estimation of emissions and removals of greenhouse gases and other climate forcers. New Zealand researchers participate in international research and observation programmes of the World Meteorological Organization (WMO); the World Climate Research Programme; the Global Climate Observing System (GCOS) and its Pacific component (PI-GCOS); the Integrated Marine Observing System; the Southern Ocean Observing System; the Scientific Committee on Antarctic Research; Future Earth; and the Asia–Pacific Network for Global Change Research.

8.2 Research and systematic observations: policy and funding

8.2.1 Strategy for research and systematic observations

The New Zealand Government supports various climate research and observations to ensure core national needs are addressed. It also aims to maintain and develop international collaboration, especially in areas of national research excellence.

Research funding agencies

Central government programmes provide most of the funding for climate change research, with additional contributions from the private sector and local government. Government-funded research ranges from fundamental and underpinning research to applied and operational research, including the development of specific tools and technologies for both mitigation of and adaptation to climate change. The different funding mechanisms are explained in more detail below.

The largest proportion of the Government's research investment is made through the Labour, Science and Enterprise Group within the Ministry of Business, Innovation and Employment (MBIE). The Ministry for Primary Industries (MPI) is also a major provider of funding for research relevant to the land-based primary sector and provides some funding for research on the marine environment. The Ministry for the Environment, which has overall responsibility for climate change policy in Aotearoa New Zealand, works closely with other government departments, scientists and science organisations to monitor and review the adequacy of the climate change research portfolio to meet national needs.

Decisions on the funding allocation for long-term nationally critical research are made by Cabinet and government agencies. This includes both non-competitive funding (see section 8.2.2) and competitive ring-fenced funds for specific challenges (see section 8.2.2 National

Science Challenges and Advanced Energy Technology Platform). Competitive bidding for open research funding for all research providers is also available, and some critical climate change research is funded through these mechanisms as well. Collaborative research projects involving subcontracting to a mix of organisations are common.

The National Institute of Water and Atmospheric Research (NIWA) receives funding for climate research and observations and for maintaining the National Climate Database. The Meteorological Service of New Zealand Limited (MetService) undertakes systematic weather observations to support its weather forecasting programme. Observations from both agencies are incorporated into the climate record through NIWA's National Climate Database, with some also available through the GCOS programme. MetService's observing network is supported in part through a contract with Te Manatū Waka – Ministry of Transport for provision of New Zealand's national meteorological service.

The Royal Society of New Zealand Te Apārangi operates New Zealand's Marsden research fund on behalf of the New Zealand Government, which awards a number of research grants annually related to climate change. The Society facilitates interactions between scientists and stakeholders in New Zealand and maintains some international links on behalf of the Government through a Catalyst: Influence fund. This supports the New Zealand science sector's participation in international scientific unions including the World Climate Research Programme, the Scientific Committee on Antarctic Research, the Scientific Committee on Oceanic Research, and the International Science Council, which supports the Future Earth research programme.

Crown research institutes

Crown research institutes (CRIs) are Crown-owned companies that carry out scientific research for the benefit of Aotearoa New Zealand. The CRIs with the most climate-related research portfolios are:

- NIWA – atmospheric and oceanic physics and chemistry, greenhouse gas measurements, climate observations and analysis, climate processes and causes of change, resilience to climate hazards, national and regional predictions and projections, impacts and adaptation options, downscaling IPCC global scenarios for national, regional and local use
- AgResearch – agricultural greenhouse gas mitigation, particularly for enteric methane and nitrous oxide, and climate change impacts and adaptation in agriculture and life-cycle analysis for the primary sectors
- Manaaki Whenua Landcare Research – indigenous forest measurement and management, agricultural greenhouse gas mitigation, soil carbon, soils and erosion, impacts of climate change on natural, productive and built environments, and assessing life-cycle greenhouse gas emissions profiles for various sectors
- Plant & Food Research – soil carbon and leaching particularly under cropping, nitrous oxide emissions mitigation, adaptation and sustainable production of arable and horticultural crops with climate change, farm management systems, land use and change impact models and tools, and breeding of forage crops, erosion control tree species, and new crops and land use models and change
- Institute of Geological and Nuclear Sciences Limited (GNS Science) – past climate reconstructions and climate system modelling, carbon emissions measurement and management, ice sheet dynamics and sea level projections, groundwater, natural hazards, geo-sequestration of carbon dioxide (CO₂)

- New Zealand Forest Research Institute Limited (Scion) – planted forests, forest sinks modelling and projections of forest sink carbon, planted and indigenous forests inventory and analysis of carbon stocks and stock change, land-use modelling, soil carbon under forests, climate change impacts on forest productivity and disturbances (eg, wildfires, pests and diseases), long-lived wood-based building products, biofuels, low carbon biomaterials, and the circular bioeconomy.

Research needs

The strategic directions and goals for research in Aotearoa New Zealand are set out by the Government in its *National Statement of Science Investment 2015–2025*.³⁴¹ This identifies climate change as one of several complex, long-term, national-scale issues to be addressed by National Science Challenges, and as a significant issue for the primary industries.

The Government is currently considering the future of the research, science and innovation (RSI) system through the Te Ara Paerangi programme, including how to set research priorities for New Zealand, in areas including climate change. Te Ara Paerangi is the Government’s response to issues raised around the RSI system across various consultations over the past several years. It is a multi-year process looking at the issues with the current system and investigating solutions to prepare it for the future.

The public process started with the release of a discussion document in 2021 followed by a series of consultation sessions, with the process expected to continue for at least two more years. The outcomes may result in changes to how future research for climate change is funded, prioritised and carried out.

Work on a new Environment and Climate Research strategy is also currently under way.³⁴² It will have a 10-year horizon, covering foundational data, collections, monitoring, capability and infrastructure. It will integrate mātauranga Māori³⁴³ and kaupapa Māori³⁴⁴ research.

Specific statements of research priorities in the field of climate change can be found in the 20-year *Conservation and Environment Science Roadmap*,³⁴⁵ in which climate change is one of six themes. The research priorities identified within the climate change theme are:

- adaptation and mitigation scenarios that test and demonstrate the sensitivity of New Zealand’s economy, environment and society to climate-related impacts and extreme events
- integrated land-use models that capture interactions between greenhouse gas mitigation, water quality and quantity, and biodiversity outcomes
- emerging technologies and practices for reducing greenhouse gas emissions across different sectors, such as agriculture (discussed in detail below), waste management and transport

³⁴¹ Ministry of Business, Innovation and Employment. 2015. *National Statement of Science Investment 2015–2025*. Wellington: Ministry of Business, Innovation and Employment.

³⁴² environment.govt.nz/facts-and-science/science-and-data/environment-and-climate-research-strategy

³⁴³ Mātauranga Māori means Māori knowledge systems and worldviews, including traditional concepts.

³⁴⁴ Kaupapa Māori means the Māori approach, topic, customary practice, institution, agenda, principles, ideology; it is a philosophical doctrine incorporating the knowledge, skills, attitudes and values of Māori society.

³⁴⁵ Ministry for the Environment. 2017. *Conservation and Environment Science Roadmap*. Wellington: Ministry for the Environment.

- improving monitoring and modelling of the impacts of climate extremes and sea-level rise on the New Zealand coast, developed in conjunction with a response system based on adaptive management practices
- understanding how to transition New Zealand to a low-carbon economy through strategic changes in land-use patterns, minimising emissions of greenhouse gases and optimising marine and land carbon sinks.

Further specific climate change research priorities are stated in the Primary Sector Science Roadmap – Te Ao Tūroa³⁴⁶ and the Aotearoa New Zealand Antarctic Research Directions and Priorities 2021–2030.³⁴⁷

Emissions reduction plan

Aotearoa New Zealand’s emissions reduction plan includes a focus on research and identifies the following key actions.

- Provide tools to support knowledge development, help sectors to transition and unlock new opportunities.
 - Work towards mission-focused climate innovation platforms to coordinate action on the greatest climate challenges facing Aotearoa.
 - Reorientate the science system to improve its ability to service a low-emissions future.
 - Scale up and further target research funding and innovation support programmes.
- Develop strategic partnerships domestically and internationally to ensure research and innovation has greater impact.
 - Support Māori to use the power of mātauranga in the transition.
 - Attract leading innovators to build a sustained research and development presence in Aotearoa.
 - Partner internationally on low-emissions initiatives with leading researchers and frontier firms.

National adaptation plan

Aotearoa New Zealand’s national adaptation plan includes a research strategy for knowledge gaps that describes the data, information and research needed to fill the gaps.

The following are knowledge gaps across several research themes to prioritise to 2028:

- collate and complete priority data on risk (vulnerability, hazards, exposure)
- provide open-access data, accessible to a variety of audiences
- design, implement and share research platforms
- transform data into knowledge about vulnerability, including monitoring and evaluating sensitivity and adaptive capacity. Studies such as monitoring and scenario modelling are needed, including in the following areas:

³⁴⁶ Ministry for Primary Industries. 2017. *Primary Sector Science Roadmap – Te Ao Tūroa*. Wellington: Ministry for Primary Industries.

³⁴⁷ Ministry of Foreign Affairs and Trade. No date. *Aotearoa New Zealand Antarctic Research Directions and Priorities 2021–2030*. Wellington: Ministry of Foreign Affairs and Trade.

- ecosystems – monitoring ecosystems helps us understand their state and changes through time
- community vulnerability to changing conditions and extreme events – studies of events and their aftermath can include the response to, and recovery from, exposure to hazards, the immediate effects and long-term follow-up
- support mātauranga Māori and kaupapa Māori research. Several proposed actions will progress the development of iwi and Māori climate data and information
- monitor and evaluate the effects of policy and interventions.

Partnering with iwi and Māori

Te Tiriti o Waitangi (the Treaty of Waitangi) relationship is an essential component of partnership with Māori. Partnership involves working together with iwi, hapū, whānau and Māori communities to develop strategies for engaging effectively with the research, science, and innovation system.³⁴⁸

Te Tiriti o Waitangi-informed participation requires Māori to be involved at all levels of the research, science, and innovation system, including in decision-making, planning, development and delivery of research outcomes. Māori want to be part of the design and delivery of research.

Te Ara Paerangi – Future Pathways programme is commencing work towards embedding Te Tiriti in the future RSI system to move towards a system that can deliver more effectively and equitably on Māori RSI aspirations. A future strategy should include improved collective collaboration and stronger partnerships with Māori that will result in a Māori-led approach to science, research and innovation. The future state is obtainable if all parts of the RSI system and national research strategies are working together to achieve the outcomes Māori want.

Mātauranga Māori

Mātauranga Māori is the indigenous knowledge of Aotearoa New Zealand and is grounded in te ao Māori (the Māori world view). The Waitangi Tribunal, in its Ko Aotearoa Tēnei report, did not set out a definition of mātauranga Māori. Rather, the report described mātauranga Māori as “the unique Māori way of viewing the world, incorporating both Māori culture and Māori traditional knowledge”. The Tribunal noted that ‘mātauranga’ encompasses not only what is known but also how it is known, that is, the way of perceiving and understanding the world, and the values or systems of thought that underpin those perceptions.

‘Mātauranga Māori’ therefore refers not only to Māori knowledge but to the Māori way of knowing.³⁴⁹ Mātauranga Māori embraces intergenerational continuity. Drawing on the knowledge of ancestors, it allows contributions to knowledge in the present to be passed on to descendants in the future. As will be evident, mātauranga Māori is a broad concept.

³⁴⁸ ‘Iwi’ – tribe, large group descended from a common ancestor; ‘hapū’ – kinship group, clan, subtribe; ‘whānau’ – family, extended family, family connection.

³⁴⁹ ‘In truth, [mātauranga] is as difficult to define as Western knowledge. But a definition is unnecessary anyway. We do not recommend that all mātauranga Māori should be protected, but only those aspects of it so personally held by traditional Māori communities that a kaitiakitanga relationship arises in respect of it. Thus, it is the proximity of the mātauranga and the community that is the core defining factor, not the broad category of mātauranga Māori itself’. Despite the broad nature of mātauranga Māori, the Tribunal concluded it is a taonga and that the Crown has an obligation to actively protect it from loss. See pp xxiii, 22, 96 of the report. URL: waitangitribunal.govt.nz/news/ko-aotearoa-tenei-report-on-the-wai-262-claim-released.

Mātauranga Māori will play many roles in Aotearoa New Zealand's climate response. This will include: providing information about the environment across temporal and spatial scales; supporting Māori-led problem solving, evidence and outcomes; and challenging assumptions on education, economic and social systems that will create diversity of knowledge. Recognising the importance of mātauranga Māori in the climate response is one way the Government will uphold Te Tiriti o Waitangi. This will involve protecting the relationship of Māori with taonga³⁵⁰ and providing support and access to the same resources, tools, institutions and developments as other knowledge systems.

Vision Mātauranga

The Vision Mātauranga policy aims to unlock the science and innovation potential of Māori knowledge, resources and people, and is embedded across all priority investment areas of the RSI portfolio.³⁵¹

The four themes of Vision Mātauranga are all relevant to the climate response, but particularly:

- mātauranga – exploring indigenous knowledge and science and innovation
- taiao/environment – achieving environmental sustainability through iwi and hapū relationships with land and sea.

These themes are supported and informed by the other themes of 'indigenous innovation' and 'hauora/health'.

The Vision Mātauranga policy has been integrated across the RSI portfolio's investment priority areas since 2010, and CRIs had it incorporated into their statements of core purpose in 2011. CRIs are now required to enable the innovation potential of Māori knowledge, resources and people as part of their operating principles.

Examples of research projects in which mātauranga plays an important role include:

- Te mana o Rangitāhua – a five-year project on ecosystem management in Rangitāhua (the Kermadec Islands) to improve resilience to issues such as climate change (Ngāti Kuri, Auckland Museum).³⁵²
- Toitū ngā taonga waimāori – cultural keystone species, Māori livelihoods and climate change (NIWA).

To support the Vision Mātauranga policy, the RSI portfolio has funded projects through Te Pūnaha Hihiko – Vision Mātauranga Capability Fund since 2013. This funds projects that strengthen capability, capacity, skills and networks between Māori and the science and innovation system. Several successful projects draw on mātauranga and knowledge of te taiao (the environment). MBIE is seeing an increase in the success rate of proposals led by Māori organisations.

³⁵⁰ Treasure, anything prized – applied to anything considered to be of value, including socially or culturally valuable objects, resources, phenomena, ideas and techniques.

³⁵¹ www.mbie.govt.nz/science-and-technology/science-and-innovation/agencies-policies-and-budget-initiatives/vision-matauranga-policy

³⁵² www.aucklandmuseum.com/discover/research/rangitahua

In Budget 2020 \$33 million was allocated to the RSI portfolio for a new initiative to support Māori to determine and make future investments in research, science and innovation. Funding will continue at \$13 million per year from 2024/25 onward. Te Tira Whakahihi (a working group that includes six Māori RSI experts as well as MBIE officials) is working to develop two new pilot Māori community-led RSI funds from Budget 2020 funding. Future community-led investments may support work in this area.

A main area of work in Te Ara Paerangi – Future Pathways (outlined above) is exploring how the research, science and innovation system can best honour Tiriti obligations and opportunities, give life to Māori research aspirations and enable mātauranga Māori.

Biological Emissions Reduction Science Accelerator – Science and mātauranga plan

This is a research and development plan for science and mātauranga to lower biological emissions from agriculture. It is part of the Government and sector's Fit for a Better World roadmap and is being developed between government, industry, Māori and the science sector.

This plan is about getting mitigation tools and practices into the hands of farmers faster. It will address the urgent need to reduce biological greenhouse gas emissions, outline future actions and ensure Aotearoa New Zealand has thriving and resilient land-based food systems that embrace both science and mātauranga (te taiao). The plan is expected to be published in late 2022.

Research programmes for agricultural greenhouse gases

Several programmes and organisations carry out research on agricultural greenhouse gas emissions. The major research programmes are described below and research highlights are detailed in section 8.4.

New Zealand Agricultural Greenhouse Gas Research Centre

The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC)³⁵³ is a government-funded partnership, hosted by AgResearch, of nine leading Aotearoa New Zealand research providers working to reduce agricultural greenhouse gas emissions. It funds research projects to discover, develop and make available products, tools and knowledge that enable the practical and cost-effective reduction of agricultural greenhouse gas emissions to New Zealand farmers and growers. The NZAGRC is a 'virtual' centre in that the research it supports is carried out by scientists working in their own organisations. Government funding for NZAGRC's work is provided by MPI and MBIE.

The work led through the NZAGRC has a strong international reputation for science excellence and is a critical part of New Zealand's approach to understanding and managing greenhouse gases from agriculture. It also plays an important role in building capacity and capability in the New Zealand science system to future-proof that research.

The NZAGRC's five areas of research focus are:

- mitigating methane emissions, including by: research required to breed low-emissions ruminant animals; identifying low-methane feeds and feed additives; developing vaccines to inhibit enteric methanogens; and discovering inhibitory compounds that reduce enteric methane emissions. This is a joint programme with the Pastoral Greenhouse Gas Research Consortium and is funded by industry and government

³⁵³ www.nzagrc.org.nz

- mitigating nitrous oxide emissions, including by: identifying and testing plant species effects on nitrous oxide emissions; manipulating denitrification processes; identifying low nitrogen feed management options; researching management effects on emission factors; developing urine patch sensors; and identifying and testing inhibitory compounds that reduce nitrous oxide emissions
- increasing soil carbon content and/or reducing soil carbon loss, including by identifying the potential of different soils to store carbon; manipulating carbon inputs to stabilise and enhance stocks; developing tools to quantify soil carbon content and the stability of stored carbon; researching and modelling the effects of management manipulations; projecting changes in soil carbon in response to climate change and soil disturbance; and establishing a baseline of soil carbon stocks in 500 sites across New Zealand
- future farm systems, including: case studies and modelling work identifying drivers and barriers for existing and future adoption of both incremental and disruptive mitigation options at the farm level; as well as exploring the wider scope and longer time-frame implications for the primary sector of adoption of mitigations to reduce emissions
- Māori-focused research that seeks to assist the Māori agribusiness sector to increase resource use efficiency and farm productivity while lowering greenhouse gas emissions through the design and development, in collaboration with Māori, of tools, models, information and processes. Work is now under way, led by the NZAGRC's Māori Advisory Group Toihau, to shape new research with Māori agribusinesses that will support them to develop integrated farm systems solutions that address multiple economic, social, cultural and environmental outcomes.

Sustainable Land Management and Climate Change (SLMACC)

In 2007, the Government set up the Sustainable Land Management and Climate Change (SLMACC)³⁵⁴ research programme as part of a wider plan of action to support the generation of new climate change knowledge across the agriculture and forestry sectors.

The research programme covered all aspects of climate change in the land-based sectors, including impacts and adaptation, freshwater mitigation, extension of knowledge, reducing greenhouse gas emissions, and increasing forest carbon sinks. Over 180 projects had been commissioned as at June 2022.

An independent review of the SLMACC research programme, completed in 2018, found the programme was creating high-quality research, engaging stakeholders and end users, and growing climate change science capability in Aotearoa New Zealand.

In 2020, the focus of the SLMACC research programme moved to climate change adaptation (including in the forestry sector) and extension, due to the availability of other funding resources for climate change mitigation research.

In addition to funding for the SLMACC adaptation and extension work, in 2020, a further \$16 million funding was allocated to a new four-year SLMACC Freshwater Mitigation programme. This fund supports field trials of existing farm technologies and practices that protect waterways and wetlands by reducing nutrient run-off and leaching, including nitrogen. The programme aims to produce scientific data that can be incorporated into decision-support tools. This work is not specifically focused on climate adaptation or mitigation but does support uptake of practices and tools that will support sustainable land management through a changing climate.

³⁵⁴ www.mpi.govt.nz/funding-rural-support/farming-funds-and-programmes/slmacc.

Since 2020, work undertaken in the SLMACC research programme includes:

- the adaptation programme, which focuses on social impacts, policy research and the science around adaptation to climate change
- the extension programme, which has helped to deliver resources and demonstration programmes directed at agriculture professionals, encouraging climate change mitigation and adaptation practices. An example is the AgMatters website,³⁵⁵ which provides science-backed information for farmers, growers and rural professionals on agricultural greenhouse gas emissions
- the freshwater mitigation programme, which supports field trials of existing farm technologies and practices that protect waterways and wetlands by reducing nutrient run-off and leaching. The programme aims to produce scientific data that can be incorporated into decision-support tools.

Greenhouse Gas Inventory Research

MPI, through its Greenhouse Gas Inventory Research fund, supports research to improve the accuracy of Aotearoa New Zealand's estimates of emissions from agriculture, forestry and other land use. Research from this fund is used to compile the annual greenhouse gas inventory and is also used to develop projections of agriculture, and land use, land-use change and forestry (LULUCF) emissions for the National Communication and Biennial Report.

Improvement of the greenhouse gas inventory is vital for climate change policy development and the recognition of greenhouse gas mitigations within the national inventory, both of which must be underpinned by accurate measurements and projections. Research funded through the Greenhouse Gas Inventory Research fund typically consists of field-based trials to develop new emissions factors, developing new sources of activity data, or desk-based research to develop or improve emissions calculation methodologies.

Centre for Climate Action on Agricultural Emissions

The Government has committed to a significant increase in investment in research and innovation in Budget 2022 (nearly \$339 million over four years). This is to accelerate the development of adoptable greenhouse gas mitigations, including the establishment of a new Centre for Climate Action on Agricultural Emissions (the Centre for Climate Action^{356, 357}). The Centre for Climate Action will include a new public-private joint venture with a focus on product development and commercialisation to get effective tools into the hands of farmers more quickly. It will deliver on three main outcomes:

- faster development, commercialisation and uptake of emissions mitigation technologies (which will enable gross emissions reduction)
- a strong system to support delivering mitigations over the long term
- strong leadership and alignment of biological emissions reduction efforts.

Discussions with the private sector on investment and participation in the joint venture are well advanced. The joint venture will be supported by an enhanced Aotearoa New Zealand Agricultural Greenhouse Gas Research Centre, with a focus on strengthening the underpinning biological emissions research and development system more broadly.

³⁵⁵ See www.AgMatters.co.nz, for more information.

³⁵⁶ www.mpi.govt.nz/funding-rural-support/environment-and-natural-resources/centre-for-climate-action-on-agricultural-emissions

³⁵⁷ www.beehive.govt.nz/release/partnership-reduce-agricultural-emissions

Global Research Alliance on Agricultural Greenhouse Gases (GRA)

The Global Research Alliance on Agricultural Greenhouse Gases (GRA), initiated by Aotearoa New Zealand in late 2009, seeks to increase global cooperation and investment to reduce the emissions intensity of agricultural production systems. The GRA encompasses the voluntary, collaborative efforts of its 66 member countries and 27 partner organisations, spread across the globe. The GRA's work is conducted through its four research groups, focused on key agricultural subsectors (Livestock, Croplands, Paddy Rice) and an Integrative Research Group that addresses cross-cutting issues, including soil carbon sequestration and greenhouse gas inventories.

New Zealand plays an active role in supporting the GRA through funding and delivery of education, training and public awareness, funding of mitigation research projects and funding of regional and international collaboration (see chapter 9, section 9.6). This is in addition to co-chairing the GRA's Livestock Research Group and hosting the GRA Secretariat and Special Representative. Up to December 2022, the Government has committed funding of NZ\$101 million to support the GRA's activities. For future years, the New Zealand Government has committed around NZ\$20 million per year to support the GRA and its activities. GRA research should ultimately contribute to global emissions reductions far greater than New Zealand's 0.16 per cent total contribution to global emissions.

Included as part of New Zealand's investment in the GRA is funding via the New Zealand International Development Cooperation Programme to build regional capability in African, Association of Southeast Asian Nations (ASEAN), Latin American countries. New Zealand invested NZ\$15 million in African and ASEAN countries, and NZ\$10 million in Caribbean and Latin American countries. This Climate-Smart initiative supports countries to identify low emissions and high productivity agricultural systems through the improvement of national greenhouse gas inventories and regional greenhouse gas measurements.

The GRA is establishing an Indigenous-led Research Network, to empower indigenous people and enhance their leadership, influence, education and employment in the Agriscience field. This network aims for inclusivity of indigenous peoples, ideas, needs and aspirations in the GRA. New Zealand is contributing to the development of this network by investing NZ\$224,000 to support Māori leadership.

Pastoral Greenhouse Gas Research Consortium

The Pastoral Greenhouse Gas Research Consortium (PGgRc) is a partnership, previously funded 50:50 by the Government and industry, which aims to provide livestock farmers with the information and means to mitigate their greenhouse gas emissions. The PGgRc and NZAGRC jointly developed a research, development and extension strategy. The PGgRc mainly focused on research to reduce methane emissions in ruminant animals.

The PGgRc has been in operation since 2002. It comprises eight partners from the dairy, sheep, beef, deer, agricultural research and fertiliser industries. This includes DairyNZ, Beef+Lamb New Zealand, DEEResearch and the Fertiliser Association of New Zealand, all of whom fund research for the benefit of the industry as a whole. In February 2013, the Government and industry partners committed a further NZ\$5.4 million per annum to the PGgRc for seven years. The Government funding ceased to the PGgRc in 2021. Industry has continued to support the PGgRc, which is the holder of Intellectual Property (IP) on greenhouse gas mitigation technologies. Government has supported the PGgRc to develop IP on vaccines and inhibitors towards commercialisation. The PGgRc continues to hold and develop greenhouse gas IP.

It has also been active in commercialising on-farm sheep genetic selection for lower methane emissions.

Significant outcomes the PGgRc has achieved include:

- identifying and developing the ability to breed low-methane-emitting sheep
- sequencing the first methanogen genome and identifying targets that are being used to develop a methane-reducing vaccine
- identifying classes of compounds that show promise as inhibitors of methane emissions.

The PGgRc also actively pursues collaborations with international agricultural animal health and other companies, to provide avenues to commercialise any products.

Biological Emissions Reference Group

The Biological Emissions Reference Group is a joint government and industry reference group established in 2016. It was set up to build a robust and agreed evidence base for what the agriculture sector can do to reduce emissions at the farm level, now and into the future, and assess the costs and opportunities of doing so. The group commissioned independent third-party research in support of this evidence base and published a final synthesis report in December 2018. This evidence helped inform future actions and policies to reduce biological emissions from agriculture. The group was disestablished in 2019.

Research support in the Pacific Islands

MetService, Aotearoa New Zealand's national meteorological service, and NIWA provide assistance to several Pacific Island nations (primarily Cook Islands, Kiribati, Niue, Samoa, Tokelau, Tonga and Tuvalu) with their weather and climate observing systems. With other New Zealand and international funding, NIWA has participated in a Pacific Islands data rescue programme. Past New Zealand official development assistance programmes have covered training in technical maintenance and observing practices in several of these countries.

New Zealand (through NIWA) continues to support the Pacific Islands with weather and climate services, collaborating closely with the Pacific Islands and scientific partners in Australia, France, South Korea and the United States of America. This includes the continued science development and production of the *Island Climate Update*, which provides a summary of current climatic and rainfall conditions across the Pacific and uses analysis of satellite-derived rainfall and a multi-model ensemble from nine global climate models to forecast rainfall for up to five months ahead. NIWA has also been an important collaborator in the Australian and New Zealand-funded Climate and Oceans Support Program in the Pacific (COSPPac), which has been installing systems in 14 Pacific countries to deliver sector-specific climate services. The underlying development of these systems, CliDEsc and CliDEsc Portal, has been supported by NIWA. NIWA also works with Pacific Islands and other regional technical partners on a range of climate-related hazard, risk and adaptation activities supported through a variety of multilateral and bilateral donor initiatives.

8.2.2 Funding policies

Several sources of funding are available for climate research and systematic observation.

Strategic Science Investment Fund

The Strategic Science Investment Fund (SSIF) supports longer-term programmes of mission-led science and science infrastructure of enduring importance to Aotearoa New Zealand. The SSIF provides longer-term funding to underpin strategically important science platforms, which are combinations of people, facilities, information and knowledge that provide a particular ongoing science and innovation capability for New Zealand. In 2022/23, the SSIF programmes are worth over NZ\$280 million per year.³⁵⁸ CRIs receive over \$212 million of funding through the SSIF.

Several SSIF investments have a climate element, as follows.

- Weather and climate hazards platform (\$14.3 million per year): Understanding large scale weather and climate systems through numerical prediction techniques, monitoring and advanced measurement, for example, predicting extreme weather events and impacts, climate adaption and mitigation – NIWA.
- Agri-food production platform (\$26 million per year): An integrated platform of farm biome genomics, biosecurity and decision-centric farm systems for sustainable livestock production. For example, genomics for improving performance while reducing emissions to the environment; supporting uptake of new practices and technologies; supporting the Free Air Carbon Dioxide Enrichment (FACE) field research platform looking at elevated CO₂ under pastoral grazing conditions – AgResearch.
- Enhancing land use platform (\$8.25 million per year): This platform supports research that enables New Zealanders to better measure and manage their land resources, reduce greenhouse gas emissions, and manage the environmental impacts of land use. It will enable the natural resources sector and primary sector, including Māori, to manage land in ways that improve the quality of land, soil and fresh water, reduce carbon emissions and verify New Zealand's environmental performance. This platform also supports Māori aspirations through investment in all research areas above, supplemented by around \$0.50 million of investment specifically focused on Māori outcomes – Manaaki Whenua Landcare Research.
- Plant-based food and seafood platform (\$20.9 million per year): Supports capabilities that contribute to the sustainable production and protection of crops and seafood. Research is developing a deeper understanding of the biology and physiology of important economic plant and seafood species, their production systems, their pests and diseases and interactions with the environment. This will support improved and novel growing systems; sustainable management of soil and water; new integrated pest and pathogen management systems; and climate change mitigations – Plant & Food Research
- Forest systems (\$7.2 million per year): Delivering innovative knowledge, tools and capability to support the continued expansion of the New Zealand forest growing industry, thereby contributing to New Zealand's economy, environmental performance and social and cultural health. Research will support an increase in forested land, improved forest productivity, a diversified forest estate, increasing carbon sequestration and increased exports – Scion.
- Manufactured products from trees (\$10.2 million per year): The platform supports research that will: increase the use of wood and fibre products in the built environment; manufacture and apply biorefinery products from wood fibre, waste and other biomaterials; and enable use of more forest biomass to improve New Zealand's energy security and reduce emissions – Scion.

³⁵⁸ The Strategic Science Investment Fund also includes infrastructure, which is not included in this figure.

- Antarctic Science Platform (\$7 million per year for seven years): The platform will be based on four Antarctic science priorities, which were developed in consultation with a range of government and sector stakeholders. The priorities are: understanding the stability of the West Antarctic Ice Sheet; understanding the impacts of change in the Antarctic atmosphere and Southern Ocean; understanding threats to ecosystem dynamics in the Ross Sea; understanding connections between terrestrial and nearshore Antarctic environments, including sea ice – hosted by Antarctica New Zealand.
- Advanced Energy Technology Platform (\$50 million over seven years): This platform is focused on engineering, physical and biological sciences research to develop technologies transforming the way we produce, use, manage and store energy. Four research programmes are funded under this platform:
 - The Research Trust of Victoria University of Wellington for its programme ‘High power electric motors for large-scale transport’
 - University of Waikato for its programme ‘Ahuora: Delivering sustainable industry through smart process heat decarbonisation’
 - University of Canterbury for its programme ‘Architecture of the future low-carbon, resilient, electrical power system’
 - GNS Science for its programme ‘Aotearoa: Green Hydrogen Technology Platform’.
- Data Science Platform (\$49 million over seven years): The Data Science platform intends to significantly lift New Zealand’s capability, and support and encourage dynamic and world class data science research. Four research programmes sit within this platform, one of which has a significant climate science element: University of Waikato’s programme ‘Time-Evolving Data Science / Artificial Intelligence for Advanced Open Environmental Science’, which is developing new data science methods that address the challenges of environmental data.
- Nationally Significant Collections and Databases: A small set of databases and collections is supported via the SSIF that provide a vehicle for systematic observations that inform climate research. This includes the national climate database held by NIWA and several databases that inform climate research, see annex D.
- Methane SAT Mission Operations Control Centre (\$6.7 million): This will provide a set of functional capabilities for the command, control and support of the MethaneSAT satellite (designed to detect global methane emissions) and future satellite missions for New Zealand.

National Science Challenges

In mid-2013, MBIE announced significant new research funding aligned to 11 National Science Challenges,³⁵⁹ to be supported for 10 years.

The funding includes NZ\$22.5 million per year for challenges relating to the environment.

The National Science Challenges are designed to take a more strategic approach to the Government’s science investment by targeting a series of goals that, if achieved, would have major and enduring benefits for Aotearoa New Zealand. The impacts of climate change are being studied in several challenges, including:

³⁵⁹ www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/national-science-challenges/the-11-challenges

- enabling New Zealanders to anticipate, adapt, manage risk and thrive in a changing climate (the Deep South)
- increasing resilience to natural hazards, particularly those faced by coastal communities (Resilience to Nature's Challenges)
- enhancing primary sector production and productivity while maintaining and improving New Zealand's land and water quality for future generations (Our Land and Water)
- enhancing the value of marine resources while providing a healthy marine environment for future generations (Sustainable Seas)
- protecting and managing biodiversity, improving biosecurity and enhancing resilience to harmful organisms (New Zealand's Biological Heritage).

Three of these challenges are outlined below, see their websites for further information.

The Deep South

The mission of the Deep South (Te Kōmata o Te Tonga) National Science Challenge: Changing with our climate is to transform the way New Zealanders adapt, manage risk, and thrive in a changing climate.³⁶⁰

The Challenge has developed a numerical earth system model to better understand New Zealand's future climate. The model, and the capacity development it enables, is resulting in improved modelling of climate processes that significantly impact Southern Hemisphere climate. It is underpinned by improved knowledge and observations of climate processes in the Southern Ocean and Antarctica.

Research in the Challenge has investigated the impacts of a changing climate on New Zealand's important climate-sensitive economic sectors, infrastructure and natural resources. After an initial focus on understanding climate impacts, the Challenge has also responded to the need to prioritise innovative studies on adaptation decision-making under uncertainty, including decision-support tools, governance and legal frameworks.

The Deep South has a Vision Mātauranga research stream that currently funds predominantly hapū-led research projects, with a funding and support programme that has been redesigned to serve those researchers and communities. Research in this programme ranges from that grounded in food sovereignty, to understanding hapū histories of relocation to inform future adaptation strategies, to developing mātauranga based environmental management frameworks. All are grounded in local knowledge and kaupapa Māori research methodologies.

The Deep South is incorporating innovative ways to connect the science with industry, regulators and planners and communities through its Engagement programme. There is a focus on contributing to dynamic Tiriti-based conversations about climate adaptation, and both engaging and supporting Māori aspirations through mainstream engagement activities, as well as those by Māori, for Māori. This will give New Zealanders a greater level of agency in their planning and decision-making in the face of a changing climate, better meet the needs of iwi, hapū and Māori business objectives and goals, now and in the future.

The science will build on long-standing, successful collaborations with leading international science and research institutions, place-based mātauranga, and New Zealand's geographic proximity and access to the Deep South region.

³⁶⁰ deepsouthchallenge.co.nz

Resilience to Nature's Challenges – *Kia Manawaroa – Nga Akina o Te Ao Turoa*

Resilience to Nature's Challenges was established in 2015 to develop and apply, through collaboration, new scientific solutions to transform the way New Zealanders understand and manage natural hazard risks and build disaster resilience.³⁶¹ The vision of the challenge is for Aotearoa New Zealand to be a nation of people who have transformed their lives, enterprises and communities to anticipate, adapt and thrive to the ever-changing challenges of nature.

In Phase 1 (2015–19), scientists and key partners co-developed new knowledge and tools across various natural hazards enabling improved resilience in New Zealand's rural, urban, coastal and Māori communities. For instance, the research has contributed to the more resilient design of New Zealand's electricity, transport and communications sectors, and agencies responsible for these networks are better able to collaborate and exchange resilience information.

An expanded programme for Phase 2 of the Challenge began in July 2019. The Phase 2 programme places a special emphasis on complex risk (where multiple natural hazards combine or cascade to threaten community sustainability). It is striving to integrate the modelling of physical, social and economic impacts of a range of natural hazards, including earthquakes, tsunamis, landslides, volcanic eruptions, extreme weather and coastal inundation. To influence resilience decision-making, it is coupling this approach with new science that addresses the barriers, benefits and incentives for building resilience, and work in partnership with a wide range of stakeholders. Phase 2 of the Challenge is also looking to lift the approach to kaupapa Māori research and Vision Mātauranga, and increase the visibility, understanding and transformational potential of mātauranga Māori in natural hazard research and resilience.

Our Land and Water – Toitū te Whenua, Toiora te Wai

Our Land and Water aims to enhance the production and productivity of Aotearoa New Zealand's primary sector, while maintaining and improving the quality of the country's land and water for future generations.³⁶² It focuses on three main areas: future landscapes, incentives for change and pathways to transition. The Challenge brings together research teams from various disciplines, from across universities, all the CRIs, and many businesses, iwi and Māori groups, government and non-governmental organisations, private citizens and regional councils.

Other government funding

Endeavour Fund

MBIE's Endeavour Fund contributes funding to climate change research.³⁶³ The Endeavour Fund provides an open, competitive process for selecting research proposals with the potential to have a significant positive and transformational impact for Aotearoa New Zealand. More than NZ\$229 million in funding has been invested through the Endeavour Fund in 2022/23, with up to NZ\$56 million per year invested in Smart Ideas and Research Programmes. The 2022–24 Endeavour Fund Investment Plan signalled that decision-makers would seek opportunities to fund proposals whose primary objective is to create new knowledge pathways to support the transition to a low emissions and climate resilient economy.

³⁶¹ resiliencechallenge.nz

³⁶² ourlandandwater.nz

³⁶³ www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/endeavour-fund

In 2022/23 \$15.97 million was invested in climate change and emissions reduction research through the fund. Examples of projects are listed below.

- **NZ SeaRise: Te Tai Pari O Aotearoa** uses statistical modelling to combine estimates of vertical land movement and global scale sea-level change projections, to predict relative sea-level rise at local scales. These data are informing local planners, insurers, homeowners and more, to understand the risks associated with specific locations (Victoria University of Wellington, GNS Science and NIWA).³⁶⁴
- **Future Coasts Aotearoa** investigates how sea-level rise will affect the natural environment and rural land use. This includes changes to salinisation of groundwater and coastal wetland evolution. It is developing methods to enable equitable land-use planning decisions, which balance social, cultural, environmental and economic wellbeing (NIWA).³⁶⁵
- **CarbonWatch NZ** combines measurements of greenhouse gases in the air above New Zealand with models that tell where those gases have come from, giving a bird's eye view of the country's carbon balance (NIWA and GNS Science).³⁶⁶
- **Natural carbon sequestration in our southern fjords** aims to understand the future of fjords and their ability to soak up carbon (University of Otago and GNS Science).³⁶⁷
- **Reversing carbon emissions in the geothermal energy industry** by reinjecting and mineral trapping greenhouse gases back to the geothermal reservoirs (University of Auckland).

Systematic observations

Systematic observations are part-funded through the Crown contract for Aotearoa New Zealand's national weather service administered by the Ministry of Transport and awarded to MetService.³⁶⁸ These cover routine upper air and surface weather observations and forecasting of extreme events that are also used for climate research. Further observations for climate research are supported by SSIF funding to NIWA, and both weather and climate observations are incorporated in the National Climate Database managed by NIWA. Limited support for observations in the Pacific is provided through the Ministry of Transport's contract with MetService.

Investing in innovation

MPI supports problem solving and innovation in Aotearoa New Zealand's food and fibre sector by co-investing in initiatives that make a positive and lasting difference through the Sustainable Food and Fibre Futures fund. Several projects and programmes supported through the fund have a focus on developing and testing tools to reduce agricultural greenhouse gases. Some of these projects are highlighted in section 8.4.

³⁶⁴ www.searise.nz

³⁶⁵ niwa.co.nz/natural-hazards/research-projects/future-coasts-aotearoa

³⁶⁶ niwa.co.nz/climate/research-projects/carbon-watch-nz

³⁶⁷ www.gns.cri.nz/research-projects/fjords-as-carbon-sinks

³⁶⁸ MetService, New Zealand's national weather authority, is a state-owned enterprise meaning it operates as a commercial business.

Regenerative farming practices

MPI is supporting projects that are undertaking research into regenerative farming through the Sustainable Food and Fibre Futures fund. This will help Aotearoa New Zealand define what regenerative agriculture means for the country and develop a sound evidence base of what works with New Zealand soils, climates and farming systems. Most projects are assessing regenerative farming practices, to test whether they increase soil carbon levels. As at September 2022, 13 regenerative farming projects are in progress or completed, representing almost \$56 million of co-investment from the Government and industry.

Additional research funding

Additional government support for research comes through:

- the Marsden Fund, which is administered by the Royal Society of New Zealand Te Apārangi and is not subject to government research priorities
- funding for university research within Vote Education
- the Health Research Council through Vote Health.

Direct funding of research occurs in some climate change areas by core government departments to meet operational and policy development needs. For example, the Ministry for the Environment's guidance to local government on flooding, planning for coastal hazards, and research on measuring land-based carbon stock changes (see section 8.4.6). For more details about the research projects funded by MBIE, search the 'Who got funded' database using the search term 'climate change'.³⁶⁹

8.3 Information exchange and dissemination of knowledge

The Ministry for the Environment and MPI work in conjunction with science providers to disseminate research findings on climate change (see chapter 9).

Outside of central government, CRIs provide information on their specific subject area on climate change on their websites and through papers, conferences and peer-reviewed publications. For example, NIWA provides public access to the National Climate Database via the internet, and produces monthly updates of recent climate data and the seasonal outlook.

8.3.1 International exchange of data and information

Aotearoa New Zealand exchanges data and information with other countries, in line with the Technical Regulations of the WMO. Selected weather observations useful for weather and climate modelling are disseminated in real time by MetService through the WMO Global Telecommunications System, and climate and greenhouse gas monitoring data are provided to appropriate world data centres. In the marine environment, New Zealand also contributes data to international databases such as Argo and the Integrated Marine Observing System (IMOS).

³⁶⁹ www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/who-got-funded

New Zealand has identified particular opportunities for the dissemination of real-time climate data throughout the Pacific to provide up-to-date information on current climate conditions and seasonal outlooks to Pacific Island nations, and to help them deal with climate variability. This has led to the establishment of the *Island Climate Update* (discussed in section 8.2.1). NIWA also produces a similar monthly publication for New Zealand, the *New Zealand Seasonal Climate Outlook*, as well as monthly, seasonal and annual climate summaries. Additional exchanges of information occur under the auspices of the Pacific Islands Global Climate Observing System (PI-GCOS) and the Asia–Pacific Network for Global Change Research.

New Zealand also provides input into the IPCC Emission Factor Data Base. A New Zealand scientist currently serves on the Editorial Board, and several emission factors based on New Zealand agricultural research have been submitted to the Emission Factor Data Base. New Zealand data contributed to the development of new emission factors for the agriculture sector in the 2019 refinement of the IPCC 2006 Guidelines for National Greenhouse Gas Inventories.

8.3.2 Partnerships

Multilateral partnerships

Global Research Alliance on Agricultural Greenhouse Gases

Aotearoa New Zealand provides funding to support GRA research to reduce agricultural greenhouse gases primarily from pastoral-based livestock farming systems.

New Zealand supported international research collaborations through multi-partner funds, such as the New Zealand Fund for Global Partnerships in Livestock Emissions Research.³⁷⁰ This was a contestable, international research fund managed by MPI to accelerate global research in mitigating greenhouse gas emissions from pastoral livestock farming. It sought solutions to research challenges in the areas of: manipulating rumen function, reducing nitrous oxide emissions from soils, manipulating rates of soil carbon change and improved tools and practices for minimising greenhouse gas emissions intensity at the farm system level.

Funding under the New Zealand GRA budget also enables New Zealand scientists to participate in other collaborative funding calls. For example, New Zealand is participating in the international programme ‘European Research Area Network’ (ERA-NET), collaborating in research projects aligned with New Zealand’s priorities in agriculture and climate change mitigation. New Zealand is also leading the Joint Research initiative with Ireland, which will enable New Zealand researchers to be involved in internationally collaborative research. This project will identify technologies and practices to help farmers mitigate greenhouse gas emissions from already advanced pasture-based systems.

The Global Research Alliance Senior Scientist awards provided short-term exchange opportunities for senior scientists from both New Zealand and other GRA member countries to encourage global research collaboration. During this reporting period, three awardees from Brazil, New Zealand and the United States of America have been supported by the programme.

³⁷⁰ www.mpi.govt.nz/funding-rural-support/farming-funds-and-programmes/global-partnerships-in-livestock-emissions-research

Other partnerships

Aotearoa New Zealand has co-funded a project with the Inter-American Development Bank's Regional Fund for Agricultural Technology (FONTAGRO). The project focuses on contributing to the design of land uses and management with a high potential for soil organic carbon (SOC) sequestration in the agricultural production systems of Latin America and the Caribbean (LAC) and to generate capacities in LAC for the quantification and monitoring of SOC stocks. This project has the involvement of five developing countries from the LAC region, for example, Argentina, Chile, Colombia, Costa Rica and Uruguay. The direct beneficiaries of the project will be the national entities of Argentina, Chile, Costa Rica, Colombia and Uruguay in charge of reporting greenhouse gas inventories, especially SOC stocks. Neighbouring LAC countries with similar agroecosystems to those of the five participating countries will also benefit from the products of this project.

MethaneSAT

Aotearoa New Zealand is contributing \$26 million towards MethaneSAT, a state-of-the-art satellite being designed to detect global methane emissions. This will deliver two main outputs: an atmospheric science research project to investigate applications of the satellite's data for New Zealand, and a satellite mission operations control centre. The operations control centre will provide a set of functional capabilities for the command, control and support of the satellite, and will effectively run the mission once the satellite is launched. The project is in partnership with Environmental Defense Fund (EDF), a US environmental non-government organisation. EDF aims to use MethaneSAT's data to reduce global oil and gas industry methane emissions.

International organisations

Aotearoa New Zealand is an active member of the WMO and exchanges information and data through both the WMO and its subsidiary and associated bodies. Through membership of GCOS and its Pacific arm, PI-GCOS, and through the Asia–Pacific Network for Global Change Research, New Zealand works to lower barriers to, and further facilitate, such data exchanges. New Zealand has provided input to the development and implementation of the Global Framework for Climate Services and is represented on the Intergovernmental Board for Climate Services.

New Zealand continues to contribute actively to the work of the IPCC. New Zealand provides support for one elected member of the IPCC Bureau, participates in plenary meetings, task groups, workshops and expert meetings, and contributes to the IPCC's assessment reports. The Government also provides financial support for New Zealand lead authors involved in the IPCC's Sixth Assessment Report. Draft reports and outlines receive wide government review. New Zealand was an active participant in all working groups and stages of the Sixth Assessment Report, from providing support to the Working Group III Vice Chair from WMO Region V (South-West Pacific), participating in 17 chapters in Working Groups I, II and III, to the writing of the synthesis report, with the involvement of 32 individual experts.

New Zealand is also involved in cryospheric science collaboration and data exchange through the Scientific Committee on Antarctic Research and the Antarctic Treaty Consultative Meeting. Several New Zealand scientists are involved at high levels in the World Climate Research Programme.

8.4 Research highlights

This section presents some of the highlights, innovations and significant projects in climate change research in Aotearoa New Zealand since the *Seventh National Communication*.

Climate change research in New Zealand seeks to develop information and knowledge on many issues. Particular information needs and areas of national research excellence include:

- past climate trends and variability
- climate processes and phenomena, and the causes of variability and change
- regional climate modelling, predictions and projections
- the effects of these projected changes on the environment of New Zealand, the southwest Pacific, Southern Ocean and Antarctica, and on society and the economy
- adaptation options
- greenhouse gas measurement and national greenhouse gas inventory development and support
- reducing emissions from pastoral agriculture
- enhancing sinks, particularly forest sinks and soil carbon
- community resilience and human health
- oceanic and atmospheric chemistry.

8.4.1 Climate processes and climate system studies

Climate variability and trends

Aotearoa New Zealand research has a strong focus on identifying regional climate trends and variability. It includes observations, analysis and documentation of atmospheric, oceanic, coastal, river and stream, lake, snow, glacier, sea-ice and sea-level conditions in New Zealand, the southwest Pacific, the Southern Ocean and Antarctica. Substantial international collaboration occurs, including analysing data from Argo floats, to provide improved knowledge of physical ocean conditions in the region, and contributions to the Atmospheric Circulation Reconstructions over the Earth project.

The research leads to journal papers, regular monthly, seasonal and annual climate updates, briefings to stakeholders (eg, on drought conditions) and annual reports on the state of the climate.

The ‘Deep South National Science Challenge: Changing with our climate’ also includes observational studies as part of its Processes and Observations programme. For example, building on previous research that resulted in significant unified model improvements, the clouds and aerosols observation project is collaborating with two joint German–New Zealand measurement campaigns, to better understand the properties of mixed-phase clouds and the influence of aerosols on cloud phase, which are of particular importance for the southern hemisphere climate. Other studies under way as part of the Deep South Challenge include a study on ocean–atmosphere interactions during storms, and the impact of climate change on snow and glacier melt and the flow-on consequences for the hydrological cycle.

Climate processes, phenomena and causes of variability and change

This research aims to understand how the dynamics of the climate system influence the atmosphere, ocean, ice and hydrospheric conditions in the Aotearoa New Zealand region, and to identify the cause of changes. This includes research on particular climate phenomena of regional relevance, including the El Niño / Southern Oscillation, the Interdecadal Pacific Oscillation, the Southern Annular Mode and tropical cyclones. It also includes studies of tropical–extra-tropical links, and detection and attribution research to identify the causes of climate change and climate extremes in the region. Further work addresses interactions between sea ice and atmospheric circulation at both the large and small scales, and the effect these have on the ocean, along with work on how ocean variability affects the regional climate. The knowledge gained in this research contributes to, and underpins, New Zealand research on seasonal climate predictions and climate change modelling.

Palaeoclimate

The past climates of the Aotearoa New Zealand region are investigated using proxy records to study temperatures, vegetation, glaciers and ocean circulation, among other climate parameters, on a variety of timescales. It is of particular interest to relate the changes seen in New Zealand to global changes in atmospheric and oceanic circulation. Research is being conducted to synthesise results from disparate sources of palaeoclimate information and quantify climate changes that have occurred in the past. This includes information on the regional and temporal patterns of climate change. In addition, such research provides information on natural periodicities, such as the frequency and intensity of El Niño–La Niña events, as well as the frequency of more extreme events.

Palaeoclimate research in Antarctica is an area of national excellence. With substantial leadership and participation from New Zealand scientists, the ANDRILL (Antarctic Drilling) project successfully recovered two long rock cores from beneath the sea floor. These cores reveal substantial glacial and interglacial fluctuations of the West Antarctic Ice Sheet over the past 20 million years, and other changes in ice, vegetation and sea level during climates warmer than the present. New Zealand has developed the capability for drilling long ice cores. A 750-metre-deep ice core was recovered from Roosevelt Island in Antarctica to investigate the past 20,000 years, and the stability of the Ross Ice Shelf and West Antarctic Ice Sheet in a warming world.

Sea level reconstructions from drilling in New Zealand’s Wanganui Basin show large portions of the Antarctic collapsed during times when atmospheric CO₂ levels last exceeded 400 parts per million and average surface temperatures were 2–3°C warmer than the pre-industrial period. Data derived from these sea level studies, ANDRILL, and similar Antarctic paleoclimate research activities have been used to guide ice sheet modelling experiments that improve process understanding and model performance. These paleo-tested models are incorporated into the suite of models in the Inter-Sectoral Impact Model Intercomparison Project that are used to project the future contribution of Antarctica to the global sea level.

Atmospheric chemistry

NIWA and GNS Science are continuing measurements and computer modelling to improve knowledge about the sources, sinks and transport of greenhouse gases in the atmosphere. This work includes participation in the international Total Carbon Column Observing Network, the WMO’s Global Atmospheric Watch and the Network for the Detection of Atmospheric Composition Change. Research is also being undertaken on the implications of climate

change for the recovery of stratospheric ozone concentrations. The Aotearoa New Zealand greenhouse gas monitoring network has recently been expanded, and observations from this are used to refine CO₂ and methane source and sink estimates for forest and grassland use. The CarbonWatch NZ programme combines measurements of greenhouse gases in the air above New Zealand with models that tell where those gases have come from, giving us a bird's eye view of the country's carbon balance.

Ocean–atmosphere gas

The Ocean Climate Interaction programme at NIWA provides information on the transfer of CO₂, significant trace gas species and aerosols between the ocean and atmosphere. The programme also investigates the dynamics and circulation of the ocean around Aotearoa New Zealand, with the aim of quantifying their variation in time and space. It considers biogeochemical and physical processes that drive exchange and their response to climate forcing through feedback mechanisms, and how this will affect future productivity, carbon uptake and ecosystem health in regional waters. Long-term regional monitoring and modelling provide critical input into national policy and strategy – and international commitments – on climate change, ocean acidification and global ocean carbon uptake.

In particular, knowledge of carbon sinks in the New Zealand region is an important requirement of regional budgets and models that inform national policy and international response to climate change. The Southern Ocean is the largest regional sink for anthropogenic CO₂, and so understanding the controls and rate of marine CO₂ uptake is critical for global carbon budgets. Related work also considers the role of marine carbon sinks, from coastal 'blue' carbon to potential large-scale climate intervention techniques, as well as other mitigation and adaptation approaches, in combating climate change.

8.4.2 Modelling and prediction, including general circulation models

Information on future climate change scenarios for Aotearoa New Zealand is provided in the Ministry for the Environment's 2018 report *Climate Projections for New Zealand*.³⁷¹ These projections are based on the IPCC's *Fifth Assessment Report*.³⁷² A further interim report provides information on how the IPCC's *Sixth Assessment Report* affects regional projections for New Zealand. However, there is *very high confidence* that projected climate changes for the region in the *Sixth Assessment Report* have not altered substantially since the fifth report.

Three main sources of uncertainty exist for projected climate change: emission scenarios, regional climate responses, and random climate variability, highlighting the importance of future adaptation. Several observed impacts in New Zealand have already been directly attributed to climate change, with further climate change and the associated impacts inevitable.³⁷³ Preliminary projections based on the Coupled Model Intercomparison Project

³⁷¹ Ministry for the Environment. 2018. *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment, 2nd Edition*. Wellington: Ministry for the Environment.

³⁷² Intergovernmental Panel on Climate Change. 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

³⁷³ See *Sixth Assessment Report*, chapter 11, Australasia.

Phase 6 (CMIP6) models are described in the IPCC Working Group I *Sixth Assessment Report*.³⁷⁴ For New Zealand, the CMIP6 projections are broadly similar to CMIP5, as reported in the *Fifth Assessment Report*. In general, the CMIP6 models indicate greater warming, a smaller increase in summer precipitation, and a larger increase in winter precipitation. Other significant differences are reported in New Zealand climate change projections guidance.³⁷⁵

Regional climate scenarios for New Zealand through the 21st century, based on statistical downscaling from global climate models and dynamical downscaling using the CMIP5 global climate models, produced in association with the IPCC's *Fifth Assessment Report*, have been completed. These regional climate scenarios are derived from the four Representative Concentration Pathways used by the IPCC in its *Fifth Assessment Report*. The downscaled data have been mapped onto a 5 kilometre grid to produce estimates of temperature and rainfall for any location across the country.

These projections, completed in 2016, were based on CMIP5 global climate model runs assessed in the *Fifth Assessment Report*. This involved both statistical and dynamical downscaling using a climate model installed in NIWA's supercomputer, and also helped in assessing likely changes in climatic extremes. Outputs from the dynamical modelling were also linked to hydrological models to provide river flow projections. More fundamental research on uncertainties in climate models and their implications for regional predictability is also under way. NIWA has begun preparation of new climate change projections downscaled from the IPCC's *Sixth Assessment Report*.

As a core member of the Unified Model Partnership,³⁷⁶ NIWA has strong links to the United Kingdom Met Office (lead partnership organisation) and other core and associate partners. NIWA also has many active collaborations with NOAA (National Oceanic and Atmospheric Administration (United States of America) and other international agencies. This international collaboration on climate modelling helps underpin the research and development within the programme.

The projections based on both the downscaling and regional climate modelling provide data that are used extensively in other research, such as for land use, engineering design, health and other biological impacts, and socio-economic modelling. This programme also produces regular seasonal climate outlooks, expressed in probabilistic terms, which when interpreted and used properly can improve the management of agriculture, energy, water and production in other climate-sensitive industries.

Research projects funded by the 'Deep South National Science Challenge: Changing with our climate' and the Endeavour project 'Whakahura: Extreme events and the emergence of climate change' are using crowd-sourced computer power to run large iterations of a weather@home regional climate model for New Zealand, to improve understanding of temperature and precipitation extremes under future warming levels.

³⁷⁴ Intergovernmental Panel on Climate Change. 2021. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Intergovernmental Panel on Climate Change.

³⁷⁵ environment.govt.nz/publications/aotearoa-new-zealand-climate-change-projections-guidance

³⁷⁶ niwa.co.nz/climate/research-projects/updated-national-climate-projections-for-aotearoa-new-zealand

8.4.3 Research on the impacts of climate change

Hydrology

Agriculture is a significant part of Aotearoa New Zealand's economy and society, and projected scenarios of rainfall and soil moisture are an important part of planning for climate change. Research drawing on various IPCC scenarios and climate models has suggested that drought extent and severity will increase in most areas of New Zealand, particularly in the northern and eastern North Island and in the lee of the main divide over the South Island. Results are now available on the implications of these same scenarios for future river flows, flooding and the availability of water for irrigation.

Research and modelling have also been undertaken on possible increases in the frequency of heavy rainfall events and potential implications for flooding in some locations. Results suggest some areas will see increases in extreme events, even beyond that expected from the higher moisture-holding capacity of warmer air. Extreme rainfall is likely to increase in most areas, with the largest increases projected for areas where average rainfall is also expected to increase.

Coastal impacts

The Government supports several nationwide research projects that aim to enable the management of coastal hazards by planners, engineers and coastal scientists. These include the development of:

- a consistent national overview of coastal vulnerability to climate change, from which local scenarios of future impacts can be derived
- readily available, consistent information on the trends and extremes for wave, swell and storm surge at a regional scale, both now and incorporating future climate change effects
- a deeper understanding of flooding hazard and risk in coastal areas and estuaries, and how these risks are affected by human and climate factors
- adaptation guidance and tools to enable communities and decision-makers to plan proactively for successful coastal adaptation
- a national spatial dataset of critical infrastructure network service disruption from future coastal flooding.

The NZ SeaRise programme has developed location specific sea-level rise projections out to the year 2300 for every 2 kilometres of the coast of Aotearoa New Zealand. These projections can be accessed through an online tool developed by Takiwā, a data management and analytics platform.³⁷⁷

In July 2022, the Ministry for the Environment published the *Interim guidance on the use of new sea-level rise projections*.³⁷⁸ This guidance supersedes parts of the coastal hazards and climate change guidance to reflect the latest sea-level rise scenarios from the IPCC and NZ SeaRise programme.

³⁷⁷ www.searise.nz/maps-2

³⁷⁸ Ministry for the Environment. 2022. *Interim guidance on the use of new sea-level rise projections*. Wellington: Ministry for the Environment.

Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand is a technical guidance manual on planning for climate change in the coastal margins.³⁷⁹ The guidance takes into account research on the impacts of climate change and sea-level rise on coastal hazards, and includes projections of future sea-level rise based on the scenarios included in the IPCC's *Fifth Assessment Report*. The coastal hazards and climate change guidance will be fully updated in early 2023.

Marine environment

MPI has funded several research projects that examine the effects of climate change on Aotearoa New Zealand's living marine resources. This includes impacts on commercial fish stocks and shellfish behaviour and life history development. The research commissioned by MPI falls under three broad categories:

- repeated physical measurements and biological observations in the marine environment
- fish stock abundance and fish recruitment correlation with environmental change
- the direct effects of changing marine environmental variables on marine species in the wild and in captivity.

Marine heatwaves are becoming a primary climate change issue for New Zealand's waters, with devastating impacts to marine species and aquaculture operations. Real-time data on marine heatwaves has been collected from sensors mounted to fishing gear by the Moana Project (\$11.5 million, five year, MBIE Endeavour Fund project led by MetService). Modelling of future marine heatwave events and expected shifts in the sub-tropical front was done by scientists at NIWA as part of the Deep South National Science Challenge. Paired with information on species biology, these data will help forecast shifts in fishing hotspots and species' distributions. New research funded by MPI over the next three years will use this information to investigate the effects of marine heatwaves on New Zealand's fisheries paired with a more detailed study of the impacts to pāua.

Long-term measurements taken off the coast of Otago (Munida transects) show ocean acidity has increased by 7.1 per cent over the past 20 years. The rate and magnitude of coastal ocean acidification has been monitored at many sites throughout New Zealand since 2016. This has been done by the New Zealand Ocean Acidification Observation Network (NZOA-ON) in collaboration with sampling partners from regional councils, the aquaculture and fishing industries, research institutes and the Department of Conservation. This initiative, led by NIWA and the Department of Conservation, is part of a global network, and data is publicly available to inform policy development and scientific research on ocean acidification.

A suite of recent climate-related research funded by MPI has synthesised both system level impacts of climate change to fisheries and impacts on particular species and environments. A major study synthesised climate impacts to New Zealand's seafood sector, noting that warming and/or acidification will affect most fisheries species, despite many knowledge gaps on species biology and interaction with climate factors.³⁸⁰ Other work modelled the distribution of commercially fished species around the country, to understand historical

³⁷⁹ Ministry for the Environment. 2008. *Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand*. Wellington: Ministry for the Environment.

³⁸⁰ Cummings V, Lundquist C, Dunn M, Francis M, Horn P, Law M, Pinkerton M, Sutton P, Tracey D, Hansen L, Mielbrecht E. 2021. *Assessment of potential effects of climate-related changes in coastal and offshore waters on New Zealand's seafood sector*. New Zealand Aquatic Environment and Biodiversity Report No. 261. Wellington: Fisheries New Zealand.

changes and predict shifts under climate change scenarios.³⁸¹ The impact of climate and environmental variability on the accuracy of fishery stock assessments was assessed and is a focal area for adaptation.³⁸² Climate impacts to the fish and megafauna in the sub-antarctic were investigated, while long-term sampling of zooplankton in the Southern Ocean, collected annually since 2008, continues to provide a valuable baseline for understanding change in this unique environment.³⁸³ Laboratory experiments touched on physiological responses of phytoplankton, green-lipped mussels³⁸⁴ and New Zealand snapper³⁸⁵ to ocean warming and acidification. Impacts to protected species were addressed by the Department of Conservation in a published a review on climate change impacts to marine mammals³⁸⁶ and a similar review on seabirds that is near completion.

Agriculture

Initial studies using the CMIP3 global climate projections addressed the primary impacts of climate change on agriculture, such as the effects of rainfall, drought, frost frequency and CO₂ fertilisation. More recent work has investigated some second-order impacts, such as the effects of changing climate on rural infrastructure and finance, and on some of the biocontrol systems used to combat noxious plants. Research is now drawing on the newer CMIP5 climate projections and projections from the IPCC *Sixth Assessment Report*. Limited research has been carried out on many second- and third-order impacts and the interactions between impact drivers. Recent research topics have included:

- Whitiwhiti Ora – Land Use Opportunities, covering various issues, including sediment load in rivers, facial eczema, fire risk, drought risk for pasture³⁸⁷
- the impacts climate change will have on the suitability of land for agriculture and other primary industries³⁸⁸

³⁸¹ Dunn M. 2022. *Climate change and the distribution of commercially caught marine fish species in New Zealand Part 1: Spatio-temporal changes since 1989*. New Zealand Aquatic Environment and Biodiversity Report No. 286. Wellington: Fisheries New Zealand. Dunn M, Goeden Z, Neubauer P, Behrens E, Arnold R. 2022. *Climate change and the distribution of commercially caught marine fish species in New Zealand. Part 2: Predicting changes in distribution*. New Zealand Aquatic Environment and Biodiversity Report No. 287. Wellington: Fisheries New Zealand.

³⁸² Neubauer P, A'mar T, Dunn M. 2021. *Effects of climate and environmental variability on fishery stock assessment accuracy*. New Zealand Fisheries Assessment Report. Wellington: Fisheries New Zealand.

³⁸³ Robinson K, Decima M, Pinkerton M, Stewart R. 2021. *Continuous Plankton Recorder sampling of zooplankton in the Southern Ocean 2002–2018: Spatial, seasonal, and long-term changes*. New Zealand Aquatic Environment and Biodiversity Report No. 257. Wellington: Fisheries New Zealand.

³⁸⁴ Law C, Gall N, Barr N, Northcote L, Sabadel A, Gutierrez A, Rodriguez M, Meyers M, Miller M, Decima M, Robinson K, McComb K, Ragg N, Frost E, Ren J, Armstrong E, Safi K. 2021. *The influence of warming and acidification on coastal plankton in New Zealand and potential effects on green-lipped mussels*. New Zealand Aquatic Environment and Biodiversity Report No. 277. Wellington: Fisheries New Zealand.

³⁸⁵ Parsons D, Allan B, Bian R, Herbert N, Gublin Y, McKenzie J, McMahan S, McQueen D, Pan H, Pether S, Radford C, Setiawan A, Munday P. 2021. *Ocean acidification and elevated temperature effects on New Zealand snapper*. New Zealand Aquatic Environment and Biodiversity Report No. 275. Wellington: Fisheries New Zealand.

³⁸⁶ Roberts JO, Hendriks HR. 2022. *Potential climate change effects on New Zealand marine mammals: A review*. DOC Research and Development Series 366. Wellington: Department of Conservation.

³⁸⁷ deepsouthchallenge.co.nz/research-project/climate-change-risk-assessment-for-land-based-activities

³⁸⁸ deepsouthchallenge.co.nz/research-project/climate-change-its-effect-on-our-agricultural-land

- primary sector preparedness and the impacts of climate change on the growth of rye grass and dairy herd heat stress and the subsequent economic impacts and adaptation strategies³⁸⁹
- systems implications of social and biophysical climate impacts on viticulture, developing sector-specific adaptation pathways³⁹⁰
- the impact of drought on farm profits.³⁹¹

Research is being carried out to understand the effects of elevated atmospheric CO₂ on pasture over time. The Free Air Carbon Dioxide Enrichment (NZ FACE) experiment has been operating for 20 years and is still in progress. The trial is providing data on grazed grassland – the only experiment in the world that includes grazing animals – making the results relevant to both Aotearoa New Zealand and temperate grasslands globally. Consequently, data sets from this experiment are in demand for international meta-analyses and modelling studies and are being supplied to many projects for these purposes.

The research has demonstrated the importance of including grazing when modelling the effect of elevated CO₂ on grasslands. Under elevated CO₂, it is expected that the proportion of legumes in pasture will increase, leading to increased levels of nitrogen through biological fixation. However, NZ FACE research has shown the increase in legumes is limited by an increased preference for legumes by grazing sheep. This has implications for the potential enhanced growth rate that could be expected from additional CO₂: the ‘CO₂-fertilisation’ effect. Further research is looking at potential plant adaptations that might overcome this preference for legumes in response to additional CO₂.

Results from the trial are also showing that responses to CO₂ change over time; this is expected given the different timeframes of feedback through the plants and soil. In the past several years, no CO₂ stimulation of pasture growth has been seen; if this is confirmed as the long-term outcome of CO₂ enrichment it would be a major change in currently assumed inputs to impact studies for the pastoral sector. NZ FACE data has been extended to a full on-farm analysis of a sheep and beef farm. A review of the published papers from the NZ FACE trial has been produced.³⁹² The impact of elevated CO₂ on pasture growth at the national level has also been estimated at an extra 560,000 tonnes dry matter per year since 1990.³⁹³

New Zealand has also commissioned research into wider climate change impacts on agriculture including microbial function and adaptation in response to climate change driven drought and the resulting effects on plant production and nutrient cycling.³⁹⁴ The impacts of

³⁸⁹ deepsouthchallenge.co.nz/research-project/primary-sector-preparedness-for-climate-change

³⁹⁰ deepsouthchallenge.co.nz/research-project/climate-water-and-wine

³⁹¹ deepsouthchallenge.co.nz/research-project/climate-change-and-drought-the-future-of-farms-and-rural-communities.

³⁹² Newton P, Liefferring M, Mackay A, Devantier B, Costall D, Rendel J, Hoogendoorn C. 2022. *Review of FACE (Free Air Carbon Dioxide Enrichment) results in relation to impacts of elevated carbon dioxide on future farm practices*. MPI Technical Paper No: 2021/39. Wellington: Ministry for Primary Industries. www.mpi.govt.nz/dmsdocument/50515-Review-of-FACE-Free-Air-Carbon-Dioxide-Enrichment-results-in-relation-to-impacts-of-elevated-carbon-dioxide-on-future-farm-practices.

³⁹³ www.nzgajournal.org.nz/index.php/rps/article/view/3461.

³⁹⁴ Lambie S, Orwin K, Müller K, Lear G, Wakelin SA, Smaill S. *Soil Microbes and Drought*. Wellington: Ministry for Primary Industries. www.mpi.govt.nz/dmsdocument/26743-slmacc-project-405211-soil-microbes-and-drought.

climate change on irrigation water supply and demand³⁹⁵ and on soil carbon³⁹⁶ have also been explored, along with the impacts on river flow and agriculture. Recent studies have looked at the impacts on the food system³⁹⁷ as well as on animal health.³⁹⁸

Biosecurity impacts

Climate change will create new biosecurity challenges by allowing establishment of new exotic aquatic and terrestrial pests, weeds and diseases that are currently prevented from doing so by Aotearoa New Zealand's climate. The potential establishment of subtropical pests and current seasonal immigrants is of greatest concern, along with taxa already recognised as high risk. Climate is just one of several factors that affect invasion potential, and others, such as import pathways, border management and host suitability, may also change in the future.

The pest status of many species currently present in New Zealand may change significantly as a result of climate change. In particular, currently innocuous 'sleeper' weeds, pests and diseases may become problematic due to changing ecological interactions with host plants and natural enemies, or shifts in their own phenology.

A large dimensional global trade, climate and economic model is being used to forecast the impacts of climate change on supply and demand for New Zealand agricultural products (where 'agriculture' includes pastoral farming, cropping, horticulture and forestry). The model covers trade patterns and pest and disease distributions and impacts, both at the national and regional level. This will help identify future market access opportunities and biosecurity policy needs.

Forestry

Initial research into plantation forestry addressed carbon sequestration rates in Aotearoa New Zealand's most common plantation forest species, *Pinus radiata*, to inform the inclusion of carbon forestry in New Zealand's Emissions Trading Scheme. More recent projects have investigated additional planted and indigenous species and forestry systems for different regions and terrains. Incentivised demand for indigenous forests will require increased supply and decreased cost for native tree seedlings into the market, this research is also under way. Research has also investigated the likely changes in forest fire risk over New Zealand in coming decades as a consequence of climate change, and the vulnerability of forests to potential major pests under a changing climate.

³⁹⁵ Collins D, Dark A, Zammit C, Bright J. 2022. *Effects of climate change on irrigation supply and demand*. MPI Technical Paper No: 2022/07. Wellington: Ministry for Primary Industries. www.mpi.govt.nz/dmsdocument/50606/direct.

³⁹⁶ Stevenson B, Garrett L, van der Weerden T, Beare M, Beets P, Bell N, Bowatte S, Clothier B, Curtin D, de Klein C, Davis M, Dickie I, Dodd M, Dominati E, Gentile R, Hedley C, Kirschbaum M, Mullan B, O'Callaghan M, Orwin K, Parfitt R, Shepherd M, Smaill S, Thomas S, Wakelin S. 2013. *Review of the impacts of climate change on soil processes and the consequences for ecosystem services – Appendices*. MPI Technical Paper No: 2018/41. Wellington: Ministry for Primary Industries. www.mpi.govt.nz/dmsdocument/30101/direct.

³⁹⁷ Lake R, Bolton A, Brightwell G, Cookson A, Benschop J, Burgess S, Tait A. No date. *Adapting to climate change: Information for the New Zealand food system*. Wellington: Ministry for Primary Industries. www.mpi.govt.nz/dmsdocument/28164-Adapting-to-climate-change-Information-for-the-New-Zealand-food-system.

³⁹⁸ Vallee E, Wada M, Cogger N, Kelly V, Marshall J, Benschop J, Macara G, Tait A. 2020. *Effects of climate change on grazing livestock health in New Zealand*. MPI Technical Paper No: 2021/10. Wellington: Ministry for Primary Industries. www.mpi.govt.nz/dmsdocument/45574-Effects-of-climate-change-on-grazing-livestock-health-in-New-Zealand.

The impacts of a changing climate on New Zealand's planted forests are now far better understood.³⁹⁹ Results indicate some potential increases in radiata productivity, a marked increase in wind risk due to taller and more slender trees, an increase in average season length with 'very high and extreme' climatic fire risk, and impacts of pests, disease and weeds are likely to increase overall.

The carbon sink potential of naturally durable hardwood species in comparison with alternative hardwood species preferred for timber production has also been assessed. The effects of natural disturbance on forest carbon has been assessed, along with the regeneration of indigenous forests from gorse and broom understory. The breeding of novel poplars and willows that can adapt to a changing climate and drought conditions has also been carried out. These species are used in spaced planting for slip erosion control, particularly in hill country.

The research above largely explores mitigation via sequestration into carbon sinks but adaptation research has been done that explores substitution of woody biomass for fossil-based and heavy emitting materials, such as steel and concrete. Fossil fuel substitution research is part of the Woody Biomass programme within the Climate Emergency Response Fund and further adaptation and forest system resilience work will be part of the Forestry and Wood Processing Industry Transformation Plan (see chapter 4, section 4.3.1 & 4.3.7).

Research using the Task Force on Climate-related Financial Disclosures framework has increased the understanding of immediate impacts of climate change on business operations and the forestry value chain, and on financial performance and enterprise risks.⁴⁰⁰

Wildfires

Wildfire can be hugely damaging to communities and livelihoods. With changing rainfall, temperature and wind patterns, climate change is expected to increase the frequency, severity and season length of fire weather conditions in Aotearoa New Zealand. Researchers have investigated what wildfire risk looks like in a changing climate, and how to better reduce this risk and prepare communities.

The highest fire dangers have been found in the seasonally drought-prone and arid locations of New Zealand. For many regions, it was found that, compared with the past two decades, the fire risk is expected to become appreciably worse through the rest of the century. For the first time, it has been predicted that conditions that led to the devastating 'Black Summer' fires in Australia will occur every 3–20 years in areas of the Mackenzie Country, Central Otago and Marlborough.⁴⁰¹ A new research project is focusing on extreme wildfire, aiming to improve existing understanding of the transitions between linear (predictable) and extreme (unpredictable) fire, especially in relation to fuels.⁴⁰²

³⁹⁹ Watt MS, Kirschbaum MUF, Moore JR, Pearce HG, Bulman LS, Bockerhoff EG, Melia N. 2019. Assessment of multiple climate change effects on plantation forests in New Zealand. *Forestry: An International Journal of Forest Research*. 92(1): 1–15. <https://doi.org/10.1093/forestry/cpy024>.

⁴⁰⁰ Dunningham AG. 2022. *Understanding Business Climate Change Risk using the TCFD Process*. MPI Technical Paper No: 2021/40. Wellington: Ministry for Primary Industries.

⁴⁰¹ Langer ER, Wegner S, Pearce G, Melia N, Luff N, Palmer D. 2021. *Adapting and mitigating wildfire risk due to climate change: extending knowledge and best practice*. Report prepared for the Ministry for Primary Industries. Rotorua: Scion. www.ruralfireresearch.co.nz/_data/assets/pdf_file/0003/80922/SLMACC-Contract-Final-report-submitted-to-MPI-linked.pdf.

⁴⁰² www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/endeavour-fund/success-stories/past-rounds/2021-endeavour-fund-successful-proposals/.

Health

In 2017, the Royal Society of New Zealand Te Aparangi released a document entitled *Human Health Impacts of Climate Change for New Zealand*.⁴⁰³ This report provides an evidence summary of how climate change will affect the health of New Zealanders. The impacts identified are:

- direct health impacts of climate change (increased flooding, fires and infrastructure damage, displacement and extreme temperatures)
- indirect health impacts of climate change (harmful algal blooms, microbial contamination, food availability, quality and safety, mental health and wellbeing, outdoor air quality, carriers of new diseases, migration of tropical species into Aotearoa New Zealand)
- potential health benefits (ie, reduced cold mortality, health co-benefits from mitigating climate change effects).

Research in the Deep South National Science Challenge is developing guidance to inform policy to mitigate risk to Māori (and others) in the context of climate change, to develop institutional responses to climate adaptation and ensure climate impacts on health are properly considered in health policy.⁴⁰⁴

Environmental health indicators

The Government contracts Massey University to maintain a set of environmental health indicators that describe the link between the environment and health. They are based on known or plausible cause-and-effect relationships between the environment and health. The indicators provide information for action. They provide key evidence to help decision-makers, and raise awareness of environmental health risks, to improve human health. Climate-related indicators help assess the health impacts of climate. This is regardless of whether there is a significant degree of 'change' over the time that the indicators are measured. The indicators include temperature (days over 25°C, days under 0°C); rainfall and drought (days of soil moisture deficit); climate change as a health issue (notifications of cryptosporidiosis, giardiasis, salmonellosis; population groups more at risk than others to the effects of a changing climate).

8.4.4 Research and development on adaptation to climate change

In addition to the research on climate change impacts described in section 8.4.3, research and the development and dissemination of methods for implementing adaptation measures have been a major focus. For more information on climate change adaptation measures, see chapter 6.

The adaptation-related research and information funded by central government includes the following.

⁴⁰³ Royal Society of New Zealand Te Aparangi. 2017. *Human Health Impacts of Climate Change for New Zealand: Evidence summary*. Wellington: Royal Society of New Zealand Te Aparangi.

⁴⁰⁴ deepsouthchallenge.co.nz/research-project/haumanu-hauora-health-responses-for-maori

- **The Deep South Challenge: Changing with our climate (2015–24)**⁴⁰⁵ has four research programmes: Processes and Observations, Earth System Modelling and Prediction, Impacts and Implications and Vision Mātauranga;⁴⁰⁶ as well as a cross-cutting Engagement programme. The Impacts and Implications programme is the current provider of most adaptation-relevant research in Aotearoa New Zealand, along with NIWA’s SSIF-funded programmes on the impacts and implications of climate change and the Resilience Science Challenge.
- Several **other National Science Challenges**⁴⁰⁷ are also relevant to adaptation, including Resilience to Nature’s Challenges (2015–25), which has projects relevant to climate change adaptation at the coast and on adaptive governance. Its mission is to inform how New Zealand will build a transformative pathway toward natural hazard resilience. It includes a Living at the Edge work programme focused on communities that are highly vulnerable to natural hazards, and a Resilience Governance programme. Other relevant challenges include New Zealand’s Biological Heritage; Our Land and Water; Sustainable Seas; and Building Better Homes, Towns and Cities.
- The **Sustainable Land Management and Climate Change** research programme, established in 2007 as part of a wider plan of action, supports the generation of new climate change knowledge across the agriculture and forestry sectors. The research programme covered all aspects of climate change in the land-based primary sectors, including impacts and adaptation, reducing greenhouse gas emissions and increasing forest carbon sinks. Over 180 projects have been commissioned as of June 2022.
- The **Coastal Acidification: Rate, Impacts and Management Project (2016–19)**⁴⁰⁸ finished in early 2020 having established the seasonal and interannual trends in pH at selected coastal sites, the sensitivity of key coastal species, including paua, greenshell mussels and snapper, to projected acidification and tools and approaches for adaptation to coastal acidification. Monitoring of some sites has been maintained through the NIWA-led NZ-OAON (Ocean Acidification Observing Network), which coordinates bimonthly weekly monitoring at 20-plus coastal sites around New Zealand.

The Ministry for the Environment has supported research to produce guidance manuals for local government on the expected impacts of climate change. These provide projections of future climate and describe a risk management framework for assessing the consequences and determining the appropriate responses. These guidance manuals are described in chapter 9, section 9.3.3. Research is also being conducted into the social aspects of successful adaptation.

Guidance documents produced by the Ministry for the Environment on the projected flooding and coastal hazard impacts of climate change are being used by local authorities to inform the development of new infrastructure. Further research has led to the development of the Urban Impacts Toolbox.⁴⁰⁹ This is a resource to help planners, engineers, asset managers and hazard analysts in New Zealand urban councils understand and evaluate the potential impacts of climate change in their city. The tools demonstrate methods and approaches that can be

⁴⁰⁵ www.deepsouthchallenge.co.nz

⁴⁰⁶ The Vision Mātauranga programme of research is investing in iwi- and hapū-led research and adaptation strategies and research collaborations that support Māori aspirations.

⁴⁰⁷ www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/national-science-challenges

⁴⁰⁸ niwa.co.nz/coasts-and-estuaries/research-projects/carim-coastal-acidification-rate-impacts-management

⁴⁰⁹ NIWA, MWH, GNS, BRANZ. 2012. *Impacts of Climate Change on Urban Infrastructure and the Built Environment: Toolbox handbook*. Retrieved from www.niwa.co.nz/climate/urban-impacts-toolbox.

used to assess climate change impacts and provide information consistent with the Australian and New Zealand Standard for Risk Management, which is widely used in the public and private sectors.

Adaptation research specific to the land-based sectors has also been carried out. This has included:

- assessing the effects of climate change on irrigation supply and demand on a national scale
- modelling the effect of climate change on land suitability for growing perennial crops
- studying adaptations and mitigations for wildfire risk due to climate change
- exploring business climate change risk using the Task Force on Climate-related Financial Disclosure process
- developing flexible policy pathways for enabling climate change adaptation
- modelling potential climate change impacts on horticulture's spatial footprint.

8.4.5 Socio-economic analysis, including impacts and response options

A study was undertaken in support of the National Climate Change Risk Assessment. This drew on international knowledge and evaluated significant risks and indicators that could be applied at the national scale to quantify risk and develop and monitor the effectiveness of climate response mechanisms.⁴¹⁰

Extreme weather events and climate-related risks can cause long-term disruption to vulnerable communities, such as rural communities, disabled people, young people, Māori, and to vital networks and support services. Some communities may need to relocate, either temporarily or permanently.

Important adaptation options in the National Adaptation Plan include connecting these vulnerable communities to wider response and recovery support. The plan outlines actions to raise awareness of climate hazards and how it will deliver public education campaigns and provide information to help vulnerable communities get ready for emergencies.

The National Adaptation Plan also provides information, guidance and tools about climate change threats and responses. It also facilitates designing and developing risk, resilience and climate adaptation information portals that will explore opportunities to collect and make available data and information on social and equity risks. The portals will help assess people's vulnerability to climate change, including disproportionately affected groups.

The Deep South National Science Challenge, in partnership with Motu Economic and Public Policy Research, has continued a series of dialogues to develop a shared understanding of important issues, come up with creative ideas to address them, and then pose and answer research questions. These dialogues frequently address issues involving socio-economic analysis. Dialogues and research topics have included insurance, coastal housing and climate adaptation; vulnerable communities and sea-level rise; drinking water and drought; and transport.

⁴¹⁰ Dunningham AD, Jones AG, Villamor G. 2022. *Support for the National Climate Risk Assessment: Processes for the identification and quantification of climate change risk for the primary sectors*. MPI Technical Paper No: 2022/03. Wellington: Ministry for Primary Industries.

A report was released focusing on an important question from the insurance, coastal housing and climate adaptation dialogue on how the risks of sea-level rise should be distributed between individuals, insurance, local and central government.⁴¹¹ Subsequent research looked at possible implications for the withdrawal of insurance,⁴¹² the ethical implications of sea-level rise policy,⁴¹³ and liability, compensation and Tiriti responsibilities in relation to sea-level rise, housing and insurance.⁴¹⁴

A research project on drinking water, drought and climate change responded to two main questions.⁴¹⁵

1. What is the likely incidence of future multi-regional drought? What is the likely nationwide spatial pattern of expected change in drought incidence?
2. What level of risk are we likely to face in relation to drinking water availability in times of drought?

A NIWA report on projected changes in Aotearoa New Zealand drought risk, which focuses on the first question, was released in 2020.⁴¹⁶ Another report on water availability under climate change has been published to focus on the second question.⁴¹⁷

Under the Fit for a Better World programme, MPI has undertaken a project to better understand the current state of New Zealand's water availability and security framework alongside projections of a warmer, drier climate with greater extremes. The quality, availability and security of fresh water are critical to food and fibre production and processing, community resilience, our identity as New Zealanders (Māori and non-Māori), and the health of te taiao (the natural world, environment and nature) on which we all depend. The studies point to the need for a strategic approach that addresses and integrates current and future supply, demand, and priorities for the use with protection of fresh water and the resources dependent on it.⁴¹⁸

Following dialogue on climate adaptation within New Zealand's transport system, a report was published in 2019 posing five priority research questions.⁴¹⁹ These questions cover issues such as criticality of transport networks, the impacts of transport disrupting events, adapting to events, institutional arrangements and lessons learned from other sectors on uncertainty.

⁴¹¹ deepsouthchallenge.co.nz/wp-content/uploads/2021/01/Insurance-housing-and-climate-adaptation-current-knowledge-and-future-research.pdf

⁴¹² deepsouthchallenge.co.nz/research-project/climate-change-and-the-withdrawal-of-insurance/

⁴¹³ deepsouthchallenge.co.nz/research-project/how-should-the-risks-of-sea-level-rise-be-shared/

⁴¹⁴ deepsouthchallenge.co.nz/research-project/sea-level-rise-housing-and-insurance-liability-and-compensation/

⁴¹⁵ deepsouthchallenge.co.nz/research-project/drinking-water-drought-and-climate-change/

⁴¹⁶ deepsouthchallenge.co.nz/wp-content/uploads/2021/01/Projected-Changes-in-New-Zealand-Drought-Risk-.pdf

⁴¹⁷ deepsouthchallenge.co.nz/wp-content/uploads/2021/01/Water-availability-under-climate-change-Final-Report.pdf

⁴¹⁸ www.mpi.govt.nz/about-mpi/our-work/fit-for-a-better-world-accelerating-our-economic-potential/water-availability-and-security/

⁴¹⁹ deepsouthchallenge.co.nz/wp-content/uploads/2021/01/Climate-Change-Adaptation-within-New-Zealands-Transport-System.pdf

The Deep South National Science Challenge research programme, aims to strengthen the capacity and capability of iwi, hapū, whānau and Māori businesses to deal with climate change impacts, risks and adaptation by resourcing them directly.

Te Kūwaha, NIWA's Māori Environmental Research Group,⁴²⁰ helps Māori communities throughout New Zealand by providing the latest scientific knowledge, tools and resources to assist in their management of natural resources.

8.4.6 Research and development on emissions and mitigation

Mitigation of agricultural greenhouse gas emissions

Because almost half of Aotearoa New Zealand's greenhouse gas emissions come from the agriculture sector, significant research is focused on reducing emissions from agriculture.

This activity will soon increase, because Budget 2022 allocated nearly \$339 million over four years to accelerate the development of high-impact technologies and practices to reduce agricultural greenhouse gas emissions (chapter 4, section 4.3.6). This investment has been informed by a research and development plan for science and mātauranga to lower biological emissions from agriculture. This research and development plan is part of the Government and sector's Fit for a Better World roadmap and has been developed between government, industry, Māori and the science sector.

Agricultural mitigation research is funded through various programmes and organisations, including the NZAGRC, the Greenhouse Gas Inventory Research fund, the Sustainable Food and Fibre Futures fund, the SLMACC research programme, and New Zealand activities in support of the GRA. Detail on progress that New Zealand has made through these research programmes is provided below.

Ruminant methane

Aotearoa New Zealand has a comprehensive research programme to address methane from enteric fermentation and manure management. Areas of research include breeding low greenhouse-gas-emitting sheep and cattle, identifying low-emissions feeds, developing vaccines to inhibit enteric methane and discovering inhibitory compounds that reduce enteric methane emissions. Progress since the last national communication includes:

- identifying and developing the ability to breed low-methane-emitting sheep by extending the programme to pilot-level animal selection on farm using portable accumulation chambers
- confirming that selected low methane in sheep has no major deleterious negative features under grazing conditions
- identifying indirect means of selecting low methane animals through the unique profiles of specific methanogen abundance
- showing that prototype vaccines can produce high levels of methanogen-specific antibody in the saliva entering the rumen, but as yet not reducing methane *in vivo*

⁴²⁰ www.niwa.co.nz/te-k%C5%ABwaha

- identifying five classes of compounds that have been shown to reduce methane emissions in animal trials. Research is focusing on two compounds that require further testing to meet all necessary regulatory requirements
- development and commercialisation of a dairy farm waste management system that reduces methane emissions by 90-plus per cent
- trialling feed-based commercial solutions (Mootral™, a natural plant-based feed supplement, and *Asparagopsis armata*, a type of seaweed that contains bromoform) to reduce enteric methane in pastoral conditions.

Nitrous oxide from livestock excreta and fertiliser

Research on mitigating nitrous oxide emissions covers identifying and testing plant species effects on nitrous oxide emissions, manipulating denitrification processes, low nitrogen feed management options, management effects on emission factors, urine patch detector and treatment development, and identifying and testing inhibitory compounds that reduce nitrous oxide emissions. Progress since the *Seventh National Communication* includes:

- identifying naturally occurring compounds that can reduce nitrification and lower nitrous oxide emissions in pastures
- further field testing and upscaling of machinery that allows farmers to better target their use of mitigation technologies on a urine patch
- researching management practices to reduce nitrate leaching from dairy farms, including low-protein forage and winter management strategies, which also helps to improve water quality
- developing more accurate nitrate leaching parameters, split by land use (pastoral farming versus arable and horticulture)
- improving understanding of the emissions of nitrous oxide from dung and urine on Aotearoa New Zealand hill country pastures and incorporating these emission factors into the national agricultural greenhouse gas inventory
- identifying a widely used animal product that has nitrification inhibitory properties on urine in pastures and assessing its effectiveness in reducing nitrous oxide and nitrate leaching over a range of soils and environments
- developing a more accurate methodology for calculating the split between nitrogen excreted in livestock dung and nitrogen excreted in livestock urine
- improving the nitrous oxide emission factors for a variety of nitrogen containing fertilisers
- developing a database of nitrogen contents in various commonly consumed grasses, forages and supplementary feeds
- trialling and developing farm nutrient technologies, including a nitrate inhibitor to use on urine patches in the paddock, as applied by Spikey, a world-leading technology
- developing and testing three technologies to reduce fertiliser use on farm: N-Retain, a new nitrification inhibitor technology; N-Test, a new soil test to inform nitrogen fertiliser decisions on pastoral farms; and N-Bio Boost, a fungal bio-inoculant to increase nitrogen use efficiency
- starting farm scale trials to demonstrate plantain's efficacy as a low-cost forage solution to nitrate leaching.

Soil carbon

New Zealand's soils have relatively high soil carbon stocks compared with soils globally. Research to increase, maintain or reduce the rate of decline of soil carbon content focuses on identifying the potential of different soils and management approaches to store more carbon and/or reduce the rate of loss of soil carbon. Research also focuses on measurement tools to quantify soil carbon content and the stability of stored carbon, and modelling greenhouse gas manipulations. Progress since the *Seventh National Communication* includes:

- establishment of a 12-year national-scale soil carbon benchmarking and monitoring study to estimate soil carbon stock changes within and between land use classes. Now in its second year, the study encompasses 500 agricultural sites across New Zealand taking samples from five different broad agricultural land uses
- a comprehensive review of research on biochar from its production to the economics of application
- research to understand the effects of farm-management practices, such as deep ploughing, normal cultivation and direct drilling, mixed-species swards, irrigation, lucerne and maize, on soil carbon stocks
- development of improved methods to estimate soil carbon, for example, digital soil-mapping methods to assess carbon stocks and changes for a target area, and rapid automated near or mid infrared scanning methods for cost-effective estimation of soil carbon in soil cores
- work seeking to understand the balance of and trade-offs between the three major greenhouse gases: CO₂, nitrous oxide and methane in parallel with changes in soil carbon under a range of field treatments using quantum cascade lasers and micrometeorological techniques.

Integrated farm systems research

Research on farm systems integrates research on different greenhouse gases and farm systems. It also includes research on profitable, practical and low greenhouse-gas-emitting sheep, beef and dairy farm systems. Another area is Māori-focused research aligned with integrated farm systems. This seeks to help the Māori pastoral sector to improve its capacity to increase resource use efficiency, sustainability and farm productivity while lowering greenhouse gases.⁴²¹ Progress since the last national communication includes:

- funding the development of a range of natural nitrogen inhibitors that will break the ammonia cycle from cow urine and reduce the leaching of nitrates and release of nitrous oxide^{422, 423}
- identifying and evaluating further mitigation options and practices on farms, using farm systems models and farm trials on dairy, beef and sheep farms⁴²⁴

⁴²¹ www.nzagrc.org.nz/domestic/integrated-solutions

⁴²² www.ravensdown.co.nz/expertise/a-vision-for-n-with-new-n-loss-project

⁴²³ ballance.co.nz/sfff-funding-announcement-dec2020

⁴²⁴ www.nzagrc.org.nz/assets/Publications/NZAGRC-Brochure-Mitigation-of-on-farm-GHG-Emissions.pdf

The Greenhouse Gas Inventory Research Fund continues to support research to ensure Aotearoa New Zealand's reporting of agricultural emissions is robust and enables the development of effective policy.⁴²⁵ Research incorporated into the national agriculture inventory since the *Seventh National Communication* includes:

- improvements to the equations used to estimate energy efficiency for maintenance for cattle, sheep and deer
- revised nitrous oxide emission factors for livestock excreta, as well as an updated methodology for allocating excreta to different hill slopes
- updated values of pasture quality for livestock
- refinement of estimates of nitrogen leaching for cropping systems
- more accurate information on the calcium carbonate purity of agricultural lime
- updated activity data on the proportion of dairy excreta entering anaerobic lagoons
- improvements to the equations used to estimate the proportion of nitrogen excreta partitioned between dung and urine.

Carbon sequestration

Significant research efforts are also being made on the role of carbon sinks, with work continuing on Aotearoa New Zealand's ability to estimate carbon fluxes for international reporting requirements. Research is also under way in Fiordland to conduct the first-ever deep analysis of fjords' ability to hold carbon, from its source to distribution.⁴²⁶ The project aims to understand the size, variability and how climate change and management decisions influence carbon sink. Focus is also increasing on the role of coastal wetlands as carbon sinks.

Land use, land-use change and forestry: inventories and sequestration research

The Aotearoa New Zealand Land Use and Carbon Analysis System (LUCAS) includes a long-term research programme designed to meet New Zealand's international reporting requirements for land use, land-use change and forestry (LULUCF). The programme's aim is to improve New Zealand's ability to estimate carbon fluxes in vegetation and soil in a transparent, robust and defensible manner.

The research continues to build on earlier work. The methodologies for data collection are undergoing continual refinement and improvement, as are the analysis methods. Some of this ongoing and completed research and improvement work conducted since the *Seventh National Communication* is described below.

Natural forests

- Continued remeasurement has been undertaken on the pre-1990 natural forest ground plot inventory on a continuous basis (on a 10-year cycle). These data are analysed and incorporated into the National Inventory Report on a periodic basis.
- Analysis of pre-1990 natural forest data published in *Forest Ecosystems*.⁴²⁷

⁴²⁵ www.mpi.govt.nz/science/open-data-and-forecasting/greenhouse-gas-reporting/agricultural-greenhouse-gas-inventory-reports/

⁴²⁶ www.gns.cri.nz/research-projects/fjords-as-carbon-sinks/

⁴²⁷ Paul TSH, Kimberley MO, Beets PN. 2021. Natural forests in New Zealand: A large terrestrial carbon pool in a national state of equilibrium. *Forest Ecosystems* 8(1): 1–21.

- The post-1989 natural forest yield table has been updated. The revised updated table is based on the remeasurement of the post-1989 natural forest plot network in 2019.
- Subclassification of pre-1990 natural forest has been refined.

Planted forests

- Continued remeasurement has been undertaken on the pre-1990 and post-1989 planted forest ground plot inventory on a continuous basis (on a 10-year cycle). These data are analysed and incorporated into the National Inventory Report on a periodic basis.
- Several improvements have been made to the methods used to calculate planted forest harvest area. These are outlined in chapter 6, section 6.3.5 of the *New Zealand Greenhouse Gas Inventory 1990–2020*.⁴²⁸
- Ongoing mapping of deforestation activity as well as development of machine learning techniques to improve classification efficiency.
- Aotearoa New Zealand’s harvested wood products estimates now include market-specific activity data and emission factors for export raw materials. Research is ongoing to produce New Zealand-specific half-lives and their associated uncertainty values for exported harvested wood products and those used domestically.

Wetlands

- A literature review was undertaken on Aotearoa New Zealand’s vegetated wetlands. This work has generated a New Zealand-specific estimate of above and below ground biomass carbon stocks for the vegetated wetland class. These data are to be implemented in the 2023 submission of the New Zealand Greenhouse Gas Inventory.

Land use mapping

- The inclusion of a new land use map for 2016 (published in 2018) and associated mapping improvements, which lead to a more accurate, consistent and complete time series.
- Continued improvement of existing land use maps.

Other research areas

In addition to the research and mitigation highlights covered above, researchers in Aotearoa New Zealand cover a broad range of other topics. Examples include:

- geo-sequestration of carbon dioxide – GNS Science is investigating the potential of sites for the geo-sequestration of CO₂.⁴²⁹ Scientists are engaged in assessing how much CO₂ can be stored in a particular region or reservoir, what chemical reactions might occur with the rocks, what risks are involved and their magnitudes, monitoring for potential leakage, and community concerns and perceptions associated with carbon capture and storage. Other organisations are also carrying out research on this topic. New Zealand also collaborates in an Australian cooperative research centre programme on CO₂ geo-sequestration.

⁴²⁸ Ministry for the Environment. 2022. *New Zealand Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

⁴²⁹ www.gns.cri.nz/our-science/energy-futures/carbon-capture-and-storage

- woody biomass – Scion is focusing significant effort on renewable woody biomass-based energy sources, with increasing interest in conversion of coal fired systems to biomass, and the development of liquid biofuels from woody and other biomass. Scion has published the *NZ Biofuels Roadmap* outlining future opportunities in this area.⁴³⁰
- renewable energy – GNS Science is researching green hydrogen, targeting technologies that do not depend on high-purity water sources and produce hydrogen directly from sunlight. The University of Canterbury is leading work on electrical grids through its research programme on ‘Architecture of the future low-carbon, resilient, electrical power system’.⁴³¹ The University of Waikato is developing a new technology platform ‘Ahuora’ to help in re-engineering the way we use, convert, provide and store renewable energy for industrial process heating using a smart systems approach.⁴³²
- transport – Victoria University of Wellington is carrying out research on high power electric motors for large-scale transport.⁴³³ The research in this programme looks at how to make superconducting machines for aircraft, beginning with proving technologies first for rail, shipping and trucks.

8.5 Systematic observations

Aotearoa New Zealand maintains observation programmes for atmospheric, terrestrial and oceanic measurements for a suite of essential climate variables. These measurements are complemented by archives of historical observations of climate-related parameters.

Details on the measurement programmes are described in New Zealand’s *Report on the Global Climate Observing System* (see annex D), and are presented in accordance with the revised UNFCCC reporting guidelines on global climate change observing systems (Decision 11/CP.13).

⁴³⁰ Scion. 2018. *The New Zealand Biofuels Roadmap: Summary Report*.

www.scionresearch.com/__data/assets/pdf_file/0005/63293/Biofuels_summary_report.pdf

⁴³¹ www.fan.ac.nz

⁴³² ahuora.waikato.ac.nz/energy

⁴³³ www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/strategic-science-investment-fund/ssif-funded-programmes/the-research-trust-of-victoria-university-of-wellington/

9 Education, training and public awareness

Key developments

- The New Zealand Government declared a climate emergency in December 2020. This has resulted in an increased focus on climate change at the highest levels within the Government.
- Public consultation provided feedback to inform the He Pou a Rangi – Climate Change Commission’s 2021 report on advice to the Government on its first three emissions budgets and direction for its first emissions reduction plan.
- In May 2022, the Government published the emissions reduction plan, which contains strategies, policies and actions for achieving Aotearoa New Zealand’s first emissions budget.
- In August 2022, the Government published the national adaptation plan, as required under the Climate Change Response Act 2002. The plan contains strategies, policies and actions that will help New Zealanders adapt to the changing climate and its effects, to reduce the potential harm of climate change, and to seize the opportunities that arise.
- The Gen Less programme, run by the Energy Efficiency and Conservation Authority, was launched in 2019 and supports businesses and the public to reduce their personal greenhouse gas emissions.
- Public consultation provided feedback to inform major climate change policies, including the Climate Change Response (Zero Carbon) Amendment Act 2019, the emissions reduction plan, the national adaptation plan, climate-related financial disclosures, action on agricultural emissions and changes to the New Zealand Emissions Trading Scheme.

9.1 Introduction

The New Zealand Government actively supports initiatives that increase public awareness of climate change and promote behavioural change, including by providing information to tangata whenua (people of the land, local indigenous people), the public, businesses, communities, local government and industry sectors. Resources and support are also provided for education and training on issues related to climate change. In addition, engagement on climate change issues has taken place over the past four years with Māori, businesses, the public and young people. The Government also engages with other countries on climate change issues.

In December 2020, the New Zealand Government declared a climate emergency. This came in response to the Intergovernmental Panel on Climate Change (IPCC) findings, calls for action from New Zealanders, and joining at the time over 32 countries to declare a climate emergency and commit to reducing emissions to avoid a more than 1.5°C rise in global warming. The Government has made significant progress on meeting that challenge through the Paris Agreement and Climate Change Response Amendment Act 2019, and Aotearoa New Zealand has committed to taking urgent action on greenhouse gas mitigation and climate change adaptation.

This chapter provides information about relevant initiatives that have been run or supported by the New Zealand Government over the reporting period. The initiatives are divided into five sections: public awareness campaigns and behavioural change, public access to information, education and training, public engagement and international engagement.

9.2 Public awareness campaigns and behavioural change

Public awareness campaigns have focused on household and vehicle energy efficiency, certification schemes, tools for measuring and reporting emissions, and environmental awards.

9.2.1 Energy efficiency and climate change campaigns

Gen Less

Gen Less is a communications platform, supported by the Energy Efficiency and Conservation Authority (EECA). EECA is a government agency dedicated to mobilising New Zealanders to be world leaders in clean and clever energy use. Gen Less was launched in 2019 and inspires people to reduce their personal greenhouse gas emissions and take positive climate action. Gen Less supports the Government's wider move in Aotearoa New Zealand's transition towards net zero emissions in 2050.

The Gen Less website, social media channels and email programme support an annual advertisement campaign designed to raise public awareness, drive engagement and, ultimately, encourage behavioural change to reduce emissions at a household, business and national level. The brand is advertised across television, radio and digital advertising platforms, and media integrations.

The website is oriented for 'everyone' and for 'business'. Under the 'everyone' tab, the support has been filtered by 'everyday life', 'on the move' and 'at home'. For business, it has been categorised by the five main impact areas for climate change improvement: moving people, moving goods, on site, in the office and product design.

For four years, EECA has been conducting extensive research into New Zealanders' beliefs, attitudes and knowledge of climate change and energy emissions. Monitoring is undertaken quarterly ('consumer') and half yearly ('business'). It provides evidence-based insights that are made available publicly to all stakeholders and helps position the future work programme for Gen Less.

The main behaviours that Gen Less has focused on include:

1. targeting small businesses to get started on their climate journey
2. encouraging New Zealanders to reduce their car use and to consider electric vehicles and other forms of transport
3. 'umbrella' messages to encourage New Zealanders to recognise that they have to act now, to waste less energy and leave a positive legacy for future generations.

An independent evaluation of the Gen Less programme, to help direct future investment and planning, will be completed by the end of 2022.

Transport

EECA provides information and tools on the Gen Less website to influence consumer behaviour in vehicle choice, mode shift, efficient driving tactics and using alternative fuels. The FuelSaver website⁴³⁴ enables consumers to compare the fuel efficiency of vehicles.

The Gen Less Vehicle Total Cost of Ownership tool⁴³⁵ lets consumers compare vehicle costs and emissions across the total ownership period of the vehicle, from buying and running to on-selling. It is one of EECA's most popular sections on the website.

The Vehicle Emissions and Energy Economy Labelling Scheme, which began in 2008, is run by EECA together with Waka Kotahi NZ Transport Agency. This scheme makes it compulsory for vehicle traders and online vendors to display information about the fuel economy and emissions of their vehicles. This helps consumers make informed decisions about environmental impacts when purchasing a car. The scheme is unique because it also applies to private sales on the internet. It covers both new and used vehicles manufactured after 2000. (See more on the programme in chapter 4, section 4.3.2.)

Because the New Zealand Government has introduced the Clean Car programme, which offers rebates for low- and no-emissions light vehicles, and imposes fees for high-emitting vehicles, significant growth has occurred in the national electric vehicle fleet.

Waka Kotahi NZ Transport Agency has worked closely with local and central government agencies, power companies, technology providers and the motor industry to provide up-to-date guidance⁴³⁶ on public charging infrastructure for electric vehicles. This guidance clarifies standards and provides recommendations to help electric vehicle infrastructure investors set up a network of charging facilities that can be used by as many drivers as possible.

Business

To complement EECA's co-funding programmes,⁴³⁷ Gen Less is a hub for all businesses, but especially small to medium enterprises, to find information and tools to reduce their energy use.

EECA's research shows that small to medium enterprises struggle to find the time and resources to consider their energy use and emissions. The Gen Less website shares authoritative information to enable businesses to better understand the need to reduce emissions, and the co-benefits from doing so. EECA has taken a collaborative approach, working with other government departments and the private sector, to help develop the Climate Action Toolbox,⁴³⁸ which allows businesses to create a tailored emissions reduction plan for their business.

⁴³⁴ www.fuelsaver.govt.nz

⁴³⁵ genless.govt.nz/for-business/moving-people/vehicle-total-cost-of-ownership-calculator/

⁴³⁶ www.nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/national-guidance-for-public-electric-vehicle-charging-infrastructure/

⁴³⁷ www.eeca.govt.nz/co-funding/

⁴³⁸ genless.govt.nz/stories/tailor-made-climate-advice-for-smaller-businesses/

9.2.2 Carbon reduction and neutrality certification

Toitū Envirocare (Toitū) operates carbon and sustainability programmes that provide tools and support for individuals and organisations to measure, reduce and offset their emissions.⁴³⁹

Toitū offers two internationally aligned certification programmes.⁴⁴⁰

- The Toitū carbon certification programme is available to companies as an organisational and/or product service with three stream options, and is internationally accredited:
- Toitū carbonreduce certification – for carbon measurement, management and reduction claims
 - Toitū net carbonzero certification – for carbon measurement, management, reduction and offsetting claims
 - Toitū climate positive certification – a new programme for carbon claims beyond net carbonzero to make a positive impact on society, on top of taking meaningful science-led action to decarbonise.
 - Toitū Enviromark (Environmental Management Programme & Certification) – the Toitū enviromark programme enables systematic development and improvement of a credible environmental management system that meets and exceeds the requirements of ISO 14001:2015 for organisational environmental performance, with three core programme options:
- Toitū enviromark bronze
 - Toitū enviromark gold
 - Toitū enviromark diamond.

The Toitū carbon certification programme is designed to help members collate data to meet the programme’s requirements. When ready, the data are audited by a programme-approved auditor. Once approved, members are issued with a certificate and can display the certification mark or logo on their website and/or products. Case studies featuring the emissions reduction achievements alongside an online directory of member companies are available on the Toitū Envirocare website.⁴⁴¹

The Toitū enviromark programme is a three-step environmental management system, with a focus on continuous improvement, as companies work from a ‘bronze’ up to a ‘diamond’ level of certification. Toitū enviromark diamond (the final step) is equivalent to the ISO 14001 international standard. Participating companies are supported through training, checklists and seminars. Online resources are also provided to participating companies, including case studies featuring the environmental performance improvements achieved by member companies.

The carbon programmes are accredited by the Joint Accreditation System of Australia and New Zealand. They are also recognised by the United Kingdom’s Environment Agency, the Carbon Disclosure Project and the International Carbon Reduction and Offset Alliance. This ensures Toitū Envirocare’s emissions reductions and offsetting programmes meet the highest international standards of environmental integrity and are in support of the Paris Agreement.

⁴³⁹ The trading name of Enviro-Mark Solutions Limited (a wholly owned subsidiary of Manaaki Whenua – Landcare Research, a Crown research institute).

⁴⁴⁰ www.toitu.co.nz/what-we-offer/carbon-management

⁴⁴¹ www.toitu.co.nz/our-members/case-studies

9.3 Public access to information

An important part of the New Zealand Government's response to climate change is providing climate change information to tangata whenua, the public, businesses, local government and the land-based sector.

9.3.1 Information for the public

The climate change section of the Ministry for the Environment's website is the main source of climate change information provided by the Government.⁴⁴² It has information on the causes of, evidence for and impacts of climate change. It describes the main government policies to reduce emissions and work being done to help people prepare for and adapt to climate change. Key initiatives⁴⁴³ are highlighted on the website and updated regularly. The roles and responsibilities of other government ministries and departments are described on the website relating to important climate change programmes.⁴⁴⁴

The Ministry for the Environment website also outlines what members of the public can do to take action, get funding for projects and contribute individual perspectives on the Government's climate change proposals.⁴⁴⁵

Our Atmosphere and Climate 2020, produced under the Environmental Reporting Act 2015, reports on the state of Aotearoa New Zealand's climate.⁴⁴⁶ The report uses a pressure–state–impact model to present an overview of what is known about New Zealand's climate and the role that increasing greenhouse gas concentrations play in changing climatic conditions. The report was written for a broad audience, is backed up by technical web pages and underpinned by rigorous analysis.

Environment Aotearoa 2022 is the latest report produced under the Environmental Reporting Act 2015. It focuses on an overall picture of New Zealand's environment across the marine, freshwater, atmosphere and climate, land and air domains.⁴⁴⁷ The report outlines the importance of the environment on wellbeing and includes mātauranga Māori⁴⁴⁸ to inform future outlooks under a changing climate.

⁴⁴² environment.govt.nz/facts-and-science/climate-change/

⁴⁴³ environment.govt.nz/what-government-is-doing/

⁴⁴⁴ environment.govt.nz/what-government-is-doing/who-does-what-in-government-on-the-environment/

⁴⁴⁵ environment.govt.nz/what-you-can-do/

⁴⁴⁶ Ministry for the Environment. 2020. *Our Atmosphere and Climate 2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/our-atmosphere-and-climate-2020/ (14 October 2022).

⁴⁴⁷ Ministry for the Environment. 2022. *Environment Aotearoa 2022*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/environment-aotearoa-2022/ (14 October 2022).

⁴⁴⁸ For the purposes of producing *Environment Aotearoa 2022*, the Ministry adopted one of the definitions from the Environmental Protection Authority's mātauranga guide, which describes mātauranga Māori as the body of knowledge arising from the experiences of Māori living in the environment of Aotearoa New Zealand. Environmental Protection Authority. 2020. *Mātauranga Guide: Guide to the Mātauranga Framework*. Wellington: Environmental Protection Authority. Retrieved from www.epa.govt.nz/assets/Uploads/Documents/Te-Hautu/Matauranga-Maori-Report_Companion-Guide.pdf (14 October 2022).

Jobs for Nature

Mahi mō te Taiao (Jobs for Nature) is an NZ\$1.219 billion programme that manages funding across multiple government agencies to bring thousands of people into nature-based employment, benefiting te taiao (the environment) and Aotearoa New Zealand's communities. The programme was set up in 2020 in response to the COVID-19 pandemic and will run for four years. The agencies administering the funding are the Ministry for the Environment, Department of Conservation, Ministry for Primary Industries, Toitū Te Whenua Land Information New Zealand and Ministry of Business, Innovation and Employment.

As of June 2022, 421 projects have been approved, which support different environmental objectives including weed and pest eradication projects, capability development projects, freshwater projects and ecosystem restoration projects. As of June 2022, over 9000 people have been or are employed in a Jobs for Nature funded project. Environmental benefits achieved by the programme include 4.36 million plants planted and 1600 hectares of freshwater, riparian and wetland restoration. More details about the Jobs for Nature programme can be found on the Ministry for the Environment's website.⁴⁴⁹

Aotearoa New Zealand's first emissions reduction plan

In May 2022, the Government published Aotearoa New Zealand's first emissions reduction plan.⁴⁵⁰ It contains strategies, policies and actions for achieving the country's first emissions budget, as required by the Climate Change Response Act 2002. In doing so, it also outlines how New Zealand intends to play its part in global efforts to limit warming to 1.5°C above pre-industrial levels. Public consultation on the draft plan is covered in section 9.5.1.

It is the first statutory plan, under the Climate Change Response Act 2002, to require the Government to act to reduce emissions across the economy. It supports all New Zealanders to make the most of the transition and to improve living standards.

Section 9.4.1 outlines the education and training initiatives embedded in the first emissions reduction plan.

Aotearoa New Zealand's first national adaptation plan

In August 2022, as required by the Climate Change Response Act 2002, the Government published Aotearoa New Zealand's first national adaptation plan.⁴⁵¹ The plan contains strategies, policies and actions that will help New Zealanders adapt to the changing climate and its effects, to reduce the potential harm of climate change, and seize the opportunities that arise.

⁴⁴⁹ environment.govt.nz/what-government-is-doing/areas-of-work/jobs-for-nature/

⁴⁵⁰ Ministry for the Environment. 2022. *Te Hau Mārohi ki Anamata: Towards a Productive, Sustainable and Inclusive Economy: Aotearoa New Zealand's First Emissions Reduction Plan*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/emissions-reduction-plan/ (14 October 2022).

⁴⁵¹ Ministry for the Environment. 2022. *Aotearoa New Zealand's First National Adaptation Plan*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/adapting-to-climate-change/national-adaptation-plan/ (14 October 2022).

This national adaptation plan is the first in a series. Every six years, He Pou a Rangi – Climate Change Commission will prepare a national climate change risk assessment. This will identify the climate risks that need to be addressed most urgently. New national adaptation plans that respond to those risks will be developed in consultation with all New Zealanders.

The first plan focuses on getting the foundations right. It sets out what the Government will do to enable better risk-informed decisions, drive climate-resilient development in the right locations, help communities assess adaptation options (including managed retreat and nature-based solutions) enabling an equitable transition for Māori, led by Māori, and embedding climate resilience into all of the Government’s work. The plan lays out an adaptation map of significant milestones from 2018 to 2028, when the second national adaptation plan will be published. Public consultation was held on the draft plan and this is covered in section 9.5.1.

International and domestic emissions reduction targets

Aotearoa New Zealand has made commitments to domestic and international emission targets.⁴⁵² Domestic targets are targets that New Zealand decided as part of its domestic policy decisions. International targets are targets that New Zealand accepted as part of international climate change agreements.

Domestically, New Zealand has reported progress towards the 2020 target in the net position report.⁴⁵³ New Zealand is on track to meet this target, with more detail being provided in the fifth biennial report⁴⁵⁴ submitted to the UNFCCC at the same time as this eighth national communication.

In 2015, New Zealand met a previous target under the Kyoto Protocol first commitment period of reducing greenhouse gas emissions to 1990 levels between 2008 and 2012. The accounting for this target was included in New Zealand’s True-up Report⁴⁵⁵ submitted to the UNFCCC in December 2015.

New Zealand’s first NDC (NDC1) was updated on 31 October 2021 and covers the period 2021–30. In addition to containing detail on the scope and coverage of New Zealand’s 2030 target, the NDC1 is accompanied by information to facilitate clarity, transparency and understanding that is requested from all countries under the Paris Agreement. More information about the NDC1 is on the Ministry for the Environment’s website.⁴⁵⁶

The Ministry for the Environment provides general information about the New Zealand Emissions Trading Scheme (NZ ETS) on its website. It describes how the NZ ETS works and how it links with New Zealand’s international climate change commitments.⁴⁵⁷

⁴⁵² environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/emissions-reduction-targets/greenhouse-gas-emissions-targets-and-reporting/

⁴⁵³ environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/emissions-reduction-targets/latest-update-on-new-zealands-2020-net-position/

⁴⁵⁴ Ministry for the Environment. 2022. *New Zealand’s Fifth Biennial Report under the United Nations Framework Convention on Climate Change*. Wellington: Ministry for the Environment.

⁴⁵⁵ environment.govt.nz/publications/report-upon-expiration-of-the-additional-period-for-fulfilling-commitments-by-new-zealand/

⁴⁵⁶ environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/nationally-determined-contribution/

⁴⁵⁷ environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/ets/

The Environmental Protection Authority – Te Mana Rauhi Taiao, which is responsible for the administration of the NZ ETS, also provides information on its website.⁴⁵⁸ For more on the Authority’s role, see section 2.4.3 and section 9.4.3.

New Zealand’s Greenhouse Gas Inventory

The New Zealand Government provides full transparency regarding its international greenhouse gas reporting. The annual report *New Zealand’s Greenhouse Gas Inventory* (the inventory) and the inventory data in tabular format are available to the public on the Ministry for the Environment’s website.⁴⁵⁹

Every year, in conjunction with the inventory’s release, the New Zealand Government publishes the *Te Rārangī Haurehu Kati Mahana a Aotearoa 1990–2020 – He whakarāpopoto New Zealand’s Greenhouse Gas Inventory 1990–2020 snapshot* on the Ministry for the Environment’s website.⁴⁶⁰ The snapshot summarises the inventory and how it is used to monitor progress towards Aotearoa New Zealand’s emissions reduction targets, with plain English descriptions and easy-to-read graphs. Because the inventory is a large, technical document, producing a summary makes the information more accessible to a wider audience. The snapshot covers the sources of emissions, yearly changes and trends, comparisons with other countries, and New Zealand’s latest net position (a domestic report on how the country is tracking towards meeting its emissions reduction targets).⁴⁶¹

In addition to the snapshot, the Ministry for the Environment maintains a visual online tool (New Zealand’s Interactive Emissions Tracker).⁴⁶² The aim of the tool is to improve the accessibility of New Zealand’s greenhouse gas statistics by providing the latest inventory data in a user-friendly format. The emissions tracker allows anyone to access and manipulate the data in the latest inventory. With the emissions tracker, the user can: easily and quickly see how New Zealand’s emissions have changed over the years; filter data by year, sector, category and gas type, or use the search function for specific queries; view the data in a table format or in graphs; and export csv files.

Quarterly estimates of New Zealand’s greenhouse gas emissions

Stats NZ provides quarterly estimates of emissions produced by Aotearoa New Zealand residents, which can be used to track emissions in relation to economic activity (gross domestic product) and other economic statistics.

The System of Environmental Economic Accounting production-based emissions estimates transforms the inventory data to be consistent with economic classifications and concepts. It does this by changing the unit of analysis (from process to industry) and applying the residency principle (as opposed to the inventory, which uses the territory principle).

⁴⁵⁸ www.epa.govt.nz/industry-areas/emissions-trading-scheme/

⁴⁵⁹ Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

⁴⁶⁰ At the time of the publication of the *Eighth National Communication*, the most recent snapshot release is: Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

⁴⁶¹ environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/emissions-reduction-targets/latest-update-on-new-zealands-2020-net-position/

⁴⁶² emissionstracker.environment.govt.nz/#NrAMBoEYF12TwCIByBTALo2wBM4egHYCcSW0QA

While the Stats NZ experimental quarterly estimates are provisional only, trends can be derived earlier than the release of the inventory (which has a 15-month lag period). The quarterly estimates are released with a three-to-four-month lag. More information about the quarterly estimates of emissions can be found on the Stats NZ website.⁴⁶³

9.3.2 Information for businesses

New Zealand Emissions Trading Scheme

Ongoing communication about participants' obligations and the development of the NZ ETS is important for participants in the scheme and other affected businesses. As the lead policy agency for climate change, the Ministry for the Environment provides regular updates on NZ ETS policy developments and how these affect participants.

As the main administering agency, the Environmental Protection Authority provides guidance material for participants in the scheme. Resources and publications are provided on the Authority's website.⁴⁶⁴ Participants also receive updates and notifications from the New Zealand Emissions Trading Register.⁴⁶⁵

NZ ETS obligations for the forestry sector are administered by the Ministry for Primary Industries. Information about NZ ETS obligations for these sectors is available on the Ministry for Primary Industries' website. It also offers information and guidance for forestry participants, including detailed information bulletins and updates.⁴⁶⁶ Proactive outreach is undertaken for significant legislative obligations.

As the NZ ETS has developed, the Government has carried out consultation with the public and affected businesses on many issues and proposals (consultation with the public is discussed further in section 9.5.1). When changes are made, newsletters or factsheets are often produced to inform affected businesses, and general information is available on the Ministry for the Environment's website. Similarly, as regulations affecting specific sectors have been introduced and amended over time, information and materials have been provided to affected groups. Much of this material is available online.⁴⁶⁷

Carbon Neutral Government Programme

The Carbon Neutral Government Programme (CNGP) was set up by the New Zealand Government to accelerate the reduction of emissions within the public sector. The programme's aim is to make several organisations within the public sector carbon neutral from 2025. It was launched in December 2020. Information about the programme is available on the Ministry for the Environment's website.⁴⁶⁸

⁴⁶³ www.stats.govt.nz/experimental/greenhouse-gas-emissions-industry-and-household-september-2020-quarter

⁴⁶⁴ www.epa.govt.nz/resources-and-publications/

⁴⁶⁵ emissionsregister.govt.nz

⁴⁶⁶ mpi.govt.nz/growing-and-producing/forestry/forestry-in-the-emissions-trading-scheme

⁴⁶⁷ environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/ets/

⁴⁶⁸ environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/carbon-neutral-government-programme/

The CNGP has published guidance for CNGP organisations on measuring and reporting their greenhouse gas emissions.⁴⁶⁹ It includes information on what sources of greenhouse gas emissions organisations need to collect data for, standards to follow, methods for calculating emissions, the required information to report, who to report to and by when.

Building for Climate Change programme

The building and construction sector is a significant contributor to greenhouse gas emissions. These are emitted when building materials are produced, buildings are constructed, and energy is used in buildings during their operation. If Aotearoa New Zealand is to achieve its climate change goals, including net zero long-lived emissions by 2050, the building and construction sector must play its part.

The Building for Climate Change programme⁴⁷⁰ is a long-term work programme run by the Ministry of Business, Innovation and Employment. Its aim is to reduce emissions from constructing and operating buildings and to make sure buildings are resilient to the future effects of climate change. More information about the Building for Climate Change programme can be found on the Building Performance website.⁴⁷¹

Voluntary greenhouse gas reporting

The *Measuring emissions guide: A guide for organisations* (previously called ‘guidance for voluntary greenhouse gas reporting’) was first introduced in 2008 and has been updated regularly. It has been prepared in response to increasing demand from organisations for guidance on how to compile a corporate greenhouse gas inventory. It is updated regularly to be the reference point, providing standard emission factors that are needed for measuring and reporting an organisation’s greenhouse gas emissions. It provides technical calculations, methodologies, example reports and inventories, and a calculation tool.

The guide is primarily for commercial and industrial organisations that wish to understand how to report their greenhouse gas emissions. It is also applicable, however, to other types of organisations with operations that give rise to greenhouse gas emissions (eg, non-governmental organisations, government agencies and universities). Members of the CNGP use the standard emission factors provided as part of the guidance to measure and report emissions across government.

The guidance encourages best practice in greenhouse gas reporting, based on the greenhouse gas protocol and ISO standards, and supports voluntary reporting initiatives. The guidance is available on the Ministry for the Environment’s website.⁴⁷²

Voluntary climate change mitigation

The Ministry for the Environment provides principle-based guidance for organisations to follow when making claims for voluntary action taken to reduce or remove greenhouse gas emissions outside the boundary of their organisation.

⁴⁶⁹ environment.govt.nz/publications/cngp-measuring-and-reporting-ghg-emissions/

⁴⁷⁰ www.mbie.govt.nz/building-and-energy/building/building-for-climate-change/

⁴⁷¹ www.building.govt.nz/getting-started/building-for-climate-change/

⁴⁷² environment.govt.nz/guides/measuring-and-reporting-greenhouse-gas-emissions-guide-for-organisations/

Best practice for voluntary carbon markets internationally is evolving, with the transition into the Paris Agreement era. The guidance is interim and will be reviewed to ensure it remains relevant for organisations in Aotearoa New Zealand undertaking voluntary climate change mitigation.

The latest guidance, *Interim guidance for voluntary climate change mitigation*,⁴⁷³ replaces all previous guidance.

9.3.3 Information for local government

The Ministry for the Environment has published guidance to provide local government with information about the predicted effects of climate change. These are:

- *Climate Change Projections for New Zealand* (September 2018)⁴⁷⁴
- *Coastal hazards and climate change: Guidance for Local Government* (December 2017).⁴⁷⁵ The coastal hazards guidance will be updated in early 2023
- *Interim guidance on the use of new sea-level rise projections*.⁴⁷⁶ This guidance supersedes parts of the 2017 coastal hazards guidance. A summary report was developed to present the key information in a more accessible format⁴⁷⁷
- A guide to local climate change risk assessments (2021).⁴⁷⁸

For more information about these publications, see chapter 6, section 6.5.

9.3.4 Information for the land-based sector

The Ministry for Primary Industries website explains what climate change means for the rural sector. It has information about forestry and agriculture, the NZ ETS, sustainable forestry and sustainable land management, international climate change, and legislation and regulation.⁴⁷⁹ The Ministry for Primary Industries also funds seminars and workshops on climate change and greenhouse gas emissions for rural professionals⁴⁸⁰ through the New Zealand Institute for Primary Industry Management⁴⁸¹ and New Zealand Agricultural Greenhouse Gas Research Centre. Since 2018/19, over 40 seminars and workshops have been delivered to over 680 rural professionals. Based on estimates from the institute, this represents nearly 40 per cent of the rural professional community,⁴⁸² which is a high level of engagement.

⁴⁷³ Ministry for the Environment. 2022. *Interim guidance for voluntary climate change mitigation*. Wellington: Ministry for the Environment.

⁴⁷⁴ Ministry for the Environment 2018. *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment, 2nd Edition*. Wellington: Ministry for the Environment.

⁴⁷⁵ Ministry for the Environment. 2017. *Coastal Hazards and Climate Change: Guidance for Local Government*. Wellington: Ministry for the Environment.

⁴⁷⁶ Ministry for the Environment. 2022. *Interim Guidance on the Use of New Sea-level Rise Projections*. Wellington: Ministry for the Environment.

⁴⁷⁷ environment.govt.nz/publications/interim-guidance-on-the-use-of-new-sea-level-rise-projections-quick-reference-guide/

⁴⁷⁸ Ministry for the Environment. 2021. *He Kupu Ārahi mō te Aromatawai Tūraru Huringa Āhuarangi Ā-rohe: A Guide to Local Climate Change Risk Assessments*. Wellington: Ministry for the Environment.

⁴⁷⁹ www.mpi.govt.nz/protection-and-response/environment-and-natural-resources/climate-change-and-the-primary-industries/

⁴⁸⁰ www.nzipim.co.nz/Event?Action=View&Event_id=533

⁴⁸¹ www.nzipim.co.nz/

⁴⁸² A small number of rural professionals have attended more than one seminar or workshop, and in some cases have attended both a seminar and a workshop.

He Waka Eke Noa – Primary Sector Climate Action Partnership

The Government has partnered with the primary sector and Māori to equip farmers to measure, manage and reduce on-farm agricultural greenhouse gas emissions and adapt to climate change. This partnership is referred to as He Waka Eke Noa, which references a Māori whakatauki⁴⁸³ about working in unity and leaving no one behind.

The goal of He Waka Eke Noa is to enable sustainable food and fibre production for future generations. This includes collaboration on the detailed development of an appropriate on-farm emissions pricing mechanism, which will come into effect in 2025.

He Waka Eke Noa is working towards all farmers and growers:

- knowing their emissions
- including measures to mitigate greenhouse gas emissions and on adaptation to climate change in their farm business and environment plans.

The programme objectives, milestones and work streams are outlined on the Ministry for the Environment’s website.⁴⁸⁴ More information about the partnership can also be found on the He Waka Eke Noa Primary Sector Climate Action Partnership website.⁴⁸⁵

Agricultural emissions calculator

The Ministry for the Environment has an online agricultural emissions calculator⁴⁸⁶ to provide farmers with a simple estimate of the greenhouse gases emissions from animals, manure management, and nitrogen fertiliser use on farms, as well as the carbon sequestered in forests on farms. The calculator uses the same methods and emission factors as *Measuring emissions: A guide for organisations* (2022). If a more detailed estimate is required, or, if the inclusion of vegetation and mitigations other than those included in the calculator are required, the He Waka Eke Noa website⁴⁸⁷ provides alternative tools and calculators.

Te Uru Rākau – New Zealand Forestry Service

Te Uru Rākau – New Zealand Forest Service is facilitated by the Ministry for Primary Industries and supports forest priorities.⁴⁸⁸ These include climate change and working with Māori on land development opportunities, industry transformation, the NZ ETS, native species planting, the One Billion Trees programme, forestry and wood processing, and workforce development.

Te Uru Rākau is developing a forestry and wood processing industry transformation plan. The plan aims to support Aotearoa New Zealand to make better use of forestry resources by processing more wood onshore, producing more high-value wood products, and using residues to grow the forest-based bioeconomy.⁴⁸⁹

⁴⁸³ Whakatauki (proverb or saying) represent the wisdom guiding Māori culture.

⁴⁸⁴ environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/he-waka-eke-noa-primary-sector-climate-action-partnership/

⁴⁸⁵ hewakaekenoa.nz/

⁴⁸⁶ environment.govt.nz/what-you-can-do/agricultural-emissions-calculator/

⁴⁸⁷ hewakaekenoa.nz/tools-and-calculators/

⁴⁸⁸ www.mpi.govt.nz/forestry/

⁴⁸⁹ www.mpi.govt.nz/forestry/forest-industry-and-workforce/forestry-and-wood-processing-industry-transformation-plan/

9.4 Education and training

The New Zealand Government provides resources and funding for climate change related education and training in schools, institutes and research centres, and industry training. Details of government-supported initiatives are set out below.

9.4.1 Education in schools

The Government provides resources and funds programmes to facilitate and encourage environmental education in schools.⁴⁹⁰ Opportunities are available to learn about climate change and sustainability issues across many areas and year levels of the current national curriculum (which includes *The New Zealand Curriculum*, *Te Marautanga o Aotearoa* and *Te Whāriki* for early learning).

New Zealand Curriculum and Te Marautanga o Aotearoa

The New Zealand Curriculum (2007) and *Te Marautanga o Aotearoa* (2008) set the direction for teaching and learning programmes in Aotearoa New Zealand schools and kura.⁴⁹¹

The curriculum plays an important role in shaping lifelong learning around transitioning to a sustainable future. A five-year programme to refresh *The New Zealand Curriculum* and redesign *Te Marautanga o Aotearoa* is under way, aimed at ensuring all ākonga (students) experience rich and responsive learning.

Each learning area in *The New Zealand Curriculum* is being refreshed, beginning with social sciences, which will be released in late 2022. The social sciences curriculum content was developed alongside a refreshed Vision for Young People. Both the draft Vision for Young People and social sciences content address climate change, regeneration and sustainability. The ‘Understand, Know, Do’ progression model is clear about the learning that cannot be left to chance. In social sciences, this includes specific learning about climate change, sustainability and regeneration within the learning areas and across the phases of learning.

The remaining curriculum learning areas, along with the principles and values, will be refreshed in a phased approach over the next four years. It is intended that climate change, regeneration and sustainability are identified and contributed to within these areas.

The *Mātauranga Whakauka Taiao – Environmental Education for Sustainability: Strategy and Action Plan* was launched on 27 July 2017.⁴⁹² Developed on behalf of the Government by the Department of Conservation, the Ministry for the Environment and Ministry of Education, the strategy refreshes the Environmental Education strategy released in 1998 to reflect the changes in priorities and approaches in the past 20 years. The strategy has a focus on Māori knowledge and values in environmental education.⁴⁹³

As part of the National Certificate of Educational Achievement Review and the Review of Achievement Standards, the subject ‘environment and societies’ is currently under

⁴⁹⁰ environment.govt.nz/what-you-can-do/environmental-education-resources/

⁴⁹¹ Kura refers to schools operating under Māori custom and using te reo Māori (the Māori language) as the medium of instruction.

⁴⁹² Department of Conservation. 2017. *Mātauranga Whakauka Taiao – Environmental Education for Sustainability: Strategy and Action Plan*. Wellington: Department of Conservation.

⁴⁹³ For further information, see www.doc.govt.nz/eefs.

development. Level 2 will be piloted in 2024 and Level 3 in 2025. This subject has a focus on knowledge and values related to regeneration and sustainability, inclusive of te ao Māori (the Māori world). Other subjects being developed as part of the review of achievement standards will also provide opportunities for students to engage in learning that focuses on the environment, such as geography.

Resources for teaching and learning

The Ministry of Education is developing a package of resources to support schools to implement the refreshed curriculum. For social sciences, this package will include resources to make it easier for teachers to design meaningful learning experiences about climate change, regeneration and sustainability.

A comprehensive ministry resource is available to schools to specifically support teaching about the environment. *Pūtātara: A call to action* focuses on global citizenship and sustainability, and explores topics such as national identity, the United Nations Sustainable Development Goals and personal and environmental wellbeing. *Pūtātara* promotes place-based learning and learning through inquiry to develop critical thinking skills.⁴⁹⁴

Te Whāriki

Quality local curriculum for children in early learning services (0 to 6 years of age) is guided by the early learning curriculum: *Te Whāriki: He whāriki mātauranga mō ngā mokopuna o Aotearoa* and *Te Whāriki a te Kōhanga Reo*.

The Ministry of Education's website Te Whāriki Online⁴⁹⁵ provides curriculum resources to enrich children's learning, including science-related thinking and knowledge, to spark curiosity and engagement in early years. This advice covers resources on sustainability and environmental education that are being updated during 2022 to inspire more early learning services to take the lead in strengthening sustainability and climate change related learning and teaching practices.

Education for Sustainability online

Education for Sustainability (EfS) empowers learning communities with the values, knowledge and skills they need to take meaningful action to ensure a thriving world.

The EfS pages on Te Kete Ipurangi⁴⁹⁶ provide the rationale for EfS, celebrate learner outcomes, discuss teaching pedagogies, and describes the ways in which EfS can inform a whole-school approach to creating a more sustainable world.

Enviroschools and Te Aho Tū Roa

The Toimata Foundation is a non-governmental organisation that runs programmes with a holistic approach to creating more sustainable communities. The programmes involve working with children and young people through both the formal education system and communities. The foundation receives part-funding from the Ministry for the Environment, regional councils and community groups.

⁴⁹⁴ putatara.education.govt.nz/#/home

⁴⁹⁵ tewhariki.tki.org.nz/

⁴⁹⁶ nzcurriculum.tki.org.nz/Curriculum-resources/Education-for-sustainability

The two programmes run by the foundation are Enviroschools and Te Aho Tū Roa. The Enviroschools programme operates in English-language schools and early childhood education centres, and Te Aho Tū Roa operates in te reo Māori (Māori language) immersion settings. Both programmes are designed to work in conjunction with the national curriculum and produce various environmental, educational, social and cultural outcomes. The resources provided as part of the programmes include information on climate change.

Students are involved in the planning, design and implementation of action projects based on local environmental priorities identified by the students in conjunction with their community. The projects across the 1400 schools,⁴⁹⁷ kura and centres involved in the Enviroschools and Te Aho Tū Roa programmes have relevance to climate change. The projects include waste minimisation, ecological restoration, school landscaping, local food production, active transport to schools and energy efficiency.

Aotearoa New Zealand’s first emissions reduction plan

Action 3.1.1 of the first emissions reduction plan is to ‘Equip all children and young people for the transition [to a low-emissions society]’.⁴⁹⁸ Significant initiatives for this action include:

- changing the national curriculum and National Certificate of Educational Achievement
- providing teaching and learning resources that support kaiako (teachers, instructors) to connect learning purposefully to climate change contexts
- focusing on wellbeing, which recognises the effect learning about climate change can have on young people’s mental health
- providing guidance on incorporating emissions reduction activities into marau ā-kura (local curriculum).

Action 3.1.2 of the first emissions reduction plan is to ‘Create an accessible, responsive and flexible tertiary education and training system’. The Reform of Vocational Education⁴⁹⁹ will provide education and skills relevant to work today and in the future, by establishing:

- industry-led workforce development councils to set industry skills standards
- regional skills leadership groups, which enable better planning for regional labour markets and ensure the workforce, education and immigration systems are working together to meet the skills and labour market needs
- Te Pūkenga⁵⁰⁰ as a single vocational education institution responsible for workplace and provider-based learning
- centres of vocational excellence⁵⁰¹ to enhance education system responsiveness and bring together stakeholders to collaborate on high-quality curriculum and programme design.

⁴⁹⁷ toimata.org.nz/

⁴⁹⁸ See pages 62–63 of the first emissions reduction plan. Ministry for the Environment. 2022. *Te Hau Mārohi ki Anamata: Towards a Productive, Sustainable and Inclusive Economy: Aotearoa New Zealand’s First Emissions Reduction Plan*. Wellington: Ministry for the Environment.

⁴⁹⁹ www.tec.govt.nz/rove/reform-of-vocational-education/

⁵⁰⁰ xn--tepkenga-szb.ac.nz/news/category/News/competenz-first-tito-to-transition-to-te-pukenga-whanau

⁵⁰¹ tec.govt.nz/rove/coves/

Alongside these initiatives, the Government is committed to ensuring that tertiary education is accessible. In 2018, the Government introduced fees free tertiary education for students or trainees in their first years of study.

As the transition progresses, the Government will continue to monitor trends in the demand for education and remove barriers to participation in lifelong learning. Options include introducing incentives to support specific types of skills, such as the recent Apprenticeship Boost initiative⁵⁰² and Targeted Training and Apprenticeship Fund initiative.⁵⁰³ These initiatives were introduced to support apprentices to keep earning and training towards their qualifications as the economy recovers from the effects of the COVID-19 pandemic.

Action 2.4 of the first emissions reduction plan is to ‘Activate kaupapa Māori and tangata Māori (incorporating the knowledge, skills, attitudes and values of Māori society) solutions’. The Government will provide a dedicated fund to invest in Māori capacity and capability to shape climate policy, education and action.

Case Study: Papatūānuku Kōkiri Marae⁵⁰⁴

Papatūānuku Kōkiri Marae in Māngere, Tāmaki Makaurau (Auckland), is a hub of community education, tikanga and practice that embodies the vision of Oranga Whenua Oranga Tangata, which the marae has had for the past 30 years.

Supported through funding from local and central government, Papatūānuku Kōkiri Marae is a champion of waste minimisation and Māori food sovereignty through its commitment to Hua Parakore: a framework for growing kai that connects the kaupapa of whakapapa, wairua, mana, māramatanga, mauri and te ao tūroa.⁵⁰⁵

An important element of Māori food sovereignty is self-sufficiency, reducing the need for fossil-fuelled supply chains by producing and distributing kai locally. Papatūānuku Kōkiri Marae grows food for the marae kitchen, its community, farmers markets and restaurants, and teaches others how to do the same, ensuring the whenua of Tāmaki Makaurau sustains the people of Tāmaki Makaurau (Auckland).

⁵⁰² www.workandincome.govt.nz/employers/subsidies-training-and-other-help/apprenticeship-boost/index.html

⁵⁰³ www.tec.govt.nz/funding/funding-and-performance/funding/fund-finder/targeted-training-and-apprenticeship-fund/

⁵⁰⁴ See page 49 of the first emissions reduction plan. Ministry for the Environment. 2022. *Te Hau Ārohi ki Anamata: Towards a Productive, Sustainable and Inclusive Economy: Aotearoa New Zealand's First Emissions Reduction Plan*. Wellington: Ministry for the Environment.

⁵⁰⁵ ‘Kaupapa’ – Māori approach, topic, customary practice, institution, agenda, principles, ideology, a philosophical doctrine incorporating the knowledge, skills, attitudes and values of Māori society; ‘whakapapa’ – genealogy, genealogical table, lineage, descent; ‘wairua’ – spirit, soul; ‘mana’ – prestige, authority, control, power, influence, status, spiritual power, charisma; ‘māramatanga’ – enlightenment, clarity, understanding; ‘mauri’ – life principle, life force, vital essence, special nature, a material symbol of a life principle, source of emotions – the essential quality and vitality of a being or entity, also used for a physical object, individual, ecosystem or social group in which this essence is located; ‘te ao tūroa’ – the natural world, the enduring world.

9.4.2 Institutes and research centres

The New Zealand Government provides support for the institutions and research centres that educate professionals and members of the public more generally on climate change issues.

Antarctic Research Centre

The Antarctic Research Centre (ARC) is a Centre of Research Excellence within the Faculty of Science of Victoria University of Wellington. The aim of the ARC is to research the field of Antarctic earth sciences with a focus on past climate history and processes and their influence on the New Zealand and global climate.

The ARC has organised events and seminars over the reporting period on topics relevant to climate change. The ARC also hosts the annual ST Lee Lecture in Antarctic Studies. Researchers from the ARC engage directly with government ministries as well.

Deep South National Science Challenge

The Deep South National Science Challenge was launched in August 2014. The Challenge is funded by the Ministry of Business, Innovation and Employment and hosted by the National Institute of Water and Atmospheric Research (NIWA). The Challenge works with industries, sectors and communities to help New Zealanders make decisions that are informed by climate science. As such, public and sector engagement are core to the development and success of the Challenge.

The Challenge has developed close relationships with the main sectors that will be affected by climate change, ensuring important decision-making groups are informing, and are informed by, Deep South research. Significant partners hail from central and local government, the Iwi Chairs Forum⁵⁰⁶ and main climate-affected sectors, such as agriculture, infrastructure, finance and insurance. They also bring end-users together with researchers to co-create research questions through Deep South Dialogues.

Partnerships with selected media and public outreach initiatives have also been leveraged to increase awareness of Deep South research and the effects and implications of climate change, with a specific focus on adaptation.

The Challenge also has a user-friendly website,⁵⁰⁷ a regular e-newsletter and an active Twitter account. It runs online seminars, webinars and drop-in online meetings that are open to the public and end-users. It invests in building capacity in climate change engagement by supporting researchers to develop their engagement skills and experience and offering end-users the opportunity to upskill members of their communities to become 'climate ambassadors'.

In both 2018 and 2019, the Deep South Challenge Conference 'Changing with our Climate' was held in Auckland. These multi-day conferences facilitated discussions between researchers, partners and stakeholders about the impacts of climate change, such as the research relating to the way climate change might affect water. Recordings from the conference are available for viewing on the Challenge's website.⁵⁰⁸

⁵⁰⁶ The Iwi Chairs Forum is a platform for sharing knowledge and information between the tangata whenua (people of the land – the indigenous people) of Aotearoa. See iwichairs.maori.nz.

⁵⁰⁷ deepsouthchallenge.co.nz/

⁵⁰⁸ deepsouthchallenge.co.nz/resource/2019-conference-panel-he-wai-ora-water-in-our-changing-climate

The Challenge conducts rigorous evaluation to ensure the wise and informed investment of engagement funds and has also funded a public engagement research project that explores the role culture plays in engagement about climate change. For more information on the Deep South National Science Challenge, see chapter 6, section 7.6 and chapter 8, sections 8.2 and 8.4.

Institute for Governance and Policy Studies

The Institute for Governance and Policy Studies (IGPS) is part of the School of Government at Victoria University of Wellington.⁵⁰⁹ Its aim is to deliver independent, high-quality and high-impact research that informs the policy-making process and influences policy development and implementation in important areas of public policy, including on climate change.

The IGPS has undertaken various activities with respect to climate change mitigation and adaptation since 2006. This has included hosting numerous conferences, forums, workshops and public seminars. The IGPS has published many articles and working papers on climate change, including special issues of its journal, *Policy Quarterly*, on climate-related topics. The IGPS has also hosted events from 2018 to 2022, however, the number of events and attendance has decreased due to cancellations in response to COVID-19 restrictions. Factoring out these losses, the overall level of public engagement remains high. Between July 2017 and December 2021, 261 articles were written for the *Conversation* newsletter, receiving over 6 million reads. Collectively, these activities provide a useful contribution to public policy and an opportunity for informal engagement among and with stakeholders.

Motu Economic and Public Policy Research

Motu Economic and Public Policy Research (Motu) is a non-profit economic and public policy research institute.⁵¹⁰ It is independent and non-partisan. It receives funding through grants and contracts from various organisations including government departments, foundations, multilateral institutions and private companies.

The focus of Motu's current and recent economic and policy research and engagement activities relevant to climate change include:

- pathways, policies and modelling for reducing greenhouse gas emissions
- design of emissions trading systems and other market-based instruments in Aotearoa New Zealand and other countries
- vulnerability and adaptation to climate change impacts.

Motu provides education information to the public through newsletters, blogs and forums, such as the blog New Zealand's Low-Emission Future and Agricultural emissions dialogue forum.⁵¹¹ The blogs and forums aim to share information and perspectives about the mitigation challenge that New Zealand faces. It aims to help identify actions government, businesses and civil society can take to prepare New Zealand to thrive in a future of global greenhouse gas constraints. Motu also provides teaching resources and materials, where staff run courses and teach in New Zealand universities. Free teaching materials, including games focused on the emissions trading scheme, are available on the website.⁵¹²

⁵⁰⁹ www.wgtn.ac.nz/igps

⁵¹⁰ www.motu.nz/

⁵¹¹ www.motu.nz/resources/newsletters/

⁵¹² www.motu.nz/resources/teaching-resources/

Motu releases many publications on its research and findings, all of which are freely available to the public.⁵¹³ Motu also shares its research and engagement outcomes by participating in other climate change initiatives in Aotearoa New Zealand and internationally.

NIWA National Climate Centre

The NIWA National Climate Centre produces climate summaries, models, forecasts and general information about Aotearoa New Zealand's climate. For more information about the services and information NIWA provides through the National Climate Database, see chapter 8.

NIWA is committed to making information available to the public. The NIWA website⁵¹⁴ has detailed information about greenhouse gas measurements, global climate models, climate change summaries and outlooks for New Zealand, information on climate change and the marine environment in New Zealand, and regional climate change impacts.

NIWA is committed to education in New Zealand at all levels, offering educational resources to the primary and secondary curriculum, internships and graduate programmes to university students, post-doctoral fellowships, scholarships and training courses.⁵¹⁵ NIWA sponsors multiple science and technology fairs as part of its long-term commitment to enhancing science and technology in young New Zealanders.

Endeavour Fund

The Endeavour Fund⁵¹⁶ generates new knowledge that supports sectors to transition to a low-emissions and climate-resilient economy, including through the development of new energy opportunities and new materials.

This includes the Institute of Geological and Nuclear Sciences Limited led 'Geothermal: The Next Generation' project,⁵¹⁷ which explores new ways to extract geothermal energy at greater depths. The knowledge developed will deliver new options to significantly reduce emissions for the energy sector and provide a vital regional perspective and opportunities for iwi⁵¹⁸ and regional development.

Te Ara Paerangi – Future Pathways

The initiative Te Ara Paerangi – Future Pathways⁵¹⁹ will ensure New Zealand's public science system can solve the challenges the country is facing. The research, science and innovation (RSI) system funds universities, Crown research institutes and international partnerships to conduct public good research. This research is focused on developing new knowledge and

⁵¹³ [motu.nz/find-publications](https://www.motu.nz/find-publications)

⁵¹⁴ www.niwa.co.nz/climate/information-and-resources

⁵¹⁵ [niwa.co.nz/education-and-training](https://www.niwa.co.nz/education-and-training)

⁵¹⁶ www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/endeavour-fund/

⁵¹⁷ www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/endeavour-fund/success-stories/past-rounds/2019-endeavour-fund-successful-proposals/

⁵¹⁸ Tribe, large group descended from a common ancestor.

⁵¹⁹ www.mbie.govt.nz/science-and-technology/science-and-innovation/research-and-data/te-ara-paerangi-future-pathways/

technology to help existing sectors move to low emissions. It also provides foundational knowledge and technology to underpin the development of new net zero sectors. More details can be found in chapter 8, section 8.2.1.

Vision Mātauranga

The Ministry of Business, Innovation and Employment's Vision Mātauranga policy⁵²⁰ enables the science and innovation potential of Māori knowledge. Mātauranga Māori offers insights and solutions to climate change issues that reflect a holistic worldview. The contribution mātauranga Māori can make to the RSI system will be important for New Zealand to meet its emissions budgets and emissions reduction targets, as well as creating a low-emissions economy for all.

To enhance the role of mātauranga Māori and reflect Māori aspirations in the RSI system, the Vision Mātauranga policy will be expanded to help Māori make future investments in RSI and technology. It will be co-developed with Māori to achieve outcomes driven by and for Māori and that reflect Te Tiriti o Waitangi (the Treaty of Waitangi).

New Zealand Climate Change Research Institute

The New Zealand Climate Change Research Institute was established in 2008 by Victoria University of Wellington to develop interdisciplinary, decision-relevant, climate change information. The researchers and policy thinkers work at the interface between climate change science and the decisions people have to make about climate change. A particular emphasis is on work that spans the natural and social sciences.

The institute collaborates internationally and within New Zealand with other researchers at Crown research institutes and universities, and with private institutes and researchers. It contributes to public debate about climate change and delivers courses to students and practitioners.

New Zealand Agricultural Greenhouse Gas Research Centre

The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) (see chapter 4, section 4.3.6 and chapter 8, section 8.2.1 for details) produces regular publications, newsletters, webinars and reports.⁵²¹ It also administers a website 'Ag Matters' that provides practical information, backed by science, to inform farmers and growers about climate change.⁵²² Webinars recently produced by the NZAGRC (in 2021 and 2022) include:

- progress towards low methane dairy sires
- pastoral systems, soil carbon and nitrous oxide emissions
- developing methane inhibitors for grazing livestock on New Zealand farms.

⁵²⁰ www.mbie.govt.nz/science-and-technology/science-and-innovation/agencies-policies-and-budget-initiatives/vision-matauranga-policy/

⁵²¹ www.nzagrc.org.nz

⁵²² www.agmatters.nz

Since the *Seventh National Communication*, the NZAGRC has published over 60 peer-reviewed publications.⁵²³ In addition to a portfolio of research, the NZAGRC attracts and supports a significant number of master's, doctoral and postdoctoral students each year, expanding the pool of researchers with skills in the area of agricultural greenhouse gas mitigation and ensuring succession in science leadership.

The NZAGRC has advanced its goal of enhancing awareness among stakeholders by getting greater alignment with industry through the Pastoral Greenhouse Gas Research Consortium. It has done this by supporting a range of knowledge transfer activities and having a Māori-specific greenhouse gas research programme. It has also developed a strong media profile through regular appearances in print, radio and television, issuing several press releases and initiating a social media presence.

The NZAGRC holds annual workshops and conferences. These are attended by NZAGRC members, government agencies, research organisations and industry stakeholders. The NZAGRC also acts as agent for the New Zealand Government in supporting the goals and objectives of the Global Research Alliance on Agricultural Greenhouse Gases. It routinely hosts visiting scientific and policy delegations from other countries.

Royal Society of New Zealand Te Apārangi

The Royal Society of New Zealand Te Apārangi is responsible for advancing and promoting research and scholarly activity.⁵²⁴ It is an independent statutory organisation and New Zealand's national academy of science, technology and the humanities. The society provides independent expert advice to the Government and community on issues of public concern, including climate change. It provides information and talks for the public, education programmes, and support for the research community. The society's independent experts come together to make transparent, effective decisions about who gets research funding, access to learning opportunities and who is celebrated as New Zealand's top researchers and scholars through its annual research honours.

The Society hosted a virtual seminar for a public discussion with the New Zealand scientists following the release of the IPCC Working Group I and Working Group II reports in 2021.

9.4.3 Science Media Centre

The Science Media Centre (SMC)⁵²⁵ is an independent centre established by the Royal Society of New Zealand Te Apārangi with funding from the Ministry of Business, Innovation and Employment. The SMC helps journalists work more effectively with the scientific community and maintains one of the largest and most comprehensive databases of expert contacts on science-related topics in the country.

The SMC facilitates links between the media and science so the media has easy access to relevant scientific information. By providing access to evidence-based information and supporting the professional development of journalists and scientists, the SMC improves media coverage of climate change, with the aim of a better-informed public.

⁵²³ www.nzagrc.org.nz/publications

⁵²⁴ www.royalsociety.org.nz/

⁵²⁵ www.sciencemediacentre.co.nz

Since 2008, it has released dozens of climate science and policy-related ‘expert reactions’ that round up commentary on new climate science journal papers, progress on global agreements, such as the Paris Agreement, and local emissions mitigation efforts, such as the NZ ETS. The SMC’s Spotting Bad Science newsroom workshops also help junior journalists interpret and cover climate science.

The SMC produces other resources such as:

- Desk Guides – free, handy reference guides with practical tips for journalists covering science and scientists working with media
- Science Media SAVVY workshops⁵²⁶ – designed to help researchers gain the confidence and skills to engage effectively with media and communicate their science in public
- Scimex⁵²⁷ – an online portal for embargoed science research news for registered journalists, in collaboration with the Australian Science Media Centre.

Science Learning Hub – Pokapū Akoranga Pūtaiao

The Science Learning Hub – Pokapū Akoranga Pūtaiao links New Zealand scientists with school students, teachers and community audiences.⁵²⁸ The Hub is a national project funded by the New Zealand Government to make examples of New Zealand science, technology and engineering more accessible and visible. It has over 10 thousand resources to showcase cutting-edge science and demonstrate how the stories of science can be used to enrich school teaching and learning, making it more relevant, engaging and meaningful.

The Hub publishes numerous articles, videos, activities, interactive citizen science projects, and teacher professions learning and development resources about climate change on its website.⁵²⁹

The Hub has recently collaborated with the Ministry for the Environment and Stats NZ to create resources using the publication *Our Atmosphere and Climate 2020*.⁵³⁰ The resources reflect the report, with a focus on science and communicating the issues New Zealand faces due to the uncertainty of a changing climate.

9.5 Public engagement

Preparation of the *Eighth National Communication* is a cross-governmental effort with contributions from various government agencies, along with organisations that receive funding or other support from the New Zealand Government. Although the public and non-governmental organisations are not consulted directly on the content of the *Eighth National Communication*, the Government actively engages with the public on climate change issues and has continued to do so since the last reporting period.

⁵²⁶ www.sciencemediacentre.co.nz/savvy

⁵²⁷ www.scimex.org

⁵²⁸ www.sciencelearn.org.nz

⁵²⁹ www.sciencelearn.org.nz/topics/climate-change

⁵³⁰ www.sciencelearn.org.nz/resources/2963-our-atmosphere-and-climate-introduction%20

This section contains information about the Government’s engagement with the public during the reporting period. This includes consultation on the national adaptation plan, the emissions reduction plan, reviews of the NZ ETS, ongoing consultation with Māori, engagement with youth, and financial support for community groups with objectives related to climate change.

9.5.1 Engaging with the public

Our climate future

The Ministry for the Environment’s ‘Our climate future’ campaign⁵³¹ is an online source for the public for climate-related resources and information. Short films describe what people can do to reduce their individual and collective impact on the planet. Case studies from around Aotearoa New Zealand demonstrate recent emissions reduction efforts by local communities, businesses and central and local government. Links to recent publications are provided, including the emissions reduction plan, *Our Atmosphere and Climate 2020*, *Environment Aotearoa 2022*, and the Science Learning Hub.

Recent public consultations

National adaptation plan

From 27 April to 3 June 2022, the Ministry for the Environment consulted on proposals to address the risks Aotearoa New Zealand faces from climate change.⁵³² This included the draft national adaptation plan, information on the early development of a managed retreat system, and emerging issues relating to residential home insurance for flood risk.

Emissions reduction plan

From 13 October to 24 November 2021, the Ministry for the Environment consulted on what needed to be included in Aotearoa New Zealand’s first emissions reduction plan. People could submit on two options during the consultation. A quick submission,⁵³³ which asked 3 high-level questions, and a detailed submission,⁵³⁴ which asked 114 questions across 18 areas.

New Zealand Emissions Trading Scheme

From 28 April to 17 March 2022, the Ministry for the Environment consulted on proposed technical amendments to regulations under the Climate Change Response Act 2002 to maintain the accuracy of the NZ ETS.⁵³⁵

From 8 July to 17 September 2021, the Ministry for the Environment consulted on various options to improve industrial allocation policy⁵³⁶ and the market governance framework⁵³⁷ of the NZ ETS and auction settings.

⁵³¹ environment.govt.nz/what-you-can-do/campaigns/ourclimatefuture/

⁵³² consult.environment.govt.nz/climate/national-adaptation-plan/

⁵³³ consult.environment.govt.nz/climate/erp-quick-submission/

⁵³⁴ consult.environment.govt.nz/climate/emissions-reduction-plan/

⁵³⁵ consult.environment.govt.nz/climate/proposed-changes-nz-ets-2022/

⁵³⁶ consult.environment.govt.nz/climate/reforming-industrial-allocation-in-the-nz-ets/

⁵³⁷ consult.environment.govt.nz/climate/designing-a-governance-framework-for-the-nz-ets/

Previous public consultations

The Ministry for the Environment's previous public consultations within the reporting period include:

- the Climate Change Response Amendment Act 2019⁵³⁸
- climate-related financial disclosures⁵³⁹
- action on agricultural emissions⁵⁴⁰
- NZ ETS: proposed technical updates for 2018⁵⁴¹ and 2019;⁵⁴² consultation on proposed improvements;⁵⁴³ reforming the NZ ETS rules for auctioning⁵⁴⁴ and proposed settings,⁵⁴⁵ and modelling for the electricity allocation factor.⁵⁴⁶

Pou Take Āhuarangi Iwi Leaders Group

Pou Take Āhuarangi is the National Iwi Leaders Group for climate-related matters. It is one of the five directorates that form part of the wider Iwi Chairs Forum, which meets four times a year. Collectively, the forum represents more than 400,000 Māori, over two-thirds of the Māori population. The Ministry for the Environment is the lead agency for the Crown relationship with Pou Take Āhuarangi.

The National Iwi Chairs Forum mandated Ihirangi, an advisory group of Māori climate and environmental experts, to be the operational arm of Pou Take Āhuarangi. One of the main objectives of Ihirangi is to empower and increase capacity of whānau (family, extended family, family connection), hapū (kinship group, clan, subtribe) and iwi to engage proactively in climate change mitigation and adaptation through the provision of robust, comprehensive and relevant data, information and analysis. The secondary objective, while building the capacity of whānau, hapū and iwi to proactively address and plan for climate change, is to increase the ability of hapū and iwi/Māori to engage with government, both local and central, around climate issues.

In March 2021, three joint priorities were agreed under Pou Take Āhuarangi: emissions, adaptation and data. Under the umbrella of these priorities, Ministry for the Environment officials have worked closely with Ihirangi to develop and reach agreement on a work programme for the year ahead. The programme focuses on both the Ministry for the Environment's policy and legislative commitments as well as Māori-facing work relating to data, that is designed to directly improve outcomes for whānau, hapū and iwi. A new priority called the Indigenous Framework has been agreed with Ihirangi to enable further conversations on the scope and application of an indigenous framework across the entire climate work programme.

⁵³⁸ pastconsultations.environment.govt.nz/past-consultation/16

⁵³⁹ pastconsultations.environment.govt.nz/past-consultation/6

⁵⁴⁰ pastconsultations.environment.govt.nz/past-consultation/10

⁵⁴¹ pastconsultations.environment.govt.nz/past-consultation/19

⁵⁴² pastconsultations.environment.govt.nz/past-consultation/11

⁵⁴³ pastconsultations.environment.govt.nz/past-consultation/12

⁵⁴⁴ pastconsultations.environment.govt.nz/past-consultation/5

⁵⁴⁵ pastconsultations.environment.govt.nz/past-consultation/2

⁵⁴⁶ pastconsultations.environment.govt.nz/past-consultation/4

Blake Inspire programmes

The Sir Peter Blake Trust, established in 2004, has a focus on inspiring environmental leadership in youth. It has multiple programmes for leadership development for students and teachers. The Blake Inspire programme,⁵⁴⁷ in partnership with the Ministry for the Environment, provides an opportunity for 100 young people aged between 15 and 18 to join a week-long residential leadership development programme. It offers the opportunity to work with scientists, environmental experts, diverse leaders and other like-minded young people to help them develop strong leadership skills while learning about topical environmental issues and how they can take action to tackle them. In 2022, Blake Inspire ran three programmes throughout the year.

Inspiring Stories – Festival for the Future

Inspiring Stories is a New Zealand charity founded in 2011 with the aim of supporting young people to change the world.⁵⁴⁸ Over 12,000 people have participated in the programmes, including Festival for the Future, the Impact Awards, Future Leaders, and Inspiring Speakers.

Festival for the Future is an annual conference, run in partnership with the Ministry for Primary Industries, Ministry for the Environment, EECA, Wellington City Council and others. The festival offers an opportunity to connect with a growing community of innovators, leaders and entrepreneurs, build knowledge of big issues affecting the future, learn practical skills and tools during the breakouts and workshops, and be inspired by powerful stories of courage and leadership. The festival audience is diverse, including entrepreneurs, leaders of business and government, young professionals and people leading change in grassroots communities. In 2021, more than 1600 people attended the festival in person, as well as an online audience engaging from 40 countries.

Environment centres

Environment centres act as a focus and meeting place for local community action on environmental issues. They provide an important community service by educating the public on major environmental issues, including climate change. An environment centre provides projects, activities and services that encourage and foster communities to improve the environment for the benefit of present and future generations. Currently 12 environment centres are in Aotearoa New Zealand. The Ministry for the Environment funds environment centres through the Community Environment Fund.⁵⁴⁹

Waste Minimisation Fund

The Waste Minimisation Fund, administered by the Ministry for the Environment, funds projects that promote or achieve waste minimisation.⁵⁵⁰ By supporting these projects, the fund increases resource efficiency, reuse, recovery and recycling and decreases waste to landfill, with the aim of reducing methane emissions from organic waste.

⁵⁴⁷ www.blakenz.org/programmes/blake-inspire/

⁵⁴⁸ www.festivalforthefuture.co

⁵⁴⁹ environment.govt.nz/what-you-can-do/funding/community-environment-fund/

⁵⁵⁰ environment.govt.nz/what-you-can-do/funding/waste-minimisation-fund/

Various education and awareness campaigns have received public funding through the Waste Minimisation Fund. One example is the Para Kore (Zero Waste) education programme. Since 2009, Para Kore has been working towards its goal “Hei te 2020 he para kore ngā marae katoa o Aotearoa” (by 2020 all marae of New Zealand are working towards zero waste). Para Kore does this by sharing knowledge about reducing, reusing, recycling and composting. The project was completed in 2021, with 48 marae⁵⁵¹ and organisations being established with waste minimisation systems and provided education, 54 wānanga (workshops) delivered, Para Kore systems were implemented in 33 kaupapa Māori⁵⁵² events, and at least 65 per cent of waste from participating marae was diverted from landfill.

9.5.2 Engaging with the land-based sector

The Sustainable Land Management and Climate Change (SLMACC) research programme was established in 2007 and is administered by the Ministry for Primary Industries.⁵⁵³ SLMACC aims to contribute to the achievement of Aotearoa New Zealand’s climate change targets through research to mitigate greenhouse gas emissions and understand the effects of climate change.

During the reporting period, SLMACC has funded over 30 projects covering issues such as quantifying risk in the primary sectors, improving the New Zealand Drought Index, enhancing the preparedness of rural land owners to extreme fires, freshwater mitigation projects, adaptation, and extension projects. For more information on the SLMACC programme, see chapter 4, section 4.3.6 and chapter 8, sections 8.2.1 and 8.4.4.

9.6 International engagement

The New Zealand Government has been active in engaging with a broader regional audience on climate change. This section outlines work undertaken to engage internationally on climate change matters over the past five years.

As detailed in chapter 7, the Government is a major funder of the Pacific regional organisations that have a strategic focus on climate change. These organisations include the Secretariat of the Pacific Regional Environment Programme (SPREP), which provides policy and technical support to its Pacific Island members to meet their commitments under the UNFCCC and to support climate change adaptation actions. The latest SPREP campaign was the ‘Pacific Year of the Coral Reef 2018–2019’,⁵⁵⁴ which involved events and distributing news and resources with a focus on the ongoing action for conservation and recovery of coral reefs well into the future. SPREP also provides resources and information portals on its website.⁵⁵⁵

The Government provides funding to support the technical contribution of Aotearoa New Zealand-based scientists at international scientific unions, such as the International Council for Science and several of its global research programmes actively involved in coordinating research into climate change. The funding ensures the Government is well

⁵⁵¹ Courtyard – the open area in front of the whareniui (meeting house) where formal greetings and discussions take place. Often also used to include the complex of buildings around the marae.

⁵⁵² Māori approach, topic, customary practice, institution, agenda, principles, ideology – a philosophical doctrine incorporating the knowledge, skills, attitudes and values of Māori society.

⁵⁵³ www.mpi.govt.nz/funding-rural-support/farming-funds-and-programmes/slmacc/slmacc-news/

⁵⁵⁴ www.sprep.org/pacific-year-coral-reef-2018-2019

⁵⁵⁵ www.sprep.org/resources

supported technically and the scientific and policy advice provided by New Zealand is valued for its excellence, relevance and strategic awareness.

The Government also supports enhancing the capacity and capability of developing countries to take effective climate change action. More details can be found in chapter 7.

9.6.1 Contribution to the IPCC

The New Zealand Government provides a financial contribution to support Aotearoa New Zealand scientists selected to be part of the author teams of IPCC reports. Several New Zealand experts were involved in the Special Reports, Working Group reports and refinement of inventory methodologies over the IPCC's sixth assessment cycle. During the reporting period, the authors also received funding from the Government to travel to attend IPCC meetings, when not subject to COVID-19 travel restrictions.

9.6.2 Global Research Alliance on Agricultural Greenhouse Gases

The Global Research Alliance on Agricultural Greenhouse Gases (GRA) was formed in 2009 to find ways to grow more food without growing greenhouse gas emissions. The GRA promotes international cooperation and investment in research to mitigate the effect of agricultural greenhouse gas emissions. Aotearoa New Zealand is a founding member of the GRA, hosts the GRA Secretariat, co-chairs the Livestock Research Group and participates in the Croplands and Integrative research groups.⁵⁵⁶ For more information on the GRA's aims and members, see chapter 4, section 4.3.6 and chapter 7, section 7.2.3.

The Ministry for Primary Industries supports and promotes the priorities and goals of the GRA and contributes to collaborative research projects and scientific capability-building activities.⁵⁵⁷

Education (fellowships and awards)

The New Zealand Global Research Alliance Doctoral Scholarship (NZ-GRADS)⁵⁵⁸ is offered to science students from developing countries who want to complete their doctorate at an Aotearoa New Zealand university. Research topics must be related to greenhouse gas emissions from agricultural systems, primarily livestock.

The Livestock Emissions Abatement Research Network (LEARN)⁵⁵⁹ awards scheme is sponsored by the New Zealand Government to build international capability in livestock emissions research for scientists from developing countries.

The Global Research Alliance Senior Scientist (GRASS)⁵⁶⁰ Award funds short-term exchange opportunities for scientists from New Zealand and other GRA member countries to encourage global research collaboration.

⁵⁵⁶ globalresearchalliance.org/country/new-zealand/

⁵⁵⁷ www.mpi.govt.nz/funding-rural-support/environment-and-natural-resources/international-response-to-climate-change/global-research-alliance-gra/

⁵⁵⁸ globalresearchalliance.org/library/nz-grads/

⁵⁵⁹ livestockemissions.net/awards/learn-technical-training-award/

⁵⁶⁰ livestockemissions.net/awards/grass-award/

New Zealand supports the Climate, Food and Farming GRA Development Scholarships (CLIFF-GRADS) programme,⁵⁶¹ provides short-term grants for doctoral students from developing countries to undertake scientific training and research on the measurement and mitigation of greenhouse gas emissions in agricultural systems, carbon storage in agricultural systems, and quantification and mitigation of greenhouse gas emissions from food loss and waste.

New Zealand is supporting the Graduate Research Grants (GRA-GRG) through African universities, which are members of the Regional Universities Forum for Capacity Building in Agriculture (RUFORM). These grants are aimed at teaching graduate and post-graduate students in Africa to conduct applied research on agricultural greenhouse gases.

As of July 2022, New Zealand has supported:

- LEARN awards to seven postdoctoral students from Brazil, China, Indonesia, Pakistan, Sri Lanka and Viet Nam
- three doctoral students from China; thirteen technicians from Argentina, China, Colombia, Ethiopia, Ghana, India, Mexico, Paraguay, Peru, Uganda and Viet Nam
- fourteen GRASS awards to support collaboration with Australia, Canada, Denmark, Ireland, the Netherlands, Spain and United States
- for the period 2018–22, 123 CLIFF-GRA awards to doctoral students from Algeria, Argentina, Benin, Brazil, Burkina Faso, Cameroon, China, Columbia, Cuba, Ecuador, Ethiopia, Ghana, India, Indonesia, Iran, Kenya, Mexico, Myanmar, Nepal, Nigeria, Pakistan, Paraguay, Peru, Philippines, Russia, South Africa, Tanzania, Togo, Tunisia, Uganda, Viet Nam and Zimbabwe.

Public awareness

Aotearoa New Zealand partners with the World Farmers' Organisation in the delivery of an annual farmer study tour. The purpose of the tours is to raise awareness within the international farming community of the issue of greenhouse gases from agriculture; to provide a way for farmers to share experiences and be informed; and to inform the global research agenda, in particular the work of the GRA. Three such study tours have been held since 2014.⁵⁶² The latest tour was held in 2019 in New Zealand with the participation of farmers from Ethiopia, Indonesia, Kenya, South Sudan and Uganda.

Training

To support the GRA, Aotearoa New Zealand provides financial and technical support for the training of technicians and scientists from developing countries. Typically, this is delivered through training workshops, often with participation by several countries in a particular region or countries sharing specific training needs.

⁵⁶¹ globalresearchalliance.org/library/cliff_grads-fellowship

⁵⁶² www.mpi.govt.nz/funding-rural-support/environment-and-natural-resources/international-response-to-climate-change/global-research-alliance-gra/

GRA-related training that New Zealand has supported from 2018 to 2022 includes:

- webinar by the GRA Integrative Research Group on linkages with the 4 Per 1000 Initiative and the Coordination of International Research Cooperation on Soil Carbon Sequestration in Agriculture (CIRCASA) project⁵⁶³
- webinar on monitoring reporting verification methods for soil carbon⁵⁶⁴
- CLIFF-GRADS alumni workshop⁵⁶⁵
- guidance to help countries track livestock emissions⁵⁶⁶
- progressing partnerships webinar series^{567, 568, 569}
- food loss and waste workshop in Sri Lanka⁵⁷⁰
- manure management network webinar^{571, 572}
- new joint research mechanism on climate and agriculture webinar from Ireland and New Zealand⁵⁷³
- free e-learning programme consisting of three foundation level courses on climate change and greenhouse gas reporting.⁵⁷⁴ This is available in Arabic, Chinese (basic), Dutch, English, French, German, Italian, Portuguese, Russian and Spanish.

Asia and Pacific activities

In October 2021, the Minister of Climate Change confirmed that at least half of Aotearoa New Zealand's new \$1.3 billion climate finance commitment, which covers 2022 to 2025, will go towards supporting New Zealand's Pacific neighbours.

The Ministry of Foreign Affairs and Trade established the Climate Change Programme to help resilience in the Pacific to the effect of climate change.⁵⁷⁵ The programme focuses on 14 countries and territories across the Pacific, including the Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Nauru, Niue, Papua New Guinea, Republic of the Marshall Islands, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu and Vanuatu.

⁵⁶³ globalresearchalliance.org/n/webinar-gra-integrative-research-group-linkages-with-the-4p1000-initiative-and-the-circasa-project/

⁵⁶⁴ globalresearchalliance.org/n/webinar-meeting-monitoring-reporting-verification-methods-for-soil-carbon/

⁵⁶⁵ globalresearchalliance.org/n/first-cliff-grads-alumni-workshop-indonesia-october-2019/

⁵⁶⁶ globalresearchalliance.org/n/new-activity-data-guidance/

⁵⁶⁷ globalresearchalliance.org/n/progressing-partnerships-in-africa-gra-webinar-series-2020/

⁵⁶⁸ globalresearchalliance.org/n/africa-partnership-webinar-2-creating-impact-through-collaboration/

⁵⁶⁹ globalresearchalliance.org/n/africa-partnership-webinar-3-demonstrating-impact/

⁵⁷⁰ globalresearchalliance.org/n/food-loss-and-waste-workshop-in-sri-lanka/

⁵⁷¹ globalresearchalliance.org/n/manure-management-network-webinar-feb-2022/

⁵⁷² globalresearchalliance.org/n/manure-management-projects-webinar/

⁵⁷³ globalresearchalliance.org/n/new-joint-research-mechanism-on-climate-and-agriculture-launched-between-ireland-and-new-zealand/

⁵⁷⁴ globalresearchalliance.org/n/new-e-learning-available/

⁵⁷⁵ www.mfat.govt.nz/en/environment/climate-change/supporting-our-region/the-climate-change-programme

New Zealand holds one of the World Meteorological Organization Region V (southwest Pacific) seats on the IPCC Bureau. In 2020, the sixth Pacific Island Climate Outlook Forum (PICOFF) was hosted virtually for the first time.⁵⁷⁶ PICOFF brings together representatives of the Pacific National Meteorological and Hydrological Services, regional partners and global climate centres, to ensure consistency in the access to and interpretation of climate information for the Pacific and the implications for critical sectors. PICOFF embraces the model of the Global Framework for Climate Services User Interface Platform, which provides a structured means for users, researchers and climate services providers to interact at the global, regional and national level, to ensure user needs for climate services are met.

For more detailed descriptions of New Zealand's engagement with Pacific Island countries, see chapter 7.

⁵⁷⁶ public.wmo.int/en/media/news/pacific-island-climate-outlook-forum

Appendix A: Summary of emissions and removals from New Zealand's 2022 Greenhouse Gas Inventory

Table A.1: Emissions trends summary (CTF Table 1) (three parts)

Table A.1: Emissions trends summary (CTF Table 1) (part 1 of 3)

Greenhouse gas emissions	Base year 1990 (kt CO ₂ - equivalent)	1991 (kt CO ₂ - equivalent)	1992 (kt CO ₂ - equivalent)	1993 (kt CO ₂ - equivalent)	1994 (kt CO ₂ - equivalent)	1995 (kt CO ₂ - equivalent)	1996 (kt CO ₂ - equivalent)	1997 (kt CO ₂ - equivalent)	1998 (kt CO ₂ - equivalent)
CO ₂ emissions without net CO ₂ from LULUCF	25,502.51	26,182.59	28,166.92	27,761.18	27,900.04	28,003.49	29,304.54	31,278.67	29,858.54
CO ₂ emissions with net CO ₂ from LULUCF	3,878.45	2,537.68	4,736.30	3,503.99	3,819.14	5,102.66	6,837.28	8,160.84	6,067.45
CH ₄ emissions without CH ₄ from LULUCF	32,972.51	33,208.11	32,793.87	33,091.81	33,991.44	34,237.19	34,881.11	35,676.09	35,023.70
CH ₄ emissions with CH ₄ from LULUCF	33,041.22	33,256.37	32,850.72	33,165.14	34,071.64	34,314.43	34,969.32	35,762.95	35,145.18
N ₂ O emissions without N ₂ O from LULUCF	5,792.05	5,860.17	5,887.35	6,108.18	6,334.50	6,570.02	6,647.84	6,732.60	6,666.35
N ₂ O emissions with N ₂ O from LULUCF	6,118.17	6,180.19	6,216.66	6,450.51	6,701.33	6,947.71	7,042.40	7,139.94	7,076.75
HFCs	NO, NA	NO, NA	0.29	0.36	7.91	24.52	54.36	113.42	97.52
PFCs	909.95	903.79	461.88	210.16	186.18	153.28	278.98	201.11	151.38
Unspecified mix of HFCs and PFCs	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
SF ₆	19.97	20.86	21.91	22.69	23.43	24.42	24.65	25.58	24.86
NF ₃	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA

Greenhouse gas emissions	Base year 1990 (kt CO ₂ - equivalent)	1991 (kt CO ₂ - equivalent)	1992 (kt CO ₂ - equivalent)	1993 (kt CO ₂ - equivalent)	1994 (kt CO ₂ - equivalent)	1995 (kt CO ₂ - equivalent)	1996 (kt CO ₂ - equivalent)	1997 (kt CO ₂ - equivalent)	1998 (kt CO ₂ - equivalent)
Total (without LULUCF)	65,196.98	66,175.53	67,332.21	67,194.37	68,443.50	69,012.91	71,191.49	74,027.48	71,822.35
Total (with LULUCF)	43,967.76	42,898.90	44,287.76	43,352.84	44,809.62	46,567.01	49,206.99	51,403.84	48,563.14
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories	Base year 1990 (kt CO ₂ - equivalent)	1991 (kt CO ₂ - equivalent)	1992 (kt CO ₂ - equivalent)	1993 (kt CO ₂ - equivalent)	1994 (kt CO ₂ - equivalent)	1995 (kt CO ₂ - equivalent)	1996 (kt CO ₂ - equivalent)	1997 (kt CO ₂ - equivalent)	1998 (kt CO ₂ - equivalent)
1. Energy	23,877.89	24,367.64	26,228.40	25,762.94	26,081.68	25,866.12	27,462.16	29,493.97	27,912.15
2. Industrial processes and product use	3,579.92	3,728.61	3,374.09	3,213.46	3,082.80	3,174.43	3,365.55	3,253.36	3,237.01
3. Agriculture	33,792.88	34,022.51	33,570.98	33,956.39	35,133.36	35,734.70	36,038.26	36,893.06	36,287.58
4. Land Use, Land-Use Change and Forestry*	-21,229.22	-23,276.63	-23,044.46	-23,841.53	-23,633.88	-22,445.90	-21,984.50	-22,623.64	-23,259.21
5. Waste	3,943.11	4,053.49	4,155.50	4,258.37	4,142.48	4,234.51	4,322.41	4,383.88	4,382.31
6. Other	3.17	3.28	3.24	3.21	3.17	3.14	3.11	3.21	3.30
Total (including LULUCF)	43,967.76	42,898.90	44,287.76	43,352.84	44,809.62	46,567.01	49,206.99	51,403.84	48,563.14

Table A.1: Emissions trends summary (CTF Table 1) (part 2 of 3)

Greenhouse gas emissions	1999 (kt CO ₂ - equivalent)	2000 (kt CO ₂ - equivalent)	2001 (kt CO ₂ - equivalent)	2002 (kt CO ₂ - equivalent)	2003 (kt CO ₂ - equivalent)	2004 (kt CO ₂ - equivalent)	2005 (kt CO ₂ - equivalent)	2006 (kt CO ₂ - equivalent)	2007 (kt CO ₂ - equivalent)	2008 (kt CO ₂ - equivalent)	2009 (kt CO ₂ - equivalent)
CO ₂ emissions without net CO ₂ from LULUCF	31,465.59	32,246.01	34,379.21	34,542.29	36,241.47	35,836.30	37,424.07	37,330.16	36,410.66	37,509.26	34,620.67
CO ₂ emissions with net CO ₂ from LULUCF	4,962.54	4,831.02	6,416.75	7,991.84	8,501.47	8,165.39	11,490.90	13,458.24	13,772.75	7,645.31	5,893.12
CH ₄ emissions without CH ₄ from LULUCF	35,127.95	35,951.60	36,370.66	36,079.86	36,160.67	36,215.13	36,522.93	36,850.14	35,794.38	34,369.57	34,522.16
CH ₄ emissions with CH ₄ from LULUCF	35,207.39	36,021.62	36,445.11	36,156.64	36,242.71	36,290.72	36,633.80	36,963.59	35,944.48	34,446.58	34,620.16
N ₂ O emissions without N ₂ O from LULUCF	6,697.21	6,996.74	7,363.34	7,463.59	7,726.31	7,859.35	7,930.30	7,725.79	7,537.10	7,537.22	7,539.78
N ₂ O emissions with N ₂ O from LULUCF	7,101.17	7,406.82	7,772.22	7,867.80	8,126.58	8,254.91	8,328.06	8,121.28	7,947.78	7,901.20	7,902.83
HFCs	192.28	233.65	300.10	401.36	503.85	582.58	694.01	798.68	917.09	1,013.31	1,075.61
PFCs	68.67	67.61	70.61	84.48	126.81	99.12	69.38	106.73	48.41	45.47	53.86
Unspecified mix of HFCs and PFCs	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
SF ₆	24.56	19.56	20.04	23.32	25.19	28.92	25.41	21.05	19.87	19.34	22.54
NF ₃	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
Total (without LULUCF)	73,576.26	75,515.17	78,503.95	78,594.91	80,784.30	80,621.38	82,666.10	82,832.55	80,727.52	80,494.16	77,834.61
Total (with LULUCF)	47,556.61	48,580.27	51,024.83	52,525.44	53,526.60	53,421.62	57,241.57	59,469.58	58,650.37	51,071.20	49,568.11
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas emissions	1999 (kt CO ₂ -equivalent)	2000 (kt CO ₂ -equivalent)	2001 (kt CO ₂ -equivalent)	2002 (kt CO ₂ -equivalent)	2003 (kt CO ₂ -equivalent)	2004 (kt CO ₂ -equivalent)	2005 (kt CO ₂ -equivalent)	2006 (kt CO ₂ -equivalent)	2007 (kt CO ₂ -equivalent)	2008 (kt CO ₂ -equivalent)	2009 (kt CO ₂ -equivalent)
1. Energy	29,283.48	30,019.02	32,039.08	31,989.04	33,413.74	33,056.30	34,649.77	35,047.74	33,639.79	34,775.53	32,091.90
2. Industrial processes and product use	3,412.94	3,443.22	3,558.48	3,680.46	3,916.54	3,953.00	4,061.65	4,171.18	4,431.19	4,322.44	4,274.59
3. Agriculture	36,468.19	37,614.88	38,445.14	38,452.90	39,075.43	39,219.07	39,571.90	39,427.40	38,508.10	37,332.25	37,535.96
4. Land Use, Land-Use Change and Forestry*	-26,019.65	-26,934.90	-27,479.12	-26,069.47	-27,257.70	-27,199.76	-25,424.54	-23,362.98	-22,077.15	-29,422.96	-28,266.50
5. Waste	4,408.25	4,434.56	4,457.67	4,468.91	4,375.01	4,388.98	4,378.30	4,181.76	4,143.96	4,059.45	3,927.65
6. Other	3.40	3.49	3.59	3.59	3.59	4.04	4.49	4.47	4.48	4.50	4.51
Total (including LULUCF)	47,556.61	48,580.27	51,024.83	52,525.44	53,526.60	53,421.62	57,241.57	59,469.58	58,650.37	51,071.20	49,568.11

Table A.1: Emissions trends summary (CTF Table 1) (part 3 of 3)

Greenhouse gas emissions	2010 (kt CO ₂ -equivalent)	2011 (kt CO ₂ -equivalent)	2012 (kt CO ₂ -equivalent)	2013 (kt CO ₂ -equivalent)	2014 (kt CO ₂ -equivalent)	2015 (kt CO ₂ -equivalent)	2016 (kt CO ₂ -equivalent)	2017 (kt CO ₂ -equivalent)	2018 (kt CO ₂ -equivalent)	2019 (kt CO ₂ -equivalent)	2020 (kt CO ₂ -equivalent)
CO ₂ emissions without net CO ₂ from LULUCF	34,811.08	34,265.85	35,945.09	35,241.00	35,438.93	35,813.11	34,152.64	35,688.13	35,704.54	37,121.03	34,456.75
CO ₂ emissions with net CO ₂ from LULUCF	5,035.98	4,219.69	8,794.23	8,533.86	8,410.44	8,826.78	7,525.91	10,635.80	11,091.04	13,736.29	10,790.52
CH ₄ emissions without CH ₄ from LULUCF	34,764.35	34,932.72	35,238.02	35,186.88	35,486.17	34,989.09	34,538.48	34,415.85	34,445.83	34,510.42	34,272.94
CH ₄ emissions with CH ₄ from LULUCF	34,856.74	34,997.35	35,314.42	35,262.48	35,554.94	35,066.39	34,646.16	34,507.58	34,512.51	34,594.17	34,354.60

Greenhouse gas emissions	2010 (kt CO ₂ - equivalent)	2011 (kt CO ₂ - equivalent)	2012 (kt CO ₂ - equivalent)	2013 (kt CO ₂ - equivalent)	2014 (kt CO ₂ - equivalent)	2015 (kt CO ₂ - equivalent)	2016 (kt CO ₂ - equivalent)	2017 (kt CO ₂ - equivalent)	2018 (kt CO ₂ - equivalent)	2019 (kt CO ₂ - equivalent)	2020 (kt CO ₂ - equivalent)
N ₂ O emissions without N ₂ O from LULUCF	7,679.68	7,859.78	7,968.75	8,000.41	8,267.30	8,186.65	8,214.77	8,244.40	8,363.08	8,399.49	8,463.78
N ₂ O emissions with N ₂ O from LULUCF	8,036.12	8,211.11	8,318.08	8,336.69	8,577.65	8,485.51	8,495.85	8,501.19	8,607.59	8,665.57	8,735.10
HFCs	1,100.81	1,177.84	1,262.35	1,311.05	1,335.79	1,386.17	1,419.55	1,465.97	1,479.03	1,481.00	1,480.29
PFCs	47.56	35.15	47.46	48.13	73.41	58.59	48.69	60.46	72.40	89.13	87.92
Unspecified mix of HFCs and PFCs	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
SF ₆	22.84	18.94	20.90	18.18	16.80	16.46	17.36	14.79	14.71	15.98	16.69
NF ₃	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
Total (without LULUCF)	78,426.32	78,290.28	80,482.57	79,805.66	80,618.40	80,450.06	78,391.48	79,889.59	80,079.58	81,617.06	78,778.37
Total (with LULUCF)	49,100.05	48,660.08	53,757.43	53,510.39	53,969.03	53,839.90	52,153.51	55,185.79	55,777.28	58,582.14	55,465.11
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas emissions	2010 (kt CO ₂ - equivalent)	2011 (kt CO ₂ - equivalent)	2012 (kt CO ₂ - equivalent)	2013 (kt CO ₂ - equivalent)	2014 (kt CO ₂ - equivalent)	2015 (kt CO ₂ - equivalent)	2016 (kt CO ₂ - equivalent)	2017 (kt CO ₂ - equivalent)	2018 (kt CO ₂ - equivalent)	2019 (kt CO ₂ - equivalent)	2020 (kt CO ₂ - equivalent)
1. Energy	32,247.49	31,571.43	32,953.12	32,089.37	32,159.28	32,405.70	31,001.33	32,452.95	32,524.23	33,920.37	31,461.42
2. Industrial processes and product use	4,591.13	4,627.39	4,703.19	4,836.35	5,006.98	5,137.32	4,883.07	4,928.44	4,825.07	4,861.05	4,618.35
3. Agriculture	37,711.50	38,362.27	39,203.36	39,306.76	39,922.77	39,415.79	39,042.96	39,082.39	39,368.29	39,518.64	39,425.54

Greenhouse gas emissions	2010 (kt CO ₂ -equivalent)	2011 (kt CO ₂ -equivalent)	2012 (kt CO ₂ -equivalent)	2013 (kt CO ₂ -equivalent)	2014 (kt CO ₂ -equivalent)	2015 (kt CO ₂ -equivalent)	2016 (kt CO ₂ -equivalent)	2017 (kt CO ₂ -equivalent)	2018 (kt CO ₂ -equivalent)	2019 (kt CO ₂ -equivalent)	2020 (kt CO ₂ -equivalent)
4. Land Use, Land-Use Change and Forestry	-29,326.27	-29,630.20	-26,725.14	-26,295.26	-26,649.37	-26,610.16	-26,237.97	-24,703.80	-24,302.31	-23,034.92	-23,313.25
5. Waste	3,871.67	3,724.65	3,618.63	3,569.66	3,525.88	3,487.83	3,460.68	3,422.28	3,358.36	3,312.70	3,268.87
6. Other	4.52	4.54	4.27	3.52	3.48	3.42	3.45	3.53	3.64	4.30	4.18
Total (including LULUCF)	49,100.05	48,660.08	53,757.43	53,510.39	53,969.03	53,839.90	52,153.51	55,185.79	55,777.28	58,582.14	55,465.11

Note: CO₂ = carbon dioxide; CH₄ = methane; HFCs = hydrofluorocarbons; kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land, land-use change and forestry; N₂O = nitrous oxide; NA = not applicable; NF₃ = nitrogen trifluoride; NO = not occurring; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride.

Table A.2: Emissions trends (CO₂) (CTF Table 1(a)) (three parts)

Table A.2: Emissions trends (CO₂) (CTF Table 1(a)) (part 1 of 3)

Greenhouse gas source and sink categories	Base year 1990 (kt)	1991 (kt)	1992 (kt)	1993 (kt)	1994 (kt)	1995 (kt)	1996 (kt)	1997 (kt)	1998 (kt)
1. Energy	22,486.66	22,992.05	24,857.07	24,310.71	24,535.02	24,469.65	25,804.65	27,837.20	26,271.64
A. Fuel combustion (sectoral approach)	22,026.93	22,437.43	24,316.72	23,792.14	23,994.18	23,969.28	25,138.05	27,123.36	25,566.61
1. Energy industries	5,979.07	6,089.88	7,577.04	6,639.27	5,512.76	4,775.29	5,524.41	7,125.46	5,514.30
2. Manufacturing industries and construction	4,676.53	5,160.36	5,012.94	5,282.32	5,599.81	5,693.44	6,043.97	6,132.86	5,871.92
3. Transport	7,936.45	7,915.24	8,271.97	8,720.40	9,373.66	10,029.86	10,161.48	10,383.51	10,587.78
4. Other sectors	3,434.88	3,271.95	3,454.78	3,150.14	3,507.96	3,470.69	3,408.19	3,481.53	3,592.62
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	459.73	554.61	540.35	518.56	540.84	500.37	666.61	713.84	705.02
1. Solid fuels	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
2. Oil and natural gas and other emissions from energy production	459.73	554.61	540.35	518.56	540.84	500.37	666.61	713.84	705.02

Greenhouse gas source and sink categories	Base year 1990 (kt)	1991 (kt)	1992 (kt)	1993 (kt)	1994 (kt)	1995 (kt)	1996 (kt)	1997 (kt)	1998 (kt)
C. CO ₂ transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Industrial processes	2,519.96	2,659.49	2,757.60	2,847.57	2,725.62	2,813.83	2,826.09	2,732.19	2,792.19
A. Mineral industry	561.87	572.41	648.54	646.71	625.40	674.60	646.19	695.08	650.96
B. Chemical industry	175.40	189.82	181.80	179.40	196.23	171.54	190.79	190.39	195.43
C. Metal industry	1,757.51	1,872.16	1,901.17	1,994.16	1,874.88	1,936.83	1,957.86	1,814.77	1,913.27
D. Non-energy products from fuels and solvent use	25.17	25.10	26.10	27.30	29.12	30.87	31.25	31.95	32.54
E. Electronic industry									
F. Product uses as ODS substitutes									
G. Other product manufacture and use	NA	NA	NA	NA	NA	NA	NA	NA	NA
H. Other									
3. Agriculture	335.68	371.91	394.77	442.64	500.41	582.38	541.38	568.01	644.78
A. Enteric fermentation									
B. Manure management									
C. Rice cultivation									
D. Agricultural soils									
E. Prescribed burning of savannas									
F. Field burning of agricultural residues									
G. Liming	296.48	320.06	343.64	372.15	408.87	445.60	399.54	440.22	480.89
H. Urea application	39.19	51.84	51.13	70.49	91.54	136.78	141.84	127.79	163.89
I. Other carbon-containing fertilizers	NE	NE	NE	NE	NE	NE	NE	NE	NE
J. Other									
4. Land Use, Land-Use Change and Forestry	-21,624.05	-23,644.92	-23,430.62	-24,257.20	-24,080.90	-22,900.84	-22,467.27	-23,117.84	-23,791.09
A. Forest land	-20,299.82	-21,343.38	-20,968.13	-21,545.49	-21,189.00	-19,852.84	-19,550.85	-20,151.52	-22,243.66
B. Cropland	468.69	470.94	473.20	475.46	477.72	479.97	482.23	486.39	488.81

Greenhouse gas source and sink categories	Base year 1990 (kt)	1991 (kt)	1992 (kt)	1993 (kt)	1994 (kt)	1995 (kt)	1996 (kt)	1997 (kt)	1998 (kt)
C. Grassland	609.84	713.08	809.36	903.63	996.05	1,019.31	1,046.28	1,077.75	1,102.97
D. Wetlands	-10.47	-8.75	-10.65	-8.97	-6.34	-4.42	-6.50	-2.38	-2.11
E. Settlements	75.42	76.96	78.50	80.25	82.76	85.96	88.21	90.69	92.88
F. Other land	13.50	14.74	15.99	17.24	18.48	19.73	20.97	24.25	26.06
G. Harvested wood products	-2,481.21	-3,568.51	-3,828.89	-4,179.31	-4,460.58	-4,648.55	-4,547.61	-4,643.02	-3,256.04
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Waste	158.91	157.84	156.15	158.92	137.63	136.26	131.03	139.87	148.51
A. Solid waste disposal	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
B. Biological treatment of solid waste									
C. Incineration and open burning of waste	158.91	157.84	156.15	158.92	137.63	136.26	131.03	139.87	148.51
D. Waste water treatment and discharge									
E. Other									
6. Other (as specified in summary table A.1)	1.30	1.31	1.33	1.34	1.36	1.38	1.39	1.41	1.42

Table A.2: Emissions trends (CO₂) (CTF Table 1(a)) (part 2 of 3)

Greenhouse gas source and sink categories	1999 (kt)	2000 (kt)	2001 (kt)	2002 (kt)	2003 (kt)	2004 (kt)	2005 (kt)	2006 (kt)	2007 (kt)	2008 (kt)	2009 (kt)
1. Energy	27,619.96	28,381.57	30,350.58	30,390.50	31,961.87	31,571.68	33,029.43	33,098.46	31,920.63	33,295.23	30,522.36
A. Fuel combustion (sectoral approach)	27,003.80	27,788.31	29,737.66	29,803.51	31,350.65	30,708.36	32,120.18	32,139.58	30,899.30	32,053.05	29,155.62
1. Energy industries	6,743.71	6,385.09	7,871.10	7,088.55	8,408.32	8,015.66	10,055.84	9,942.64	8,295.52	9,565.39	7,342.61
2. Manufacturing industries and construction	5,729.20	6,248.83	6,621.50	6,880.90	6,325.45	5,798.39	4,988.20	5,038.67	5,478.82	5,471.96	5,166.17
3. Transport	10,868.59	11,410.88	11,473.86	11,925.66	12,453.65	12,742.48	12,817.90	12,944.51	13,053.26	13,073.80	12,887.11
4. Other sectors	3,662.30	3,743.51	3,771.20	3,908.39	4,163.23	4,151.83	4,258.23	4,213.76	4,071.70	3,941.90	3,759.73
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	616.16	593.26	612.92	586.99	611.22	863.32	909.25	958.88	1,021.33	1,242.18	1,366.74
1. Solid fuels	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
2. Oil and natural gas and other emissions from energy production	616.16	593.26	612.92	586.99	611.22	863.32	909.25	958.88	1,021.33	1,242.18	1,366.74
C. CO ₂ transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Industrial processes	2,944.29	2,922.48	2,986.90	2,984.81	3,152.96	3,131.49	3,208.64	3,180.88	3,376.87	3,158.99	3,022.38
A. Mineral industry	728.35	718.54	716.89	706.97	697.26	666.68	756.18	719.14	861.50	807.03	752.17
B. Chemical industry	196.71	198.26	206.31	213.07	201.42	194.29	229.12	243.05	249.96	265.66	261.66
C. Metal industry	1,985.89	1,970.95	2,028.69	2,028.55	2,216.67	2,232.09	2,184.66	2,179.63	2,226.05	2,046.67	1,969.13
D. Non-energy products from fuels and solvent use	33.33	34.74	35.01	36.23	37.60	38.43	38.67	39.06	39.36	39.64	39.43
E. Electronic industry											
F. Product uses as ODS substitutes											
G. Other product manufacture and use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H. Other											

Greenhouse gas source and sink categories	1999 (kt)	2000 (kt)	2001 (kt)	2002 (kt)	2003 (kt)	2004 (kt)	2005 (kt)	2006 (kt)	2007 (kt)	2008 (kt)	2009 (kt)
3. Agriculture	743.18	790.78	901.75	1,033.90	1,001.73	1,006.91	1,064.10	929.82	995.82	942.64	965.77
A. Enteric fermentation											
B. Manure management											
C. Rice cultivation											
D. Agricultural soils											
E. Prescribed burning of savannas											
F. Field burning of agricultural residues											
G. Liming	521.56	562.24	602.91	643.58	567.62	551.86	607.51	507.57	539.53	502.31	591.86
H. Urea application	221.62	228.54	298.84	390.32	434.11	455.04	456.60	422.26	456.29	440.33	373.91
I. Other carbon-containing fertilizers	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
J. Other											
4. Land Use, Land-Use Change and Forestry	-26,503.05	-27,414.99	-27,962.46	-26,550.45	-27,740.01	-27,670.91	-25,933.17	-23,871.92	-22,637.92	-29,863.95	-28,727.55
A. Forest land	-23,598.32	-25,961.60	-25,777.53	-23,302.28	-26,515.86	-29,911.62	-32,965.13	-33,460.20	-36,728.82	-30,634.70	-30,973.26
B. Cropland	491.24	506.77	508.71	506.73	522.26	548.46	597.33	623.13	668.83	493.87	476.43
C. Grassland	1,132.51	3,108.33	3,081.02	2,844.45	4,206.36	6,673.21	10,805.29	13,206.41	17,588.20	4,295.18	6,615.04
D. Wetlands	-3.02	3.03	3.19	4.17	-0.06	4.60	18.25	27.67	36.53	23.82	31.42
E. Settlements	94.16	109.22	109.61	107.82	123.73	150.74	203.37	230.52	279.18	99.87	109.04
F. Other land	27.87	46.27	47.91	46.24	56.18	73.04	96.45	113.42	143.35	75.98	129.22
G. Harvested wood products	-4,647.48	-5,227.01	-5,935.37	-6,757.59	-6,132.63	-5,209.33	-4,688.74	-4,612.88	-4,625.19	-4,217.97	-5,115.44
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Waste	156.72	149.73	138.52	131.60	123.42	124.25	119.46	118.53	114.88	109.91	107.65
A. Solid waste disposal	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
B. Biological treatment of solid waste											
C. Incineration and open burning of waste	156.72	149.73	138.52	131.60	123.42	124.25	119.46	118.53	114.88	109.91	107.65

Greenhouse gas source and sink categories	1999 (kt)	2000 (kt)	2001 (kt)	2002 (kt)	2003 (kt)	2004 (kt)	2005 (kt)	2006 (kt)	2007 (kt)	2008 (kt)	2009 (kt)
D. Waste water treatment and discharge											
E. Other											
6. Other (as specified in summary table A.1)	1.44	1.45	1.47	1.48	1.50	1.97	2.45	2.46	2.48	2.49	2.51

Table A.2: Emissions trends (CO₂) (CTF Table 1(a)) (part 3 of 3)

Greenhouse gas source and sink categories	2010 (kt)	2011 (kt)	2012 (kt)	2013 (kt)	2014 (kt)	2015 (kt)	2016 (kt)	2017 (kt)	2018 (kt)	2019 (kt)	2020 (kt)
1. Energy	30,419.70	29,843.88	31,525.50	30,851.17	30,939.01	31,151.21	29,838.40	31,410.15	31,508.64	32,922.21	30,549.36
A. Fuel combustion (sectoral approach)	28,913.87	28,383.95	30,246.58	29,758.62	29,714.90	29,803.32	28,686.14	30,321.02	30,516.48	32,009.30	29,768.63
1. Energy industries	6,693.13	6,271.34	7,725.32	6,412.07	5,474.20	5,289.75	4,192.90	4,780.07	4,644.22	5,437.40	5,561.66
2. Manufacturing industries and construction	5,420.40	5,209.58	5,604.21	6,268.62	6,970.91	6,729.44	6,730.58	6,774.10	6,819.92	7,432.13	6,595.24
3. Transport	13,145.47	13,137.15	12,820.73	12,899.39	13,163.62	13,634.17	13,739.72	14,658.43	14,985.90	14,517.60	13,078.68
4. Other sectors	3,654.86	3,765.89	4,096.33	4,178.55	4,106.16	4,149.96	4,022.95	4,108.42	4,066.44	4,622.16	4,533.05
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	1,505.82	1,459.93	1,278.92	1,092.55	1,224.11	1,347.89	1,152.26	1,089.13	992.16	912.91	780.73
1. Solid fuels	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
2. Oil and natural gas and other emissions from energy production	1,505.82	1,459.93	1,278.92	1,092.55	1,224.11	1,347.89	1,152.26	1,089.13	992.16	912.91	780.73
C. CO ₂ transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Industrial processes	3,319.00	3,294.41	3,254.92	3,319.36	3,396.54	3,509.69	3,213.60	3,213.88	3,085.45	3,085.52	2,863.67
A. Mineral industry	740.23	713.26	751.88	774.42	830.50	876.33	726.79	669.67	620.54	618.07	537.43
B. Chemical industry	265.10	281.55	275.21	260.53	253.57	282.35	191.34	193.09	167.78	183.30	154.38
C. Metal industry	2,273.23	2,258.88	2,187.58	2,243.77	2,270.77	2,307.74	2,251.47	2,304.45	2,249.34	2,236.11	2,127.78

Greenhouse gas source and sink categories	2010 (kt)	2011 (kt)	2012 (kt)	2013 (kt)	2014 (kt)	2015 (kt)	2016 (kt)	2017 (kt)	2018 (kt)	2019 (kt)	2020 (kt)
D. Non-energy products from fuels and solvent use	40.44	40.73	40.26	40.64	41.70	43.27	44.00	46.67	47.79	48.04	44.08
E. Electronic industry											
F. Product uses as ODS substitutes											
G. Other product manufacture and use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H. Other											
3. Agriculture	961.20	1,019.71	1,056.78	965.93	998.76	1,050.24	998.15	967.09	1,016.14	1,020.50	951.51
A. Enteric fermentation											
B. Manure management											
C. Rice cultivation											
D. Agricultural soils											
E. Prescribed burning of savannas											
F. Field burning of agricultural residues											
G. Liming	511.84	522.70	562.54	445.75	488.05	442.01	423.75	378.83	407.95	449.78	409.48
H. Urea application	449.36	497.00	494.24	520.18	510.71	608.23	574.39	588.26	608.19	570.72	542.03
I. Other carbon-containing fertilizers	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
J. Other											
4. Land Use, Land-Use Change and Forestry	-29,775.10	-30,046.17	-27,150.86	-26,707.14	-27,028.48	-26,986.32	-26,626.73	-25,052.32	-24,613.50	-23,384.74	-23,666.23
A. Forest land	-30,968.84	-29,616.70	-27,961.26	-28,714.20	-27,704.90	-27,275.84	-26,103.40	-22,181.94	-19,858.04	-19,335.04	-19,983.31
B. Cropland	474.96	469.25	453.40	510.28	449.36	408.76	412.01	386.70	382.99	379.27	375.55
C. Grassland	7,122.63	6,045.79	7,593.73	9,836.17	7,671.00	6,367.33	6,567.89	5,150.46	3,916.57	4,319.09	2,524.46
D. Wetlands	27.97	34.66	19.92	50.09	49.62	22.40	34.98	13.60	13.31	13.29	13.31
E. Settlements	111.46	123.64	119.74	111.70	123.43	122.08	144.69	123.52	123.07	127.78	124.05
F. Other land	158.47	216.36	204.07	188.24	172.75	242.70	213.86	129.88	132.15	148.71	114.28

Greenhouse gas source and sink categories	2010 (kt)	2011 (kt)	2012 (kt)	2013 (kt)	2014 (kt)	2015 (kt)	2016 (kt)	2017 (kt)	2018 (kt)	2019 (kt)	2020 (kt)
G. Harvested wood products	-6,701.76	-7,319.15	-7,580.45	-8,689.41	-7,789.74	-6,873.75	-7,896.76	-8,674.53	-9,323.54	-9,037.85	-6,834.58
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Waste	108.66	105.31	105.57	102.91	102.98	100.34	100.78	95.22	92.42	90.26	89.80
A. Solid waste disposal	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
B. Biological treatment of solid waste											
C. Incineration and open burning of waste	108.66	105.31	105.57	102.91	102.98	100.34	100.78	95.22	92.42	90.26	89.80
D. Waste water treatment and discharge											
E. Other											
6. Other (as specified in summary table A.1)	2.52	2.54	2.32	1.62	1.64	1.63	1.71	1.79	1.89	2.54	2.42

Note: CO₂ = carbon dioxide; kt = kilotonnes; NA = not applicable; NE = not estimated; NO = not occurring; ODS = ozone-depleting substance.

Table A.3: Emissions trends (CH₄) (CTF Table 1(b) (three parts))

Table A.3: Emissions trends (CH₄) (CTF Table 1(b) (part 1 of 3))

Greenhouse gas source and sink categories	Base year 1990 (kt)	1991 (kt)	1992 (kt)	1993 (kt)	1994 (kt)	1995 (kt)	1996 (kt)	1997 (kt)	1998 (kt)
1. Energy	46.86	46.20	45.37	48.41	51.51	45.21	55.67	55.35	54.73
A. Fuel combustion (sectoral approach)	8.09	7.65	7.34	7.17	7.35	7.34	7.17	6.96	6.78
1. Energy industries	0.10	0.10	0.13	0.11	0.09	0.08	0.09	0.12	0.09
2. Manufacturing industries and construction	1.17	1.17	1.19	1.25	1.28	1.29	1.28	1.11	1.04
3. Transport	3.17	3.07	3.00	2.92	2.87	2.82	2.70	2.62	2.51
4. Other sectors	3.66	3.31	3.02	2.89	3.11	3.14	3.10	3.12	3.13
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	38.77	38.55	38.03	41.24	44.16	37.87	48.50	48.38	47.95
1. Solid fuels	13.12	8.81	9.03	8.94	10.27	13.11	18.98	13.89	15.47
2. Oil and natural gas and other emissions from energy production	25.64	29.75	29.00	32.30	33.89	24.76	29.52	34.49	32.47
C. CO ₂ transport and storage									
2. Industrial processes	1.10	1.89	1.60	1.79	2.25	3.16	4.25	4.38	4.12
A. Mineral industry									
B. Chemical industry	1.10	1.89	1.60	1.79	2.25	3.16	4.25	4.38	4.12
C. Metal industry	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
D. Non-energy products from fuels and solvent use	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Electronic industry									
F. Product uses as ODS substitutes									
G. Other product manufacture and use	NA	NA	NA	NA	NA	NA	NA	NA	NA
H. Other									

Greenhouse gas source and sink categories	Base year 1990 (kt)	1991 (kt)	1992 (kt)	1993 (kt)	1994 (kt)	1995 (kt)	1996 (kt)	1997 (kt)	1998 (kt)
3. Agriculture	1,124.03	1,128.97	1,109.41	1,114.15	1,150.26	1,161.79	1,172.31	1,202.30	1,177.65
A. Enteric fermentation	1,094.01	1,098.49	1,078.75	1,082.83	1,117.34	1,127.96	1,137.25	1,165.94	1,141.74
B. Manure management	29.11	29.68	29.90	30.45	31.99	33.04	34.14	35.30	34.96
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Prescribed burning of savannas	IE	IE	IE	IE	IE	IE	IE	IE	IE
F. Field burning of agricultural residues	0.90	0.80	0.76	0.87	0.92	0.80	0.92	1.05	0.94
G. Liming									
H. Urea application									
I. Other carbon-containing fertilizers									
J. Other									
4. Land Use, Land-Use Change and Forestry	2.75	1.93	2.27	2.93	3.21	3.09	3.53	3.47	4.86
A. Forest land	0.71	0.52	0.50	0.53	0.73	0.73	0.89	1.18	0.77
B. Cropland	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE
C. Grassland	2.03	1.41	1.78	2.40	2.48	2.36	2.64	2.29	4.08
D. Wetlands	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
E. Settlements	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA
F. Other land	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA
G. Harvested wood products									
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Waste	146.83	151.19	155.30	159.25	155.57	159.25	162.95	164.95	164.38
A. Solid waste disposal	132.73	136.74	140.70	144.68	141.49	145.01	148.71	150.32	149.58
B. Biological treatment of solid waste	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.13	0.13
C. Incineration and open burning of waste	5.09	5.06	5.00	5.10	4.35	4.31	4.14	4.45	4.76

Greenhouse gas source and sink categories	Base year 1990 (kt)	1991 (kt)	1992 (kt)	1993 (kt)	1994 (kt)	1995 (kt)	1996 (kt)	1997 (kt)	1998 (kt)
D. Waste water treatment and discharge	8.90	9.27	9.49	9.35	9.61	9.81	9.97	10.05	9.91
E. Other									
6. Other (as specified in summary table A.1)	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Table A.3: Emissions trends (CH₄) (CTF Table 1(b) (part 2 of 3))

Greenhouse gas source and sink categories	1999 (kt)	2000 (kt)	2001 (kt)	2002 (kt)	2003 (kt)	2004 (kt)	2005 (kt)	2006 (kt)	2007 (kt)	2008 (kt)	2009 (kt)
1. Energy	55.05	53.45	55.39	51.34	44.67	45.45	50.69	64.07	55.40	46.08	50.38
A. Fuel combustion (sectoral approach)	6.69	6.68	6.58	6.56	6.59	6.52	6.60	6.63	6.38	6.20	5.84
1. Energy industries	0.11	0.11	0.13	0.12	0.13	0.12	0.14	0.14	0.13	0.14	0.11
2. Manufacturing industries and construction	1.12	1.19	1.24	1.30	1.32	1.33	1.29	1.31	1.33	1.26	1.14
3. Transport	2.41	2.28	2.18	2.12	2.04	1.96	1.84	1.71	1.64	1.52	1.44
4. Other sectors	3.05	3.10	3.03	3.02	3.09	3.12	3.32	3.47	3.28	3.29	3.15
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	48.36	46.77	48.81	44.78	38.08	38.94	44.08	57.44	49.02	39.88	44.54
1. Solid fuels	17.14	16.72	17.08	16.98	15.98	15.00	15.87	20.19	12.93	16.29	19.52
2. Oil and natural gas and other emissions from energy production	31.22	30.05	31.73	27.80	22.11	23.93	28.21	37.24	36.08	23.59	25.02
C. CO ₂ transport and storage											
2. Industrial processes	4.74	5.54	4.90	5.25	2.23	2.50	0.79	0.93	1.00	1.31	1.89
A. Mineral industry											
B. Chemical industry	4.74	5.54	4.90	5.25	2.23	2.50	0.79	0.93	1.00	1.31	1.89
C. Metal industry	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
D. Non-energy products from fuels and solvent use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories	1999 (kt)	2000 (kt)	2001 (kt)	2002 (kt)	2003 (kt)	2004 (kt)	2005 (kt)	2006 (kt)	2007 (kt)	2008 (kt)	2009 (kt)
E. Electronic industry											
F. Product uses as ODS substitutes											
G. Other product manufacture and use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H. Other											
3. Agriculture	1,180.30	1,212.76	1,226.91	1,218.02	1,234.38	1,235.03	1,244.05	1,251.47	1,219.22	1,174.42	1,180.87
A. Enteric fermentation	1,144.58	1,175.14	1,187.55	1,177.89	1,192.83	1,192.84	1,201.34	1,207.76	1,174.99	1,129.56	1,133.28
B. Manure management	34.77	36.69	38.32	39.11	40.57	41.46	41.84	42.89	43.20	44.01	46.76
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Prescribed burning of savannas	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
F. Field burning of agricultural residues	0.94	0.94	1.04	1.03	0.98	0.73	0.88	0.83	1.03	0.85	0.84
G. Liming											
H. Urea application											
I. Other carbon-containing fertilizers											
J. Other											
4. Land Use, Land-Use Change and Forestry	3.18	2.80	2.98	3.07	3.28	3.02	4.44	4.54	6.00	3.08	3.92
A. Forest land	0.50	0.58	0.52	0.58	0.47	0.45	0.43	0.48	0.78	0.59	0.82
B. Cropland	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE
C. Grassland	2.68	2.22	2.45	2.49	2.81	2.57	4.00	4.06	5.22	2.49	3.10
D. Wetlands	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
E. Settlements	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA
F. Other land	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA
G. Harvested wood products											
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories	1999 (kt)	2000 (kt)	2001 (kt)	2002 (kt)	2003 (kt)	2004 (kt)	2005 (kt)	2006 (kt)	2007 (kt)	2008 (kt)	2009 (kt)
5. Waste	164.95	166.23	167.54	168.50	165.07	165.55	165.31	157.46	156.08	152.90	147.67
A. Solid waste disposal	150.37	151.88	153.55	154.90	151.62	152.01	151.95	144.23	142.85	139.76	134.69
B. Biological treatment of solid waste	0.13	0.13	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.20
C. Incineration and open burning of waste	5.07	4.85	4.63	4.40	4.14	4.17	4.04	4.05	3.97	3.80	3.72
D. Waste water treatment and discharge	9.38	9.36	9.23	9.06	9.16	9.22	9.18	9.03	9.11	9.19	9.05
E. Other											
6. Other (as specified in summary table A.1)	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07

Table A.3: Emissions trends (CH₄) (CTF Table 1(b) (part 3 of 3))

Greenhouse gas source and sink categories	2010 (kt)	2011 (kt)	2012 (kt)	2013 (kt)	2014 (kt)	2015 (kt)	2016 (kt)	2017 (kt)	2018 (kt)	2019 (kt)	2020 (kt)
1. Energy	61.23	57.36	45.29	37.89	37.61	39.11	35.64	31.59	30.53	29.45	27.66
A. Fuel combustion (sectoral approach)	6.07	6.06	6.38	6.22	5.66	5.76	5.42	5.61	5.34	5.35	4.99
1. Energy industries	0.11	0.10	0.12	0.10	0.09	0.09	0.07	0.08	0.08	0.09	0.09
2. Manufacturing industries and construction	1.24	1.22	1.24	1.24	1.25	1.28	1.28	1.24	1.24	1.23	1.09
3. Transport	1.37	1.29	1.22	1.19	1.15	1.11	1.07	0.90	0.83	0.77	0.62
4. Other sectors	3.35	3.46	3.81	3.69	3.17	3.29	3.00	3.39	3.20	3.26	3.19
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	55.16	51.30	38.91	31.67	31.95	33.34	30.21	25.98	25.18	24.10	22.67
1. Solid fuels	23.65	16.52	11.52	10.83	9.01	7.61	6.96	2.54	2.81	2.64	2.46
2. Oil and natural gas and other emissions from energy production	31.51	34.78	27.39	20.84	22.94	25.73	23.25	23.44	22.37	21.46	20.21
C. CO ₂ transport and storage											

Greenhouse gas source and sink categories	2010 (kt)	2011 (kt)	2012 (kt)	2013 (kt)	2014 (kt)	2015 (kt)	2016 (kt)	2017 (kt)	2018 (kt)	2019 (kt)	2020 (kt)
2. Industrial processes	1.91	1.92	2.55	3.27	5.06	4.27	5.01	4.48	3.69	4.29	3.85
A. Mineral industry											
B. Chemical industry	1.91	1.92	2.55	3.27	5.06	4.27	5.01	4.48	3.69	4.29	3.85
C. Metal industry	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
D. Non-energy products from fuels and solvent use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Electronic industry											
F. Product uses as ODS substitutes											
G. Other product manufacture and use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H. Other											
3. Agriculture	1,182.08	1,198.51	1,226.50	1,233.12	1,245.51	1,226.51	1,212.53	1,213.68	1,219.31	1,224.30	1,218.88
A. Enteric fermentation	1,131.59	1,144.55	1,167.90	1,170.50	1,179.24	1,160.90	1,147.10	1,148.26	1,153.69	1,158.60	1,153.26
B. Manure management	49.53	53.31	57.56	61.54	65.37	65.00	64.63	64.65	64.99	64.89	64.82
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Prescribed burning of savannas	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
F. Field burning of agricultural residues	0.96	0.65	1.04	1.08	0.90	0.61	0.80	0.77	0.63	0.80	0.80
G. Liming											
H. Urea application											
I. Other carbon-containing fertilizers											
J. Other											
4. Land Use, Land-Use Change and Forestry	3.70	2.59	3.06	3.02	2.75	3.09	4.31	3.67	2.67	3.35	3.27
A. Forest land	0.67	0.57	0.56	0.44	0.54	1.27	1.08	0.55	0.67	2.19	2.37
B. Cropland	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE	NE, IE
C. Grassland	3.02	2.01	2.49	2.59	2.21	1.82	3.23	3.12	2.00	1.16	0.90

Greenhouse gas source and sink categories	2010 (kt)	2011 (kt)	2012 (kt)	2013 (kt)	2014 (kt)	2015 (kt)	2016 (kt)	2017 (kt)	2018 (kt)	2019 (kt)	2020 (kt)
D. Wetlands	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NO, NE	NO, NE	NO, NE	NO, NE	NO, NE
E. Settlements	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA
F. Other land	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA	NE, NA
G. Harvested wood products											
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Waste	145.28	139.46	135.11	133.13	131.21	129.62	128.30	126.83	124.24	122.32	120.48
A. Solid waste disposal	132.18	126.30	121.85	119.73	117.56	115.70	114.11	112.50	109.71	107.55	105.51
B. Biological treatment of solid waste	0.28	0.40	0.50	0.62	0.75	0.90	1.08	1.24	1.36	1.52	1.60
C. Incineration and open burning of waste	3.76	3.64	3.65	3.55	3.56	3.46	3.48	3.29	3.19	3.11	3.10
D. Waste water treatment and discharge	9.06	9.12	9.12	9.23	9.35	9.56	9.63	9.81	9.99	10.14	10.28
E. Other											
6. Other (as specified in summary table A.1)	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06

Note: CO₂ = carbon dioxide; CH₄ = methane; IE = included elsewhere; kt = kilotonnes; NA = not applicable; NE = not estimated; NO = not occurring; ODS = ozone-depleting substances.

Table A.4: Emissions trends (N₂O) (CTF Table 1(c)) (three parts)

Table A.4: Emissions trends (N₂O) (CTF Table 1(c)) (part 1 of 3)

Greenhouse gas source and sink categories	Base year 1990 (kt)	1991 (kt)	1992 (kt)	1993 (kt)	1994 (kt)	1995 (kt)	1996 (kt)	1997 (kt)	1998 (kt)
1. Energy	0.74	0.74	0.80	0.81	0.87	0.89	0.89	0.92	0.91
A. Fuel combustion (sectoral approach)	0.74	0.74	0.80	0.81	0.87	0.89	0.89	0.92	0.91
1. Energy industries	0.02	0.01	0.03	0.02	0.02	0.02	0.02	0.03	0.02
2. Manufacturing industries and construction	0.17	0.17	0.18	0.19	0.19	0.19	0.19	0.18	0.17
3. Transport	0.37	0.39	0.41	0.43	0.46	0.49	0.50	0.52	0.54
4. Other sectors	0.17	0.17	0.18	0.17	0.20	0.19	0.18	0.18	0.19
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. CO ₂ transport and storage									
2. Industrial processes	0.34	0.33	0.31	0.29	0.28	0.27	0.25	0.24	0.23
A. Mineral industry									
B. Chemical industry	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
C. Metal industry									
D. Non-energy products from fuels and solvent use	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Electronic industry									
F. Product uses as ODS substitutes									
G. Other product manufacture and use	0.34	0.33	0.31	0.29	0.28	0.27	0.25	0.24	0.23

Greenhouse gas source and sink categories	Base year 1990 (kt)	1991 (kt)	1992 (kt)	1993 (kt)	1994 (kt)	1995 (kt)	1996 (kt)	1997 (kt)	1998 (kt)
H. Other									
3. Agriculture	17.97	18.21	18.26	18.99	19.72	20.49	20.77	21.03	20.81
A. Enteric fermentation									
B. Manure management	0.17	0.18	0.18	0.18	0.19	0.20	0.21	0.22	0.22
C. Rice cultivation									
D. Agricultural soils	17.79	18.02	18.06	18.79	19.51	20.28	20.54	20.80	20.58
E. Prescribed burning of savannas	IE	IE	IE	IE	IE	IE	IE	IE	IE
F. Field burning of agricultural residues	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02
G. Liming									
H. Urea application									
I. Other carbon-containing fertilizers									
J. Other									
4. Land Use, Land-Use Change and Forestry	1.09	1.07	1.11	1.15	1.23	1.27	1.32	1.37	1.38
A. Forest land	0.72	0.72	0.76	0.81	0.90	0.93	0.98	1.03	1.02
B. Cropland	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
C. Grassland	0.21	0.19	0.18	0.17	0.15	0.15	0.15	0.14	0.16
D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F. Other land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. Harvested wood products									
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories	Base year 1990 (kt)	1991 (kt)	1992 (kt)	1993 (kt)	1994 (kt)	1995 (kt)	1996 (kt)	1997 (kt)	1998 (kt)
5. Waste	0.38	0.39	0.39	0.40	0.39	0.39	0.39	0.40	0.42
A. Solid waste disposal									
B. Biological treatment of solid waste	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C. Incineration and open burning of waste	0.10	0.10	0.10	0.10	0.09	0.08	0.08	0.09	0.09
D. Waste water treatment and discharge	0.28	0.28	0.29	0.29	0.30	0.30	0.31	0.31	0.32
E. Other									
6. Other (as specified in summary table A.1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A.4: Emissions trends (N₂O) (CTF Table 1(c)) (part 2 of 3)

Greenhouse gas source and sink categories	1999 (kt)	2000 (kt)	2001 (kt)	2002 (kt)	2003 (kt)	2004 (kt)	2005 (kt)	2006 (kt)	2007 (kt)	2008 (kt)	2009 (kt)
1. Energy	0.96	1.01	1.02	1.06	1.12	1.17	1.19	1.17	1.12	1.10	1.04
A. Fuel combustion (sectoral approach)	0.96	1.01	1.02	1.06	1.12	1.17	1.19	1.17	1.12	1.10	1.04
1. Energy industries	0.03	0.02	0.03	0.03	0.06	0.07	0.09	0.08	0.05	0.07	0.05
2. Manufacturing industries and construction	0.18	0.19	0.20	0.21	0.21	0.22	0.22	0.22	0.22	0.21	0.20
3. Transport	0.56	0.61	0.60	0.62	0.65	0.67	0.67	0.65	0.64	0.61	0.60
4. Other sectors	0.19	0.19	0.19	0.20	0.21	0.21	0.21	0.21	0.21	0.20	0.20
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. CO ₂ transport and storage											

Greenhouse gas source and sink categories	1999 (kt)	2000 (kt)	2001 (kt)	2002 (kt)	2003 (kt)	2004 (kt)	2005 (kt)	2006 (kt)	2007 (kt)	2008 (kt)	2009 (kt)
2. Industrial processes	0.22	0.21	0.20	0.19	0.18	0.16	0.15	0.14	0.15	0.18	0.18
A. Mineral industry											
B. Chemical industry	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
C. Metal industry											
D. Non-energy products from fuels and solvent use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Electronic industry											
F. Product uses as ODS substitutes											
G. Other product manufacture and use	0.22	0.21	0.20	0.19	0.18	0.16	0.15	0.14	0.15	0.18	0.18
H. Other											
3. Agriculture	20.86	21.83	23.06	23.38	24.21	24.62	24.85	24.20	23.60	23.59	23.65
A. Enteric fermentation											
B. Manure management	0.21	0.22	0.23	0.23	0.25	0.26	0.26	0.26	0.27	0.27	0.29
C. Rice cultivation											
D. Agricultural soils	20.64	21.59	22.81	23.13	23.94	24.35	24.58	23.92	23.31	23.30	23.35
E. Prescribed burning of savannas	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
F. Field burning of agricultural residues	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.01
G. Liming											
H. Urea application											
I. Other carbon-containing fertilizers											
J. Other											
4. Land Use, Land-Use Change and Forestry	1.36	1.38	1.37	1.36	1.34	1.33	1.33	1.33	1.38	1.22	1.22
A. Forest land	1.01	1.02	1.01	1.00	0.98	0.95	0.92	0.90	0.89	0.87	0.87
B. Cropland	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05
C. Grassland	0.14	0.16	0.16	0.15	0.17	0.18	0.22	0.24	0.30	0.17	0.17

Greenhouse gas source and sink categories	1999 (kt)	2000 (kt)	2001 (kt)	2002 (kt)	2003 (kt)	2004 (kt)	2005 (kt)	2006 (kt)	2007 (kt)	2008 (kt)	2009 (kt)
D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F. Other land	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
G. Harvested wood products											
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Waste	0.43	0.43	0.44	0.42	0.42	0.42	0.42	0.43	0.43	0.43	0.43
A. Solid waste disposal											
B. Biological treatment of solid waste	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C. Incineration and open burning of waste	0.10	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.07	0.07
D. Waste water treatment and discharge	0.32	0.33	0.34	0.33	0.33	0.33	0.34	0.34	0.34	0.34	0.35
E. Other											
6. Other (as specified in summary table A.1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A.4: Emissions trends (N₂O) (CTF Table 1(c)) (part 3 of 3)

Greenhouse gas source and sink categories	2010 (kt)	2011 (kt)	2012 (kt)	2013 (kt)	2014 (kt)	2015 (kt)	2016 (kt)	2017 (kt)	2018 (kt)	2019 (kt)	2020 (kt)
1. Energy	1.00	0.99	0.99	0.98	0.94	0.93	0.91	0.85	0.85	0.88	0.74
A. Fuel combustion (sectoral approach)	1.00	0.98	0.99	0.98	0.94	0.93	0.91	0.85	0.85	0.88	0.74
1. Energy industries	0.03	0.03	0.05	0.03	0.03	0.03	0.01	0.02	0.02	0.03	0.04
2. Manufacturing industries and construction	0.21	0.21	0.21	0.21	0.21	0.21	0.22	0.21	0.22	0.22	0.20
3. Transport	0.57	0.55	0.52	0.51	0.50	0.48	0.47	0.41	0.40	0.40	0.28
4. Other sectors	0.19	0.20	0.21	0.22	0.21	0.21	0.21	0.21	0.21	0.23	0.23
5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories	2010 (kt)	2011 (kt)	2012 (kt)	2013 (kt)	2014 (kt)	2015 (kt)	2016 (kt)	2017 (kt)	2018 (kt)	2019 (kt)	2020 (kt)
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Oil and natural gas and other emissions from energy production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. CO ₂ transport and storage											
2. Industrial processes	0.18	0.18	0.18	0.20	0.20	0.20	0.20	0.21	0.27	0.28	0.25
A. Mineral industry											
B. Chemical industry	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
C. Metal industry											
D. Non-energy products from fuels and solvent use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Electronic industry											
F. Product uses as ODS substitutes											
G. Other product manufacture and use	0.18	0.18	0.18	0.20	0.20	0.20	0.20	0.21	0.27	0.28	0.25
H. Other											
3. Agriculture	24.16	24.76	25.11	25.21	26.13	25.85	25.94	26.09	26.41	26.48	26.85
A. Enteric fermentation											
B. Manure management	0.31	0.33	0.36	0.38	0.39	0.39	0.39	0.39	0.40	0.39	0.39
C. Rice cultivation											
D. Agricultural soils	23.83	24.42	24.74	24.81	25.72	25.45	25.54	25.68	26.00	26.07	26.45
E. Prescribed burning of savannas	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
F. Field burning of agricultural residues	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
G. Liming											

Greenhouse gas source and sink categories	2010 (kt)	2011 (kt)	2012 (kt)	2013 (kt)	2014 (kt)	2015 (kt)	2016 (kt)	2017 (kt)	2018 (kt)	2019 (kt)	2020 (kt)
H. Urea application											
I. Other carbon-containing fertilizers											
J. Other											
4. Land Use, Land-Use Change and Forestry	1.20	1.18	1.17	1.13	1.04	1.00	0.94	0.86	0.82	0.89	0.91
A. Forest land	0.86	0.86	0.84	0.80	0.75	0.75	0.70	0.64	0.63	0.71	0.74
B. Cropland	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02
C. Grassland	0.16	0.15	0.17	0.17	0.15	0.12	0.13	0.11	0.09	0.08	0.08
D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F. Other land	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
G. Harvested wood products											
H. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Waste	0.44	0.45	0.45	0.46	0.48	0.49	0.51	0.52	0.54	0.55	0.56
A. Solid waste disposal											
B. Biological treatment of solid waste	0.02	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.08	0.09	0.10
C. Incineration and open burning of waste	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06
D. Waste water treatment and discharge	0.35	0.35	0.35	0.36	0.36	0.37	0.38	0.39	0.39	0.40	0.40
E. Other											
6. Other (as specified in summary table A.1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: CO₂ = carbon dioxide; CH₄ = methane; IE = included elsewhere; kt = kilotonnes; N₂O = nitrous oxide; NA = not applicable; NO = not occurring; ODS = ozone-depleting substances.

Table A.5: Emissions trends (HFCs, PFCs and SF₆) (CTF Table 1(d)) (three parts)

Table A.5: Emissions trends (HFCs, PFCs and SF₆) (CTF Table 1(d)) (part 1 of 3)

Greenhouse gas source and sink categories	Base year 1990 (kt)	1991 (kt)	1992 (kt)	1993 (kt)	1994 (kt)	1995 (kt)	1996 (kt)	1997 (kt)	1998 (kt)
Emissions of HFCs and PFCs (kt CO₂-equivalent)	909.95	903.79	462.17	210.51	194.08	177.80	333.34	314.53	248.90
Emissions of HFCs (kt CO₂-equivalent)	NO, NA	NO, NA	0.29	0.36	7.91	24.52	54.36	113.42	97.52
HFC-23	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
HFC-32	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0.00	0.00	0.00	0.00
HFC-41	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-43-10mee	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
HFC-125	NO, NA	NO, NA	NO, NA	NO, NA	0.00	0.00	0.00	0.01	0.00
HFC-134	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-134a	NO, NA	NO, NA	0.00	0.00	0.00	0.01	0.02	0.06	0.04
HFC-143	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-143a	NO, NA	NO, NA	NO, NA	NO, NA	0.00	0.00	0.00	0.00	0.01
HFC-152	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-152a	NO, NA	NO, NA	NO, NA	NO, NA	0.00	0.00	0.00	0.00	0.00
HFC-161	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-227ea	NO, NA	NO, NA	NO, NA	NO, NA	0.00	0.00	0.00	0.00	0.00
HFC-236cb	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-236ea	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-236fa	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-245ca	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-245fa	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
HFC-365mfc	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA

Greenhouse gas source and sink categories	Base year 1990 (kt)	1991 (kt)	1992 (kt)	1993 (kt)	1994 (kt)	1995 (kt)	1996 (kt)	1997 (kt)	1998 (kt)
Unspecified mix of HFCs (kt CO ₂ -equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions of PFCs (kt CO₂-equivalent)	909.95	903.79	461.88	210.16	186.18	153.28	278.98	201.11	151.38
CF ₄	0.11	0.10	0.05	0.02	0.02	0.02	0.03	0.02	0.01
C ₂ F ₆	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
C ₃ F ₈	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0.00	0.00	0.00	0.01
C ₄ F ₁₀	NA	NA	NA	NA	NA	NA	NA	NA	NA
c-C ₄ F ₈	NA	NA	NA	NA	NA	NA	NA	NA	NA
C ₅ F ₁₂	NA	NA	NA	NA	NA	NA	NA	NA	NA
C ₆ F ₁₄	NA	NA	NA	NA	NA	NA	NA	NA	NA
C10F18	NA	NA	NA	NA	NA	NA	NA	NA	NA
c-C3F6	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of PFCs (kt CO ₂ -equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs (kt CO₂-equivalent)	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
Emissions of SF₆ (kt CO₂-equivalent)	19.97	20.86	21.91	22.69	23.43	24.42	24.65	25.58	24.86
SF ₆	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emissions of NF₃ (kt CO₂-equivalent)	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
NF ₃	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA

Table A.5: Emissions trends (HFCs, PFCs and SF₆) (CTF Table 1(d)) (part 2 of 3)

Greenhouse gas source and sink categories	1999 (kt)	2000 (kt)	2001 (kt)	2002 (kt)	2003 (kt)	2004 (kt)	2005 (kt)	2006 (kt)	2007 (kt)	2008 (kt)	2009 (kt)
Emissions of HFCs and PFCs (kt CO₂-equivalent)	260.95	301.26	370.71	485.85	630.66	681.69	763.39	905.41	965.49	1,058.77	1,129.46
Emissions of HFCs (kt CO₂-equivalent)	192.28	233.65	300.10	401.36	503.85	582.58	694.01	798.68	917.09	1,013.31	1,075.61
HFC-23	NO, NA	NO, NA	NO, NA	0.00	0.00	NO, NA	NO, NA	0.00	NO, NA	NO, NA	NO, NA
HFC-32	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02
HFC-41	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-43-10mee	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
HFC-125	0.00	0.01	0.02	0.02	0.03	0.04	0.05	0.05	0.07	0.08	0.09
HFC-134	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-134a	0.09	0.11	0.13	0.17	0.20	0.21	0.24	0.26	0.26	0.29	0.27
HFC-143	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-143a	0.01	0.01	0.01	0.02	0.03	0.03	0.04	0.05	0.06	0.07	0.08
HFC-152	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-152a	0.00	NO, NA	0.00	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
HFC-161	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-227ea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236cb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-236ea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-236fa	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-245ca	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-245fa	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0.00	0.00	0.00	0.00	0.00	0.00
HFC-365mfc	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0.00	0.00	0.00	0.00	0.00	0.00
Unspecified mix of HFCs (kt CO ₂ -equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories	1999 (kt)	2000 (kt)	2001 (kt)	2002 (kt)	2003 (kt)	2004 (kt)	2005 (kt)	2006 (kt)	2007 (kt)	2008 (kt)	2009 (kt)
Emissions of PFCs (kt CO₂-equivalent)	68.67	67.61	70.61	84.48	126.81	99.12	69.38	106.73	48.41	45.47	53.86
CF ₄	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
C ₂ F ₆	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C ₃ F ₈	NO, NA	NO, NA	NO, NA	0.00	0.00	0.00	NO, NA	0.00	0.00	0.00	0.00
C ₄ F ₁₀	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
c-C ₄ F ₈	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C ₅ F ₁₂	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C ₆ F ₁₄	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C10F18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
c-C3F6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of PFCs (kt CO ₂ -equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs (kt CO₂-equivalent)	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
Emissions of SF₆ (kt CO₂-equivalent)	24.56	19.56	20.04	23.32	25.19	28.92	25.41	21.05	19.87	19.34	22.54
SF ₆	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emissions of NF₃ (kt CO₂-equivalent)	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
NF ₃	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA

Table A.5: Emissions trends (HFCs, PFCs and SF₆) (CTF Table 1(d)) (part 3 of 3)

Greenhouse gas source and sink categories	2010 (kt)	2011 (kt)	2012 (kt)	2013 (kt)	2014 (kt)	2015 (kt)	2016 (kt)	2017 (kt)	2018 (kt)	2019 (kt)	2020 (kt)
Emissions of HFCs and PFCs (kt CO₂-equivalent)	1,148.37	1,212.99	1,309.81	1,359.18	1,409.20	1,444.76	1,468.24	1,526.43	1,551.43	1,570.13	1,568.21
Emissions of HFCs (kt CO₂-equivalent)	1,100.81	1,177.84	1,262.35	1,311.05	1,335.79	1,386.17	1,419.55	1,465.97	1,479.03	1,481.00	1,480.29
HFC-23	0.00	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0.00	0.00	NO, NA	NO, NA
HFC-32	0.02	0.04	0.04	0.04	0.04	0.05	0.07	0.08	0.10	0.12	0.10
HFC-41	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-43-10mee	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0.00
HFC-125	0.09	0.10	0.11	0.12	0.11	0.13	0.15	0.15	0.16	0.17	0.16
HFC-134	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-134a	0.31	0.31	0.34	0.34	0.36	0.36	0.33	0.34	0.37	0.34	0.36
HFC-143	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-143a	0.07	0.07	0.08	0.08	0.09	0.08	0.08	0.08	0.07	0.07	0.07
HFC-152	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-152a	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0.00	0.00	0.00	0.00	0.00	0.00
HFC-161	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-227ea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236cb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-236ea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-236fa	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-245ca	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-245fa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-365mfc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unspecified mix of HFCs (kt CO ₂ -equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories	2010 (kt)	2011 (kt)	2012 (kt)	2013 (kt)	2014 (kt)	2015 (kt)	2016 (kt)	2017 (kt)	2018 (kt)	2019 (kt)	2020 (kt)
Emissions of PFCs (kt CO₂-equivalent)	47.56	35.15	47.46	48.13	73.41	58.59	48.69	60.46	72.40	89.13	87.92
CF ₄	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C ₂ F ₆	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C ₃ F ₈	NO, NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C ₄ F ₁₀	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
c-C ₄ F ₈	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C ₅ F ₁₂	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C ₆ F ₁₄	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C10F18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
c-C3F6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of PFCs (kt CO ₂ -equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs (kt CO₂-equivalent)	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
Emissions of SF₆ (kt CO₂-equivalent)	22.84	18.94	20.90	18.18	16.80	16.46	17.36	14.79	14.71	15.98	16.69
SF ₆	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emissions of NF₃ (kt CO₂-equivalent)	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
NF ₃	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA

Note: HFCs = hydrofluorocarbons; kt = kilotonnes; kt CO₂-equivalent = kilotonnes of carbon dioxide equivalent; NA = not applicable; NF₃ = nitrogen trifluoride; NO = not occurring; PFCs = perfluorocarbons; SF₆ = sulphur hexafluoride.

Appendix B: Supplementary information under Article 7.2 of the Kyoto Protocol

Aotearoa New Zealand's national inventory system: Supplementary information under Article 7.2 of the Kyoto Protocol

Overview

The Climate Change Response Act 2002 was enacted to enable Aotearoa New Zealand to meet its international obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. According to the UNFCCC definition, a national system includes all institutional, legal and procedural arrangements made within a Party included in Annex I for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and for reporting and archiving inventory information. Essentially, a Party's national inventory system is the basis on which a country inventories its greenhouse gas emissions.

A prime ministerial directive for the administration of the Climate Change Response Act 2002 names the Ministry for the Environment (MfE) as New Zealand's 'inventory agency'. MfE is responsible for the overall development, compilation and submission of the national greenhouse gas inventory (the inventory) to the UNFCCC secretariat.

National entity contact

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Inventory roles and responsibilities

New Zealand uses a hybrid (both centralised and distributed) approach to managing the inventory programme. Management and coordination of the inventory programme, as well as compilation, publication and submission of the inventory, are carried out by the inventory agency, MfE, in a centralised manner. Sector-specific work, which includes obtaining and processing activity data, estimating emissions, preparing sectoral common reporting format (CRF) tables and writing sectoral inventory chapters, is carried out by designated agencies across New Zealand's natural resources sector.

Inventory governance within each sector, as well as sectoral quality control, is managed by the agency responsible for the sector. A Reporting Governance Group (RGG) provides cross-agency governance over the climate change reporting, modelling and projections of greenhouse gas emissions and removals. The RGG is chaired by MfE, and its membership includes representation from MfE, the Environmental Protection Authority – Te Mana Rauhi Taiao (EPA), the Ministry for Primary Industries (MPI) and the Ministry of Business, Innovation and Employment (MBIE). The main roles and expectations of RGG are to:

- guide, confer and approve (on the basis of advice from technical experts) major inventory recalculations and improvements; greenhouse gas emissions projections and their assumptions; analytical systems and tools for climate change reporting; planning and priorities; key messages; and management of stakeholders and risks
- focus on delivery of reporting commitments to meet national and international requirements
- provide reporting leadership and guidance to analysts and technical specialists involved in this work
- share information, provide feedback and resolve any differences between departments that impact on the delivery of the work programme
- keep the Climate Change Directors' Group informed of the 'big picture' of the reporting work programme, including its direction, progress in delivery and capability to deliver.

As New Zealand's single national inventory agency, MfE is responsible for the overall coordination, compilation and submission of the inventory to the UNFCCC secretariat. The National Inventory Compiler is based at MfE. Arrangements with other government agencies have evolved as resources and capacity have allowed, and as MfE has developed a greater understanding of the reporting requirements.

As well as fulfilling its overall inventory coordination role, MfE compiles emissions estimates for the industrial processes and product use (IPPU) sector (with carbon dioxide (CO₂) data provided by MBIE and data on non-CO₂ gases obtained through industry surveys), waste sector, emissions and removals for the land use, land-use change and forestry (LULUCF) sector and Article 3.3 and Article 3.4 activities under the Kyoto Protocol.

MfE conducts field measurement programmes, land-use mapping and research to contribute towards emissions estimates within the LULUCF sector and Article 3.3 and Article 3.4 activities under the Kyoto Protocol. This is supplemented with data on harvested wood products production and non-CO₂ emissions collected through surveys of the sector.

MBIE estimates all emissions from the energy sector and CO₂ emissions from the IPPU sector.

MPI estimates emissions from the agriculture sector. The estimates are underpinned by research and modelling undertaken at New Zealand's Crown research institutes, universities and private research companies and survey data collected by the national statistics agency, Stats NZ.

The Ministry of Foreign Affairs and Trade provides information on the minimisation of adverse impacts reported in chapter 15 of the inventory.

The Climate Change Response Act 2002 establishes the requirement for a registry and a registrar. The EPA is designated as the agency responsible for the implementation and operation of New Zealand's national registry under the Kyoto Protocol, the New Zealand

Emissions Trading Register. The registry is electronic and accessible via the internet.⁵⁷⁷ Refer to chapter 12 of the latest inventory⁵⁷⁸ for further information.

Stats NZ provides many of the official statistics for the agricultural sector through regular agricultural censuses and surveys. Population (human) census data from Stats NZ are used in the waste and IPPU sectors.

Consultants are used to provide essential data for the IPPU, waste, agriculture and LULUCF sectors of the inventory as needed.

Where an expert in a relevant sector is identified outside MfE or any of the other key contributing government departments, a contract is established to ensure the inventory can be completed in an accurate and timely manner and to a standard that meets the satisfaction of the Minister of Climate Change. The contracts are legally binding and require transparency in their work and processes. Legislation relating to the public sector accountability framework is extensive and includes the:

- Public Finance Act 1989
- Public Audit Act 2001
- Official Information Act 1982
- Ombudsmen Act 1975
- Public Records Act 2005
- Crown Entities Act 2004.

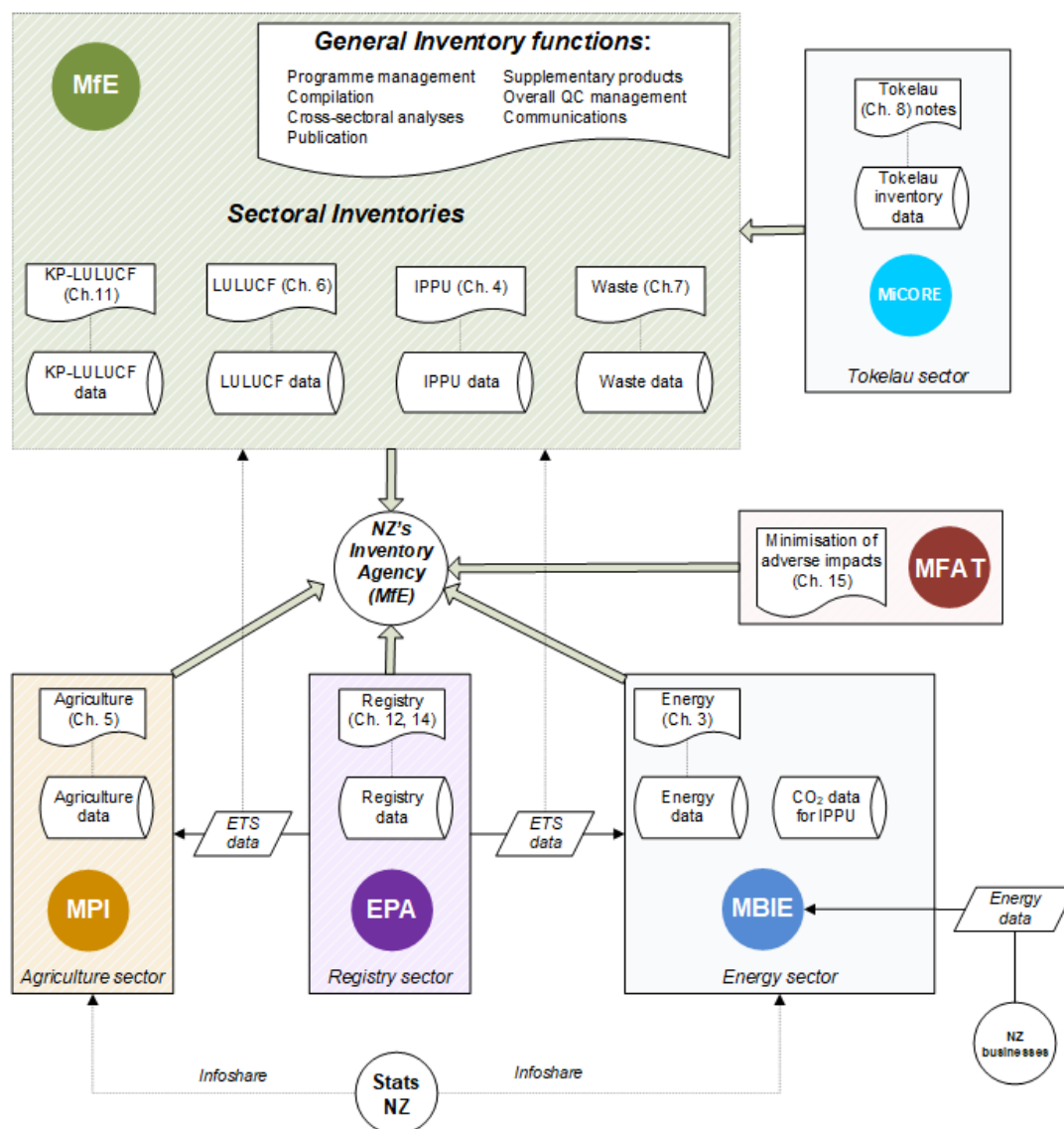
Contractors for the annual inventory are selected for being experts in their fields. They must also understand the relevant UNFCCC reporting requirements and their resulting products must be in line with the appropriate Intergovernmental Panel on Climate Change (IPCC) methodological guidelines. Although it is preferable to use the same contractor each year, contractors are reviewed regularly, with the precise timeframe depending on the terms of each specific contract. Through this competitive process, the best contractor is selected, ensuring inventory data are of the highest quality and will meet our reporting obligations.

Figure B.1 shows the specific responsibilities of different agencies involved in the inventory production as well as their contribution to the inventory submission.

⁵⁷⁷ emissionsregister.govt.nz

⁵⁷⁸ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

Figure B.1: New Zealand's inventory system at a glance: how different agencies are involved



Note: EPA = Environmental Protection Authority; ETS = Emissions Trading Scheme; IPPU = industrial processes and product use; KP-LULUCF = land use, land-use change and forestry activities under the Kyoto Protocol; LULUCF = land use, land-use change and forestry; MBIE = Ministry of Business, Innovation and Employment; MFAT = Ministry of Foreign Affairs and Trade; MfE = Ministry for the Environment; MiCORE = Ministry of Climate, Oceans and Resilience (Tokelau); MPI = Ministry for Primary Industries; QC = quality control.

Source: Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2022*. Wellington: Ministry for the Environment.

Changes to arrangements

Inclusion of Tokelau in New Zealand's inventory system

Changes have been made to the national inventory system since the *Seventh National Communication* was submitted in December 2017. These were reported in the *Fourth Biennial Report* submitted in December 2019. Specifically New Zealand's inventory system now includes Tokelau and reports on its greenhouse gas emissions. In November 2017 New Zealand extended its ratification of the UNFCCC and the Paris Agreement to include Tokelau, and as a result Tokelau is now included in the obligatory climate change reporting managed by the Ministry for the Environment.

New Zealand and Tokelau signed a Memorandum of Understanding (MoU) for the inclusion of Tokelau in New Zealand's inventory. According to the MoU, both New Zealand's central inventory agency, the Ministry for the Environment, and the Tokelau Department for Climate Change have roles in inventory reporting.

MfE is responsible for coordinating the overall inclusion of Tokelau in New Zealand's inventory system. Part of this responsibility is to develop the reporting system and the reporting guidelines for Tokelau to use. MfE is also responsible for supporting the emissions estimates prepared by Tokelau, and integrating the emissions estimates with New Zealand's main CRF data, as well as including Tokelau in the inventory report. For further details on how Tokelau's data and information are incorporated, see chapter 8 of *New Zealand's Greenhouse Gas Inventory 1990–2020*, published in 2022.

The Tokelau Ministry for Climate, Oceans and Resilience is responsible for collecting activity data, providing the written content and emissions estimates where possible and advising on Tokelau's national circumstances and specific cultural aspects for consideration.

Both New Zealand's Ministry for the Environment and the Tokelau Ministry for Climate, Oceans and Resilience are responsible for adhering to the principles and protocols for producers of Tier 1 statistics under the New Zealand official statistics system.

Operational and programme improvements

Improvements designed to improve the quality and efficiency of the National Inventory System have occurred during the past two years. The focus of this work was on making the National Inventory System more robust, and achieving better transparency, comparability, consistency, completeness and accuracy in the inventory. Since New Zealand's *Fourth Biennial Report* and *Seventh National Communication* were submitted, improvements in the inventory have focused on increasing the quality and efficiency of the inventory production. They include:

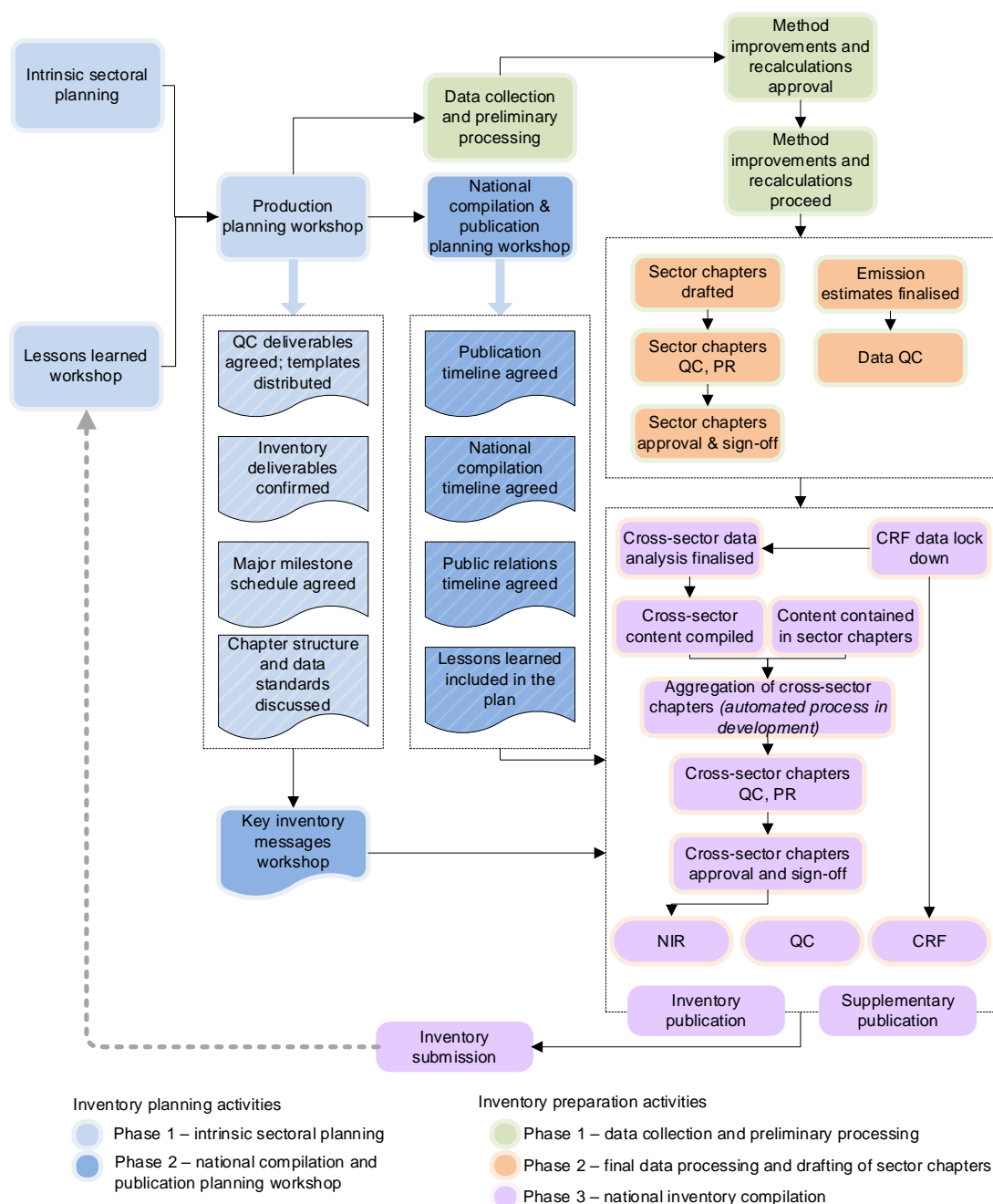
- continuing to develop automated methods for the National Inventory Report production, especially where large quantities of reported data are within several different source documents
- continuing to develop the expertise of inventory contributors through coaching and structured training courses
- securing project management and quality control staff resources within the central inventory agency (MfE).

These programme and operational improvements are expected to enhance the functioning of the national system and, in doing so, ensure continuous improvement of national inventory submissions into the future.

Inventory preparation process

Consistent with the UNFCCC's reporting guidelines, each inventory report is published 15 months in arrears of the calendar year reported, allowing time for collecting and analysing data. Figure B.2 summarises New Zealand's inventory preparation cycle.

Figure B.2: Summary of New Zealand's inventory planning and preparation



Note: CRF = common reporting format; NIR = National Inventory Report; PR = peer review; QC = quality control.

Source: Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment.

Inventory planning is a two-phase process. The first phase, intrinsic sectoral planning, involves planning for the inventory compilation at the sector level. This includes planning for technical projects, actions and procedures that are specific to each sector. The second phase, national compilation and publication planning, involves planning for the cross-sectoral compilation.

Once the intrinsic sectoral planning is complete, the plans are coordinated between the agencies and adjustments made as necessary. This usually happens through a lessons learned workshop and a production planning workshop. The lessons learned workshop is dedicated to analysing what worked well and what did not in the previous inventory cycle. During the production planning workshop, the following are discussed and agreed:

- inventory deliverables
- quality control (QC) deliverables
- schedule of major milestones
- changes to chapter structure
- approach for solving problems during inventory preparation.

The second phase of inventory planning, the national compilation and publication planning, is comprised of two workshops. The first workshop, scheduled towards the end of each calendar year, is dedicated to cross-sectoral compilation and publication planning. Participants include MfE's publication and public liaison teams as well as the inventory production team. They discuss different aspects of the compilation process and agree on a detailed plan for the cross-sectoral compilation and publication. Timelines discussed and agreed cover:

- national compilation
- publication
- public relations.

Lessons learned are also considered in developing the plan.

The second workshop in the second phase of the inventory planning is dedicated to key messages for the inventory, which is an integral part of the cross-sectoral compilation. The workshop's output is the set of key inventory messages agreed among the sector leads, National Inventory Compiler and primary peer reviewers. The key messages are used for both the National Inventory Report and the inventory summary on MfE's website, which presents a brief description of the inventory findings.

The inventory planning process for Tokelau is governed by the MoU between New Zealand and Tokelau.

Activity data, emission factors and methods

The guiding documents in the inventory's preparation are the:

- *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (2006 IPCC Guidelines)⁵⁷⁹
- *Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*⁵⁸⁰
- *revised UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention*⁵⁸¹

⁵⁷⁹ IPCC. 2006. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. National Greenhouse Gas Inventories Programme. Hayama: Institute for Global Environmental Strategies.

⁵⁸⁰ IPCC. 2014. Hiraishi T, Krug T, Tanabe K, Srivastava N, Baasansuren J, et al (eds). *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*. Geneva, Switzerland: IPCC.

⁵⁸¹ UNFCCC. 2013. FCCC/CP/2013/10/Add.3. *Report of the Conference of the Parties on its nineteenth session, held in Warsaw from 11 to 23 November 2013, Addendum; Decision 24/CP.19 Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention*.

- Kyoto Protocol^{582, 583}
- decisions 3/CMP.11 and 4/CMP.11 that cover a range of reporting and review issues^{584, 585}
- guidelines on reporting and review.⁵⁸⁶

The concepts contained in the 2006 IPCC Guidelines are implemented in stages, according to sector priorities and national circumstances.

The 2006 IPCC Guidelines provide a number of possible methodologies for calculating emissions or removals from a given category. In most cases, these possibilities represent calculations of the same form where the differences are in the level of detail at which the calculations are carried out. The methodologies are provided in a structure of three tiers that describe and connect the various levels of detail at which estimates can be made.

The choice of method depends on factors such as the importance of the source category and availability of data. The tiered structure ensures that estimates calculated at a highly detailed level can be aggregated up to a common minimum level of detail for comparison with all other reporting countries. The methods for estimating emissions and/or removals are distinguished between the tiers as follows.

⁵⁸² UNFCCC. 2012. FCCC/KP/CMP/2011/10/Add.1. *Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its seventh session, held in Durban from 28 November to 11 December 2011; Decision 2/CMP.7, Land use, land-use change and forestry.*

⁵⁸³ UNFCCC. 2013. FCCC/KP/CMP/2012/13/Add.1. *Decision 2/CMP.8 Implications of the implementation of decisions 2/CMP.7 to 5/CMP.7 on the previous decisions on methodological issues related to the Kyoto Protocol, including those relating to Articles 5, 7 and 8 of the Kyoto Protocol, Annex 2.*

⁵⁸⁴ UNFCCC. 2016. FCCC/KP/CMP/2015/8/Add.1. *Decision 3/CMP.11 Implications of the implementation of decisions 2/CMP.7 to 4/CMP.7 and 1/CMP.8 on the previous decisions on methodological issues related to the Kyoto Protocol, including those relating to Articles 5, 7 and 8 of the Kyoto Protocol, part I: implications related to accounting and reporting and other related issues.*

⁵⁸⁵ UNFCCC. 2016. FCCC/KP/CMP/2015/8/Add.1. *Decision 4/CMP.11 Implications of the implementation of decisions 2/CMP.7 to 4/CMP.7 and 1/CMP.8 on the previous decisions on methodological issues related to the Kyoto Protocol, including those relating to Articles 5, 7 and 8 of the Kyoto Protocol, part II: implications related to review and adjustments and other related issues.*

⁵⁸⁶ UNFCCC. 2005. FCCC/KP/CMP/2005/8/Add.3. *Land use, land-use change and forestry.*

UNFCCC. 2005. FCCC/KP/CMP/2005/8/Add.2. *Modalities for the accounting of assigned amounts under Article 7, paragraph 4 of the Kyoto Protocol.*

UNFCCC. 2005. FCCC/KP/CMP/2005/8/Add.2. *Standard electronic format for reporting Kyoto Protocol units.*

UNFCCC. 2005. FCCC/KP/CMP/2005/8/Add.2. *Guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol.*

UNFCCC. 2005. FCCC/KP/CMP/2005/8/Add.3 *Guidelines for national systems under Article 5, paragraph 1 of the Kyoto Protocol.*

UNFCCC. 2005. FCCC/KP/CMP/2005/8/Add.3 *Good practice guidance and adjustments under Article 5, paragraph 2 of the Kyoto Protocol.*

UNFCCC. 2005. FCCC/KP/CMP/2005/8/Add.3 *Issues relating to adjustments under Article 5, paragraph 2 of the Kyoto Protocol.*

UNFCCC. 2005. FCCC/KP/CMP/2005/8/Add.3 *Guidelines for review under Article 8 of the Kyoto Protocol.*

UNFCCC. 2005. FCCC/KP/CMP/2005/8/Add.3 *Terms of service for lead reviewers.*

UNFCCC. 2005. FCCC/KP/CMP/2005/8/Add.3 *Issues relating to the implementation of Article 8 of the Kyoto Protocol – 1 (Training programme for members of expert review teams).*

UNFCCC. 2005. FCCC/KP/CMP/2005/8/Add.3 *Issues relating to the implementation of Article 8 of the Kyoto Protocol – 2 (Confidential information).*

- Tier 1 methods apply IPCC default emission factors and use IPCC default methods.
- Tier 2 methods apply country-specific emission factors and use IPCC default methods.
- Tier 3 methods apply country-specific emission factors and use country-specific methods.

Methodology for each sector in the inventory is described briefly in the sections below. Refer to each sector chapter in the inventory⁵⁸⁷ for more detail.

Energy

Greenhouse gas emissions from the energy sector are calculated using a detailed sectoral approach. This bottom-up approach is demand based; it involves processing energy data collected on a regular basis through various surveys. For verification, New Zealand also applies the reference approach, as described in the 2006 IPCC Guidelines, to estimate CO₂ emissions from fuel combustion for the time series 1990–2020 (see annex 4 in the inventory report).⁵⁸⁸

The activity data used for the sectoral approach are referred to as ‘observed’ energy-use figures. These are based on surveys and questionnaires administered by MBIE. The differences between ‘calculated’ and ‘observed’ figures are reported as statistical differences in the energy balance tables released along with *Energy in New Zealand*.⁵⁸⁹ See chapter 3 of the inventory report⁵⁹⁰ for further details on methodologies applied in the energy sector and a description of the sources for activity data for the inventory.

Industrial processes and product use

Activity data in the IPPU sector have been derived from a variety of sources. In the *Mineral industry* category, the primary data source is emissions data reported under the New Zealand Emissions Trading Scheme (NZ ETS). For the *Chemical industry* and *Metal industry* categories, data (including activity data) are provided to MBIE in response to an annual survey.

For some large-scale activities in the *Mineral industry*, *Chemical industry* and *Metal industry* categories, which are carried out by only one or two companies in New Zealand, activity data are reported as confidential in the CRF tables.

Emissions data for glass production (2.A.3) are reported in 2.A.4 to aggregate the data with other sources and preserve confidentiality. Also, data on emissions from hydrogen making at the Marsden Point oil refinery are reported in the *Chemical industry* category. This allows data from the country’s only industrial hydrogen-making process, which is smaller in scale than refining, to be aggregated and kept confidential.

⁵⁸⁷ Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

⁵⁸⁸ Ibid.

⁵⁸⁹ Ministry of Business, Innovation and Employment. 2021. *Energy in New Zealand*. Wellington: MBIE. Retrieved from www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-publications-and-technical-papers/energy-in-new-zealand.

⁵⁹⁰ Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

For the *Product uses as substitutes for ODS* category, updated activity data have been obtained by a detailed annual survey covering electrical, refrigeration and other industry participants⁵⁹¹ as well as importers of hydrofluorocarbons (HFCs) and other substances in this category.

New Zealand uses a combination of Tier 1 and Tier 2 methods for the IPPU sector. Tier 2 methods are used for all key categories.

For small amounts of indirect greenhouse gas emissions reported in the *Chemical industry* category and the *Other product manufacture and use* category, data were obtained by a detailed industry survey and analysis in 2006.⁵⁹² Emissions and activity data have been extrapolated for the years since that time.

Country-specific emission factors have been used where available, including for emissions of indirect greenhouse gases.

Agriculture

New Zealand uses a range of models and tiers appropriate to the size of the different emission categories for calculating emissions. For example, 90 per cent of New Zealand's livestock emissions come from *Dairy cattle*, *Non-dairy (beef) cattle*, *Sheep* and *Deer* ('major' livestock categories). Emissions from major livestock categories are estimated using Tier 2 methodologies. Other livestock species, including *Swine*, *Goats*, *Horses*, llamas and alpacas, *Mules and asses* and *Poultry* ('minor' livestock categories) account for only 0.5 per cent of agriculture emissions, and are estimated using Tier 1 methodologies with some Tier 2 components. As such, most of New Zealand's reported agricultural emissions are calculated using Tier 2 methodology.

Further technical details on emissions calculations are provided in MPI's inventory methodology document⁵⁹³ and in the methodological issues section for each category in the inventory report.⁵⁹⁴ The approach for determining livestock nutritional and energy requirements, which is required to calculate *Enteric fermentation* emissions and nitrogen excreted by livestock as the precursor for calculating *Manure management* (and some *Agricultural soils emissions*), is also described in the inventory report.⁵⁹⁵

Land use, land-use change and forestry

New Zealand uses a combination of Tier 1, Tier 2 and Tier 3 methods, as described in the 2006 IPCC Guidelines, for estimating net emissions for the LULUCF sector. A Tier 1 approach has been used to estimate carbon stock change in the four biomass pools (above-ground and below-ground biomass, dead wood and litter) for all land uses except *Forest land*, *Perennial cropland* and *Grassland with woody biomass*, which use Tier 2 or Tier 3 approaches.

⁵⁹¹ Hennessy W. 2021. Inventory of HFC, SF₆ and Other Industrial Process Emissions for New Zealand 2020. Unpublished report prepared for the Ministry for the Environment by Verum Group Ltd.

⁵⁹² Hennessy W, Maxwell D. 2006. Inventory of HFC, PFC and SF₆ Emissions for New Zealand 2004–2005. Unpublished report prepared for the Ministry for the Environment by CRL Energy Ltd.

⁵⁹³ Ministry for Primary Industries. 2022. *Methodology for Calculation of New Zealand's Agricultural Greenhouse Gas Emissions*. Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/dmsdocument/13906-detailed-methodologies-for-agricultural-greenhouse-gas-emission-calculation

⁵⁹⁴ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

⁵⁹⁵ Ibid.

For all land uses, Tier 1 approaches are used to estimate carbon stock changes in organic soils, and a Tier 2 modelling approach is applied to estimate soil organic carbon changes from mineral soils. This model is described in more detail under 'Mineral soils' in annex A3.2.4 of the inventory report.⁵⁹⁶

New Zealand's forests are disaggregated into four reporting categories to represent the different growth characteristics of the forest types more accurately: pre-1990 planted forest, pre-1990 natural forest, post-1989 planted forest and post-1989 natural forest. The terms 'post-1989' and 'pre-1990' distinguish between forests that existed at 31 December 1989 and those that did not. The terms 'natural' and 'planted' forest are used to identify whether the trees were established from natural regeneration or from managed planting. The term 'harvesting' refers to temporary forest loss as part of ongoing forestry land use, whereas 'deforestation' refers to permanent destocking of forest as a result of land-use change.

Similarly, the species compositions reported in the *Grassland* category are diverse, ranging from different grass types to woody trees that do not meet New Zealand's forest definition. To allow for this, the *Grassland* category is divided into four types for modelling the emissions from land-use change.

Waste

Activity data have come from a variety of sources. Municipal solid waste disposal data, from mandatory reporting under the Waste Minimisation Act 2008 and from the NZ ETS, were used for the years for which they are available (2010 onwards). Activity data for all other sources were based on specific surveys. Interpolation based on gross domestic product (GDP) or population is used for other years.

New Zealand uses Tier 2 methodologies for estimating emissions from the *Solid waste disposal* source category, which is a key category, and for some wastewater emissions. Tier 1 methods are used to estimate other emissions from the waste sector.

Country-specific emission factors have been used where available, including parameters for municipal waste⁵⁹⁷ and for treatment of some types of industrial wastewater.⁵⁹⁸

Methodological issues are discussed under each source category in the waste chapter of the inventory report.⁵⁹⁹

Country-specific emission factors have been used where available, including parameters for municipal waste and for treatment of some types of industrial wastewater.

⁵⁹⁶ Ibid.

⁵⁹⁷ Eunomia. 2020. Improvements to Estimates of Greenhouse Gas Emissions from Landfills. Unpublished report prepared for the Ministry for the Environment.

⁵⁹⁸ Cardno. 2015. *Greenhouse Gas Emissions from Industrial Wastewater Treatment*. Report prepared for the Ministry for the Environment. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/greenhouse-gas-emissions-from-industrial-wastewater-treatment-inventory-basis-review.

⁵⁹⁹ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

Process and results of key category identification

The 2006 IPCC Guidelines identify a key category as:

...one that is prioritised within the National Inventory System because its estimate has a significant influence on a country's total Inventory of direct greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both.⁶⁰⁰

Key categories identified within the inventory are used to prioritise inventory improvements.

As some categories in the inventory apply default uncertainty values for emissions estimates and developing country-specific uncertainty values is resource-prohibitive, the key categories in the inventory have been assessed using the Approach 1 level (L1) and Approach 1 trend (T1) methodologies from the 2006 IPCC Guidelines. The key category analysis identifies key categories of emissions and removals as those that sum to 95 per cent of the gross or net level of emissions and those that are within the top 95 per cent of the categories that contribute to the change between 1990 and the latest emission year, or the trend of emissions.

The key categories identified in the 2020 year are summarised in annex 1 of the inventory report. In accordance with the 2006 IPCC Guidelines, the key category analysis is performed once for the inventory excluding the LULUCF sector and then repeated for the inventory including the LULUCF sector. Non-LULUCF categories that are identified as key in the first analysis are still counted even when they are not identified as a key category when the LULUCF sector is included.

The key category analysis performed for the National Inventory Report differs from that produced in the CRF tables, as the level of aggregation of categories is adjusted to better reflect New Zealand's emissions profile. Specifically, a large proportion of emissions from the energy and agriculture sectors are disaggregated further than the key category analysis generated in the CRF tables, to allow for a more evenly proportioned analysis of categories.

Recalculation of previously submitted inventory data

Activity data, emission factors, methods and modelling techniques used in the inventory compilation process may be refined as government agencies and consultants identify areas for improvement. Recalculations that may result from the improvement process are regarded as a standard element of inventory compilation. Specifically, recalculations of estimates reported in the previous submission of the inventory are due to improvements in:

- activity data
- parameters for estimating emissions and removals, including emission and removal factors
- methodology, including correcting errors
- the availability of activity data and emission factors for certain sources that were previously reported as not estimated because of insufficient data.

⁶⁰⁰ IPCC. 2006. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1. General Guidance and Reporting*. IPCC National Greenhouse Gas Inventories Programme. Hayama: Institute for Global Environmental Strategies, section 4.1.1, p 4.5.

Before the annual inventory is compiled, areas for improvement are identified at a planning session. The quality assurance and quality control (QA/QC) plan is reviewed annually during the inventory debrief and planning phase.

Planned recalculations and improvements for the inventory are subject to approval by the Reporting Governance Group. All recalculations must be approved before changes are made to the inventory data tables.

QA/QC plan, quality objectives, internal and external evaluation and review processes and their results

Quality assurance and quality control plan

Overview

Quality assurance and quality control are integral parts of preparing New Zealand’s inventory. QA/QC procedures are documented in a QA/QC plan in line with requirements.^{601, 602} Details of the QA/QC activities performed during the compilation of the 2022 submission are discussed in the relevant sections of the inventory.⁶⁰³ Examples of QC checks are available to view on request.

The QA/QC processes have a significant role in the preparation of the inventory to ensure the core principles of transparency, accuracy, completeness, comparability and consistency are achieved. Table B.1 describes the key QA/QC processes used in the preparation of the inventory. These processes are under continual review and improvement to ensure they are fit for purpose.

Table B.1: Quality assurance and quality control processes used in preparation of the inventory

ID	QA/QC process or activity description
QA file	All external reviews of the whole or part of the inventory are documented in the QA file.
QC 1 Planned recalculations and improvements	Planned recalculations and improvements are approved by the RGG.
QC 2 Planned improvements peer review	Planned improvements are peer reviewed before being implemented, when they affect the emission factor, parameter, methodology or activity data source. Some sectors have a dedicated panel of experts that reviews improvements.
QC 3 check sheets	QC check sheets are completed to ensure transparency, accuracy, completeness, comparability and consistency principles are met.
QC 4 Peer review	The chapter text for each sector is peer reviewed and follows the checklist provided, to ensure that the peer review is comprehensive and consistent.

⁶⁰¹ IPCC. 2006. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1. General Guidance and Reporting*. IPCC National Greenhouse Gas Inventories Programme. Hayama: Institute for Global Environmental Strategies.

⁶⁰² UNFCCC. 2013. FCCC/CP/2013/10/Add.3. *Report of the Conference of the Parties on its nineteenth session, held in Warsaw from 11 to 23 November 2013, Addendum; Decision 24/CP.19 Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention*.

⁶⁰³ Ministry for the Environment. 2022. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

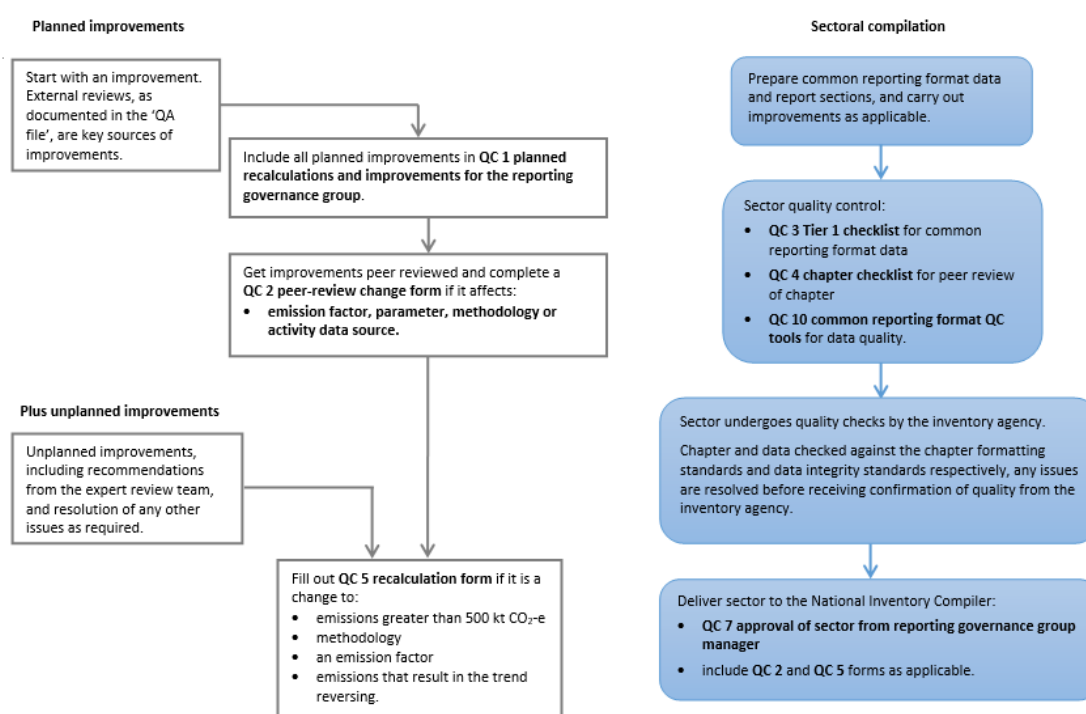
ID	QA/QC process or activity description
QC 5 Recalculations	Recalculations that exceed a certain threshold are analysed and clearly documented.
QC 7 Approval	All sectors in the inventory are approved by the applicable member of the RGG before being submitted to the National Inventory Compiler.
QC 10 QC tools	Common reporting format QC tools identify any potential issues with the data and are used to ensure the data integrity standards are met.

Note: QA = quality assurance; QC = quality control; RGG = Reporting Governance Group.

Source: Ministry for the Environment. 2022. *Quality Assurance/Quality Control Plan for New Zealand's Greenhouse Gas Inventory Production*. Wellington: Ministry for the Environment.

Figure B.3 shows how these QA/QC processes align with the overall preparation of the inventory.

Figure B.3: How the quality assurance and quality control processes and products align with the preparation of the inventory



Source: Ministry for the Environment. 2022. *Quality Assurance/Quality Control Plan for New Zealand's Greenhouse Gas Inventory Production*. Wellington: Ministry for the Environment.

New Zealand's greenhouse gas inventory QA/QC plan has been designed to improve the transparency, accuracy, consistency, comparability and completeness of the country's annual inventory in order to align with IPCC good practice. The plan closely follows the definitions, guidelines and processes presented in the 2006 IPCC Guidelines.⁶⁰⁴ As a living document, it is subject to modification and improvement when changes in processes are updated, or on advice from independent reviewers.

⁶⁰⁴ IPCC. 2006. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1. General Guidance and Reporting*. IPCC National Greenhouse Gas Inventories Programme. Hayama: Institute for Global Environmental Strategies, chapter 6.

The QA/QC plan is intended to ensure the transparency and quality of New Zealand's inventory. The principles of the plan include:

- applying greater quality control efforts for key categories and for those categories where data and methodological changes have recently occurred
- periodically checking the validity of all information as changes occur in sample size, methods of collection or frequency of data collection
- conducting general quality control procedures (Tier 1) on all parts of the inventory over a period of time
- balancing efforts between development and implementation of QA/QC procedures and continuous improvement of inventory estimates
- customising the quality control procedures to the resources available and the particular characteristics of New Zealand's inventory
- confirming that the national statistical agency and other agencies supplying data to the inventory have implemented QA/QC procedures.

Quality control

The focus of New Zealand's QA/QC plan is to meet the principles of transparency, accuracy, completeness, consistency, comparability while ensuring efficient use of resources and a particular focus on mitigating QC-related risks in the inventory planning and preparation process.

The main elements of the QA/QC plan include:

- revising the QC deliverables to ensure they are fit for purpose, well supported with relevant templates and adapted to the changes in the inventory software tools
- reinforcing the error-checking process by providing dedicated personnel and support to the sector leads
- automating inventory tools to minimise the number of errors during data transfers
- adjusting QC tools to accommodate any changes in the CRF that happened since the previous submission
- prioritising the QA/QC issues that were raised during bilateral exchanges, such as those that have previously occurred with the Austrian, German and Australian national inventory teams
- ensuring the structure of chapters in the inventory demonstrates transparency of the methods and incorporates suggestions from previous inventory reviews.

Completion of QC check sheets for each sector is the responsibility of each sector lead. The QC check sheets are based on the procedures suggested in Annex 6a.1, Volume 1 of the 2006 IPCC Guidelines. Sectoral QC processes and procedures have been revised and thoroughly documented in the updated version of New Zealand's National Inventory System Guidelines. Wherever possible, manual checking has been replaced by automated checks.

All sector-level data are entered into the web-based CRF database by sector compilers in February each year, with a possibility of further updates.

The sectoral contributions to the inventory and QC checks are signed off by the responsible agency before final approval of the inventory and submission to the UNFCCC.

MfE uses the QC checking procedures included in the web-based CRF Reporter to ensure the data submitted to the UNFCCC secretariat are complete. In addition, data in the CRF tables are checked for anomalies, errors and omissions.

The energy and agriculture activity data provided by Stats NZ are official national statistics. As such, they are subject to their own rigorous QA/QC procedures.

Quality assurance

New Zealand's QA system includes prioritisation of improvements, processes around accepting improvements into the inventory, in-depth review of sector inventories or their components every 5 to 10 years, and improving the expertise of key contributors to the inventory. The government audit agency (Audit New Zealand) makes annual audits of the inventory performance. New Zealand also considers the international inventory reviews performed by the expert review teams under the UNFCCC (and the Kyoto Protocol) as an important element of quality assurance. Regular meetings take place to discuss progress of QA/QC activities and relevant issues with each sector lead. The main aspects of QA are explained in detail below.

All sector leads are encouraged to schedule QA audits of their systems at least once every five years.

The energy sector lead discussed sectoral issues with the Danish inventory team during bilateral meetings in 2017 dedicated to different aspects of the energy sectoral inventory. Specific issues covered were: data sources, data collection and verification processes; using NZ ETS data for higher-tier methods in the energy sector; applying higher-tier methods for road transport; disaggregation of non-road liquid fuel use; and fugitive emissions from fuels. In 2019, an external consultant was contracted to review and develop a QA plan for the energy sector. Most recommendations from that review have already been implemented, and work continues on addressing the remaining issues.

The agriculture sector completed a major QA review of its calculation models with an external party in 2013. Since then, other QA activities for the sector have included a bilateral review with Australia in 2014, and an external review of equations used to determine metabolisable energy requirements in 2016. For more information, see chapter 5 of the inventory report.⁶⁰⁵

The QA/QC plan, combined with annual inventory experience, indicates areas for future improvements for the inventory, which are then incorporated into the following inventory and each subsequent inventory. For more detailed information on the QA/QC plan for the 2022 inventory submission, see annex 6 of the inventory report.⁶⁰⁶

Internal review

A review of the complete inventory check is performed to ensure all planned checks have been completed before the inventory is submitted. This review includes checking that:

- all the planned QC checks have been completed
- the results of the QC checks have been included in the appropriate Excel tables

⁶⁰⁵ Ministry for the Environment. 2022. *New Zealand's Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020.

⁶⁰⁶ Ibid.

- QA exercises have been completed
- mandatory checks in the CRF software are complete for all sectors.

Before submitting the inventory to the UNFCCC secretariat, MfE staff who have not been involved in the inventory compilation process undertake an internal review.

The UNFCCC annual inventory review

New Zealand's inventory was reviewed⁶⁰⁷ in 2001 and 2002 as part of a pilot study of the technical review process. The inventory was subject to detailed in-country, centralised and desk review procedures. The inventories submitted for the years 2001 and 2003 were reviewed in a centralised review process. The 2006 inventory submission was reviewed as part of the Kyoto Protocol initial review. This was an in-country review held from 19–24 February 2007. The 2007–09 and 2011–12 inventory submissions were reviewed during centralised reviews, as were the 2011–17 and 2021 submissions. The 2010 and 2019 inventory submissions were subject to in-country reviews. Since 2017, reviews have not always been conducted annually. New Zealand's inventory was reviewed annually up until 2017, then in 2019, 2021 and 2022. New Zealand's review report for the 2021 inventory submission had not been completed and published before making the 2022 submission. In all instances, the reviews were coordinated by the UNFCCC secretariat and were conducted by an international team of experts drawn from experts nominated by Parties to the UNFCCC Roster of Experts.

Because New Zealand consistently meets the reporting requirements, it was one of the first four Parties to be eligible to participate in the Kyoto Protocol mechanisms for the first commitment period. Its registry for holding the official records of transactions and balances of its Kyoto Protocol units was operational on 1 January 2008, the first day of the first commitment period.

Procedures for the official consideration and approval of the inventory

The finalised inventory submission is signed off by the manager responsible for the MfE team compiling the inventory. The final approval is given by the director who is the designated management sign-off individual for the Chief Executive Officer at MfE.

National registry

Overview

The New Zealand Emissions Trading Register (the Register) went live on the weekend of 27 August 2016. The Register replaced Aotearoa New Zealand's Emission Unit Register, which had been operational since December 2007. The Register is the country's only official register of Kyoto Units.

The NZ ETS was established in December 2009 by amendment of the Climate Change Response Act 2002. The Register manages the accounting, reporting and reconciliation of emissions and unit holdings and transactions as part of the NZ ETS.

⁶⁰⁷ The review reports for each review event mentioned in this section are published by the UNFCCC and can be retrieved from unfccc.int/national_reports/annex_i_ghg_inventories/inventory_review_reports/items/6616.php.

The Register is currently managed by the EPA, which is the government agency responsible for operating the NZ ETS. The Register contains multiple accounts (known as holding accounts, held by both the Crown and private entities) and allows the transfer of units between Register holding accounts. The Register supports the:

- opening of holding accounts
- holdings of both Kyoto Units and New Zealand's domestic unit of trade, commonly known as New Zealand Units (or NZUs)
- transfer of units between holding accounts within the Register
- registration of participants' activities under the NZ ETS, and reporting of non-forestry activities.

The latest reporting period is up to 31 December 2021. The report was submitted to the UNFCCC secretariat as part of the national inventory submission package in April 2022.

In January 2008 New Zealand's national registry was issued with the country's assigned amount of 309,564,733 metric tonnes of CO₂ equivalent.

In July 2015 the national registry issued 91,795,399 Removal Units according to rules relating to Kyoto Protocol Article 3.3 afforestation/reforestation, of which 20,242,601 Removal Units were cancelled according to rules relating to Kyoto Protocol Article 3.3 deforestation.

In 2015 New Zealand retired units to meet first commitment period obligations under the Kyoto Protocol. The details of the units retired were submitted as part of its True-up Report (Report upon expiration of the additional period for fulfilling commitments by New Zealand). New Zealand retired:

- 179,055,090 assigned amount units
- 97,027,042 emissions reduction units
- 16,117,338 certified emissions reduction units
- 80,598,152 removal units.

The number of Kyoto Units held in New Zealand's national registry did not change during 2021. At the beginning and end of 2021, the national registry held only first commitment period Kyoto Units, including cancelled and retired units. These consisted of:

- 308,343,858 assigned amount units
- 110,744,560 emissions reduction units
- 21,685,909 certified emissions reduction units
- 100,845,399 removal units.

Registry contact details

The Register can be accessed at: <http://emissionsregister.govt.nz>.

Organisation designated as the administrator of New Zealand's national registry	<i>Environmental Protection Authority</i> Private Bag 63002, Wellington 6140, New Zealand Phone: +64 4 916 2426 Fax: +64 4 914 0433 Web: www.epa.govt.nz
Main contact	<i>Guy Windley</i> Manager, ETS Operations, Climate Land and Oceans Group, Environmental Protection Authority Phone: + 64 4 474 5514
Alternative contact	<i>Dave Stuart</i> Team Leader, ETS Operations, Climate Land and Oceans Group, Environmental Protection Authority Phone: + 64 4 474 5750

Consolidated registry with other parties

New Zealand does not maintain a consolidated registry with other Parties.

Key category analysis

Please refer to annex 1 of *New Zealand' Greenhouse Gas Inventory 1990–2020: Volume 2, Annexes* at: environment.govt.nz/assets/publications/GhG-Inventory/New-Zealand-Greenhouse-Gas-Inventory-1990-2020-Annexes.pdf.

National registry: a detailed description

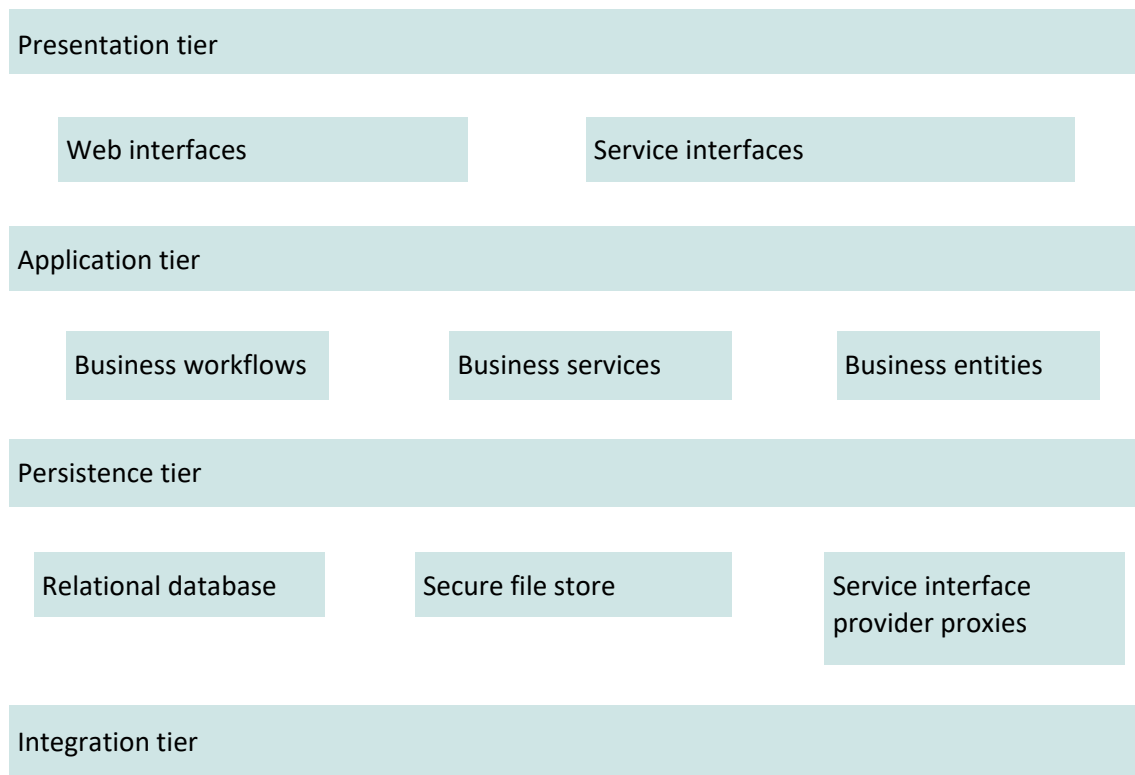
Database structure and capacity

The New Zealand Emissions Trading Register is a customised application solution developed by Datacom NZ and based on the Emissions Trading Scheme Workflow Automation Project and Greenhouse Gas Registry for Emissions Trading Arrangements products. The Register is used for online emissions reporting, the opening of holding accounts, and the management of allowances and emissions, including units and project credits issued under the Kyoto Protocol.

The solution architecture has been formed around standard design approaches using classic n-tier distribution of services augmented by firewalls, load balancers, segmented subnets geared around security zoning to support presentation, application and database services. Additionally a management tier provides common infrastructure services such as jump server, monitoring, test server and release management tools to support the solution.

Figure B.4 shows the configuration of the Register production environment. The various components of this configuration are discussed next.

Figure B.4: Configuration of the production environment of the New Zealand Emissions Trading Register



Presentation tier

Web application

The web presentation tier is realised using ASP.NET with bespoke written Web Controls and Web Forms.

The presentation layer produces a custom CSS stylesheet specifically designed for displaying the main application for desktop users.

Reports

Reports are provided using Microsoft SQL Server Reporting Services. The reports are presented to users by making use of Microsoft's ReportViewer control. This allows the Register to render reports directly within the application itself.

Application tier

Business logic

The business logic is broken into multiple components within the business layer. This is done to aid modularity of design such that any component could be rewritten without affecting the rest of the business logic as long as its interface remains the same.

Persistence framework

Access to the database is through Microsoft Entity Framework 6. This provides an object-relation mapping between entity objects and the underlying database tables. The solution makes extensive use of stored procedures for both data retrieval and data updates.

Windows services

The application requires several services to provide background processing. These include:

- sending SMS messages
- sending messages to and from the International Transaction Log (ITL) and processing those messages.

Forms module

A Forms module is used for managing the creation, storage and retrieval of form data and the merging of it with the information in form templates for display purposes.

Persistence tier

All databases are Microsoft SQL Server 2012 Enterprise Edition. All databases are replicated.

Application database

The main database is clustered using Microsoft SQL 2012 Always-on Availability group. Synchronous Mirroring is used to provide a high-availability database for the production databases. Transactions are written into both databases before transaction is completed, giving zero data loss in the event of a local database server failure. Asynchronous mirroring is used to replicate the data to the disaster recovery site.

SQL Server Reporting Services

SQL Server Reporting Services (SSRS) provides the following interface to access reporting data via the application layer.

SSRS Report Server

The SSRS Report Server provides a webservice interface to allow report templates and data sources to be created, modified or deleted and also to allow the execution of a report against a given template.

Reporting database

The reporting database has two parts. One is a direct copy of the main application database. The other has been transformed to extract some of the more difficult to query information into a simpler schema (to make authoring and executing reports easier).

Forms database

The Forms database stores all data for forms, including a full version history of forms as they are edited.

Integration tier

ITL integration

The integration with the ITL consists of one webservice that is published by the ITL and is referenced by the Register and one webservice that is published by the Register and is referenced by the ITL. These webservices conform to the Data Exchange Standards as published by the UNFCCC.

SMS integration

An SMS Gateway interface allows the Register to send SMS messages to users that have a valid SMS number.

Data exchange

The integration with the ITL consists of one webservice that is published by the ITL and is referenced by the Register and one webservice that must be published by the Register and is referenced by the ITL. These webservices conform to the Data Exchange Standards as published by the UNFCCC.

Before the Register went live, it underwent Data Exchange Standards Annex H testing, which was completed successfully in late July 2016. This testing, in combination with ITL review and collective assessment of readiness documentation, confirmed that the Register conformed to required technical standards of data exchange.

Minimising discrepancies

The Register has multiple checks in place to minimise discrepancies in transactions. For example, the application interface prevents users from selecting the wrong units to fulfil a notification or instruction. Checks in the Register generally follow the checks performed by the ITL on a given transaction.

Transactions made in error can be reversed, noting that transactions that have been approved and finalised through the ITL cannot be rolled back without the agreement of the ITL administrator. Whether or not a transaction needs to be verified by the ITL depends on the transaction type.

To minimise discrepancies between the Register and the ITL, the following measures have been adopted.

- An ITL approval step is provided for transaction workflows involving Kyoto Units in which discrepancies could occur.
- All units that are involved in a transaction are earmarked within the Register, thereby preventing the units from being involved in another transaction until a response has been received from the ITL and the current transaction has been completed.
- The Register implements internal controls in accordance with the checks performed by the ITL, as documented in Annex H of the Data Exchange Standards.
- Daily reconciliation between the Register and the ITL occurs. Any discrepancies will display as alerts in the Register.

- If an unforeseen failure occurs, the data discrepancies between the Register and the ITL can be corrected via manual intervention functionality within the Register. Reconciliation would then be performed to verify that the data are synchronous between the Register and the ITL. If a discrepancy recurs in the Register, the following measures will be applied:
 1. identification and registration of the discrepancy
 2. identification of the source of the discrepancy
 3. elaboration of a resolution plan and testing plan
 4. correction and testing of the software
 5. release and deployment of the corrected software.

Security measures

In the Register, we continue to manage security in three main ways:

- user management – individuals need to log on to the Register as a registered user to use services
- database management – best-practice systems are in place to manage internet and database security
- a digital certificate and VPN are used to connect to the ITL.

The Register uses a number of security standards, including, significantly, the New Zealand Information Security Manual (NZISM), which provides the security framework for the country's government agencies, as the blueprint for protecting services and integrations. The stated purpose of NZISM is to ensure that a risk-managed approach to cyber security is applied within the Aotearoa New Zealand public sector.

Alignment with NZISM ensures that the Register uses the very best security standards, practices and guidelines available to protect the security of information held and used. This is achieved through implementation of a number of safeguards to protect the overall system, its individual services, its data and its customers. Examples of these safeguards are:

- secured communications between all external systems and with each end-user and customer – using best-practice encryption and signing algorithms
- access via multiple-level firewalls – preventing unauthorised access
- intrusion detection systems
- security attack-resilient architecture
- rigorous and ongoing vulnerability testing
- best-practice audits of infrastructure and software.

Monitoring is implemented, which includes tracking of:

- the availability, performance and capacity of the Windows server infrastructure and SQL databases managed by Datacom in the Register's EPA production, pre-production and disaster recovery environments
- the availability of the services/processes of the critical application(s) running on the infrastructure.

ITL review and collective assessment of Register readiness documentation before it went live confirmed that the Register conforms to required technical and security standards.

Public information

The publicly accessible information from New Zealand’s national registry is available online⁶⁰⁸ and from public information and reports. Note that several components of the Register’s information are deemed confidential at the detailed level and are instead presented at summary levels. The following types of information can be accessed via the Register’s publicly accessible user interface:

- emissions unit holdings and transactions
- transactions between the Register and overseas registers
- accounts in the Register
- account holders in the Register
- New Zealand projects eligible for emissions units.

For a detailed list of publicly accessible information, see table 12.4.1 of *New Zealand’s Greenhouse Gas Inventory 1990–2020*.⁶⁰⁹

New Zealand Emissions Trading Register application and database backup and disaster recovery

Hypervisor-based backups are used to provide backups for the Registry solution. The backups taken are as a full machine snapshot (capturing the entire virtual machine disk images, including both the operating system and additional virtual machine (VM) volumes within the guest). The machines are captured in a running state, which includes a copy of memory. If restored, then the machine will be equivalent to a live server. Backups occur at night, when transaction counts are low.

All databases are backed up to local disks using standard SQL Server maintenance plans and are retained on local disk for two days. The database file backups are written to tape. Table B.2 gives details of the backup approach and timing.

Table B.2: Database backup process for the New Zealand Emissions Trading Register

Type	Method	Schedule	Retention period		
			Local DD	Remote DD	Offsite tape
Daily	2D (incremental to disk)	Saturday through to Thursday nights	1 month		–
Weekly	3D (full to disk)	Friday night	1 month	1 month	–
Monthly	3DT (full to disk to tape)	First Friday night each month	1 month	1 month	10 years

⁶⁰⁸ <https://emissionsregister.govt.nz>.

⁶⁰⁹ Ministry for the Environment. 2020. *New Zealand’s Greenhouse Gas Inventory 1990–2020*. Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/nzs-greenhouse-gas-inventory, p 401.

The disaster recovery (DR) environment consists of dual web and application servers replicated using Zerto VM replication service, Symmetric Remote Data Facility (SRDF) for file share replication and a permanent DR database server hosting a DR database that is a member of the SQL 'Always On' availability group. Data are asynchronously replicated between the Production and DR databases. The production and DR sites are geographically separated.

ITL review and collective assessment of the Register readiness documentation before it went live confirmed that the Register conformed to required backup and disaster recovery standards.

Test results

ITL review and collective assessment of Register readiness documentation before it went live confirmed that the Register system operated under satisfactory and well-documented arrangements. It also confirmed the Register was ready to be connected to the ITL system without conditions.

Results of Annex H testing before the Register went live led to official confirmation that the functionalities of the registry software tested on 19 and 20 July 2016 were compliant with the requirements of the technical specifications of the ITL for a country that is not a party to a Qualified Emission Limitation or Reduction Commitment for the second commitment period (with the caveat that carry-over was not tested, because it was not implemented by the software provider).⁶¹⁰

Supplementary notes related to Articles 6, 12 and 17

While Aotearoa New Zealand committed to an emissions reduction target under the Kyoto Protocol's first commitment period (2008–12), its 2013–20 target is pledged under the UNFCCC. As described above, New Zealand maintains its linkages with the ITL but did not actively participate in the mechanisms established by Articles 6, 12 and 17 of the Kyoto Protocol during the target period.

Policies and measures in accordance with Article 2

Sustainable development

New Zealand's climate change policies promote sustainable development through seeking to reduce the causes and impacts of climate change (see chapters 4 and 7).

⁶¹⁰ New Zealand chose to take its 2020 emissions reduction target under the UNFCCC but will meet that target using rules applicable to the Kyoto Protocol's second commitment period.

Aviation and marine bunker fuels

In 2016, the Government agreed to participate in the Carbon Offsetting Reduction Scheme for International Aviation (CORSIA). It is one of four measures⁶¹¹ the international aviation sector is focused on to reduce its carbon footprint. Implementation of CORSIA is included in the Civil Aviation Bill, which is currently being progressed through the House of Representatives and anticipated to be passed into law by the end of 2022. In the interim, a Memorandum of Understanding is in place between the State and airline operator that falls under CORSIA to ensure New Zealand meets its monitoring, reporting and offsetting obligations.

For international shipping, States, including New Zealand, work through the International Maritime Organization (IMO) to pursue emissions reductions from international shipping. The IMO adopted its Initial Strategy on the Reduction of GHG Emissions from Ships in 2018.⁶¹² The Initial Strategy sets a target of reducing the total annual greenhouse gas emissions from international shipping by at least 50 per cent by 2050 compared with 2008. This Initial Strategy will be reviewed by 2023. New Zealand will be represented at the IMO negotiations in December 2022, which will include a focus on the revision of the Strategy.

In 2022 New Zealand acceded to Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL), which seeks to address the impact of shipping emissions on human health and environments in and around port communities, as well as on climate change and ozone layer depletion. MARPOL Annex VI will be the main 'vehicle' to bring in globally consistent greenhouse gas emissions reduction measures negotiated at the IMO.

Minimising adverse effects

New Zealand's Cabinet and legislative processes to establish and implement climate change response measures include consultation with the Ministry of Foreign Affairs and Trade and with members of the public. The Ministry of Foreign Affairs and Trade advises the Government on international aspects of proposed policies. During the public consultation phase, any person or organisation can raise concerns about issues relating to a proposed measure.

The New Zealand Government's regular trade, economic and political consultations with other governments, including developing country Parties, provide opportunities to bilaterally raise and resolve concerns about possible or actual impacts of New Zealand policies. No government has raised specific concerns about any negative impact of New Zealand's climate change response policies.

In particular, New Zealand has regular high-level consultations Pacific partner governments, at which partners have the opportunity to raise concerns about any impacts and to ask for or prioritise assistance to deal with those impacts.

New Zealand maintains a liberal and open trading environment, consistent with the principles of free trade and investment. In this way it ensures that both developed and developing countries can maximise opportunities in its market regardless of the response measures undertaken.

⁶¹¹ Other measures are sustainable aviation fuels, aircraft technology and standards, and operational improvements (eg, improved ground operations and air traffic management).

⁶¹² Marine Environment Protection Committee. 2018. Initial IMO Strategy on the Reduction of GHG Emissions from Ships. Retrieved from www.imo.org/en/OurWork/Environment/Pages/GHG-Emissions.aspx.

Domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures

The Climate Change Response Act 2002 established an institutional and legal framework to support New Zealand in meeting its obligations under the UNFCCC and the Kyoto Protocol. The Act includes powers for the Minister of Finance to manage New Zealand's holdings of units that represent the country's target allocation for greenhouse gas emissions under the Kyoto Protocol. It establishes a registry to record holdings and transfers of units. The Act also establishes a national inventory agency to record and report information relating to greenhouse gas emissions in accordance with international requirements. The Act established the New Zealand Emissions Trading Scheme and describes its legal details. Regulations relating to the NZ ETS have been made periodically under the Climate Change Response Act 2002. For more detail on the NZ ETS, see chapter 4.

The Act has been amended numerous times, including through the Climate Change Response (Zero Carbon) Amendment Act 2019 (the Zero Carbon Act). The Zero Carbon Act provides a framework by which New Zealand can develop and implement clear and stable climate change policies that:

- contribute to the global effort under the Paris Agreement to limit the increase in global average temperature to 1.5°C above pre-industrial levels
- allow New Zealand to prepare for, and adapt to, the effects of climate change.

The four key changes are to:

- set a new domestic greenhouse gas emissions reduction target for New Zealand to:
 - reduce net emissions of all greenhouse gases (except biogenic methane) to zero by 2050
 - reduce emissions of biogenic methane to 24–47 per cent below 2017 levels by 2050, including to 10 per cent below 2017 levels by 2030
- establish a system of emissions budgets to act as stepping stones towards the long-term target
- require the Government to develop and implement policies for climate change adaptation and mitigation
- establish a new, independent Climate Change Commission to provide expert advice and monitoring to help keep successive governments on track to meeting long-term goals.

MfE administers this Act.

Information under Article 10

Chapters 4, 6, 7, 8 and 9 report on activities New Zealand undertakes in fulfilment of commitments under Article 10 of the Kyoto Protocol. Chapter 7 reports its steps to promote, finance and facilitate the transfer of technology to developing countries.

Financial resources

Chapter 7 outlines the steps New Zealand has taken to meet its obligations under Article 11 of the Kyoto Protocol.

Biodiversity and sustainable use of natural resources

New Zealand's Climate Change Response Act 2002 references the Kyoto Protocol text to ensure that the implementation of activities under Article 3.3 contributes to the conservation of biodiversity and sustainable use of natural resources.

New Zealand excludes land that was natural forest at 1990 and subsequently converted to planted forest from its accounting of afforestation and reforestation activities under Article 3.3.

The New Zealand Government has funding available to encourage communities to plant trees, encourage innovation, and support projects that improve land production or reduce erosion. The One Billion Trees programme provides funding to increase tree planting across the country. The goal is to double the current planting rate to reach one billion trees planted by 2028. The Hill Country Erosion Programme is a partnership between MPI, regional councils, unitary authorities and landowners that sets plans for and treats erosion-prone land. The Matariki Tu Rākau memorial tree-planting programme accesses the One Billion Trees funding to plant living memorials to honour members of the community. Funding is provided through community groups, school, councils, marae and Royal New Zealand Returned and Services Association. Funding is available to research and innovate in forestry through the One Billion Trees programme, Sustainable Food and Fibre Futures, and the Sustainable Land Management and Climate Change (SLMACC) research programme.

The NZ ETS penalises the conversion of pre-1990 plantation forest land to any non-forest land use by imposing a deforestation liability on the landowner.

The majority of privately owned natural forests are covered by the Forests Amendment Act 1993, which promotes sustainable management of indigenous forests in perpetuity while retaining the forests' natural values. A small proportion of New Zealand's natural forest (0.2 per cent) is sustainably managed under the South Island Landless Natives Act 1906. The remainder of the country's natural forests (approximately two-thirds of New Zealand's total natural forests) is publicly owned and is protected by the Conservation Act 1987. These forests cannot be deforested. No timber is legally harvested from the natural forests on public conservation land other than in exceptional circumstances where legislation allows.

Appendix C: Supplementary material for emissions projections

C.1: Key variables and assumptions

Table C.1: Summary of key variables and assumptions used in the projections analysis (CTF Table 5)

Key underlying assumptions	Unit	Scenarios	Historical							Projected		
			1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Population	million inhabitants	WEM/WOM/WAM/Low/high	3.46	3.67	3.86	4.13	4.35	4.59	5.09	5.32	5.55	5.76
GDP	billion (real 2009/10 \$NZ)	WEM/WOM/WAM/Low/high	112.68	130.49	152.13	184.13	196.70	225.26	261.95	294.16	323.90	354.02
Effective carbon price	(\$NZ tonne CO ₂ -e)	WEM/WAM	NA	NA	NA	NA	NA	NA	\$25	\$64	\$97	\$115
		WOM	NA	NA	NA	NA	NA	NA	NA	\$0	\$0	\$0
		Low	NA	NA	NA	NA	NA	NA	NA	\$93	\$150	\$174
		High	NA	NA	NA	NA	NA	NA	NA	\$35	\$44	\$57
Population (Energy & Transport sectors)	million inhabitants	WEM/WOM/WAM	3.46	3.67	3.86	4.13	4.35	4.60	5.09	5.28	5.58	5.80
		Low	3.46	3.67	3.86	4.13	4.35	4.60	5.09	5.28	5.46	5.53
		High	3.46	3.67	3.86	4.13	4.35	4.60	5.09	5.28	5.71	6.08
GDP (Energy & Transport sectors)	billion (real 2009/10 \$NZ billion)	WEM/WOM/WAM	112.71	130.5	152.2	184.2	196.8	225.9	253.3	291.4	325.3	351.7
		Low	112.71	130.5	152.2	184.2	196.8	225.9	253.3	291.4	316.1	332.4
		High	112.71	130.5	152.2	184.2	196.8	225.9	253.3	291.4	335.4	375.8
Effective carbon price (Energy & Transport sectors)	(\$NZ tonne CO ₂ -e)	WEM/WAM/Low/High	NA	NA	NA	NA	NA	NA	NA	82	140	168

Key underlying assumptions	Unit	Scenarios	Historical							Projected		
			1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Light vehicles – Internal Combustion Engine	thousands	WEM/WOM/WAM/Low/High	NA	NA	NA	2967.41	3122.80	3482.11	4034.12	4342.35	4382.24	4126.12
Light vehicles – Electric vehicle	thousands	WEM/WOM/WAM/Low/High	NA	NA	NA	0.06	0.07	0.96	23.93	841.73	240.10	633.89
Heavy commercial vehicles – Internal Combustion Engine	thousands	WEM/WOM/WAM/Low/High	NA	NA	NA	126.20	137.01	145.63	167.73	182.23	185.69	185.68
Motorcycles	thousands	WEM/WOM/WAM/Low/High	NA	NA	NA	97.17	140.04	158.48	188.24	202.38	206.37	207.71
Trucks and buses – Electric vehicles and plug-in hybrids	thousands	WEM/WOM/WAM/Low/High	NA	NA	NA	0.07	0.07	0.07	0.19	0.86	2.99	7.65
Vehicle kilometres travelled	vehicle thousand KM	WEM/WOM/WAM/Low/High	NA	NA	NA	40398.75	40394.56	43173.49	46262.99	52700.17	56060.74	58979.55
Total energy demand	Gross PJ	WEM/WOM/WAM/Low/High	389.3	438.8	481.3	512.4	520.0	555.4	540.0	549.5	540.7	533.9
Aviation	Gross PJ	WEM/WOM/WAM/Low/High	13.87	16.34	17.18	17.41	13.98	12.41	10.31	15.64	15.64	15.64
Rail transport	Gross PJ	WEM/WOM/WAM/Low/High	1.34	2.44	3.76	2.46	2.25	2.27	1.86	1.85	1.85	1.85
Navigation	Gross PJ	WEM/WOM/WAM/Low/High	3.28	4.10	5.17	5.45	3.76	5.73	3.72	2.75	2.75	2.75
Labour Force	millions	WEM/WOM/WAM/Low/High	NA	NA	NA	NA	NA	NA	2.84	3.02	3.21	3.34
Net migration	thousands	WEM/WOM/WAM/Low/High	NA	NA	NA	NA	NA	NA	NA	35.1	32.8	25
Exchange rate	(NZ\$/US\$)	WEM/WOM/WAM/Low/High	NA	NA	NA	NA	NA	NA	0.64	0.65	0.65	0.65
Upper limit in importation of new HFCs	Percent of 1796 kt CO ₂ -e baseline*	WEM/WAM/Low/High	NA	NA	NA	NA	NA	NA	NA	47.7%	29.8%	19.4%
GWP limits on new pre-charged equipment		WEM/Low/High	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		WAM	NA	NA	NA	NA	NA	NA	NA	NA	Yes	Yes

Key underlying assumptions	Unit	Scenarios	Historical							Projected			
			1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	
Refrigerants recovery rate	Percent of retired volumes	WEM	NA	NA	NA	NA	NA	NA	NA	NA	9%	10%	12%
		High	NA	NA	NA	NA	NA	NA	NA	NA	9%	12%	14%
		Low	NA	NA	NA	NA	NA	NA	NA	NA	9%	10%	11%
		WAM	NA	NA	NA	NA	NA	NA	NA	NA	12%	12%	18%
Effective carbon price (discounted carbon price for pricing) (Agriculture)	\$NZ	WEM/WOM/WAM	NA	NA	NA	NA	NA	NA	NA	\$64 (\$3.20)	\$97 (\$9.72)	\$115 (\$23.05)	
Dairy area	thousand hectares	WEM/WAM	1,024	1,208	1,329	1,399	1,639	1,752	1,714	1,705	1,699	1,695	
		WOM	1,024	1,209	1,330	1,401	1,641	1,756	1,721	1,723	1,726	1,731	
Sheep beef deer area	thousand hectares	WEM	12,054	11,610	10,587	9,825	9,200	8,415	7,839	7,334	7,141	6,954	
		WOM	12,054	11,618	10,612	9,855	9,246	8,500	7,989	7,689	7,660	7,635	
		WAM	12,054	11,610	10,587	9,825	9,200	8,415	7,839	7,317	7,062	6,813	
Horticulture area	thousand hectares	WEM/WOM/WAM	72	94	93	97	105	104	109	116	120	124	
Arable land	thousand hectares	WEM/WOM/WAM	191	161	161	149	171	161	144	161	166	160	
Exotic forest	thousand hectares	WEM/WAM	1,315	1,541	1,744	1,776	1,733	1,731	1,789	2,039	2,232	2,419	
		WOM	1,315	1,533	1,717	1,745	1,684	1,642	1,632	1,665	1,685	1,702	
Other land	thousand hectares	WEM/WOM	2,681	1,782	1,791	1,815	1,476	1,487	1,473	1,410	1,369	1,324	
		WAM^	2,681	1,782	1,791	1,815	1,476	1,487	1,473	1,426	1,448	1,465	
Total agriculture land use	thousand hectares	WEM/WOM/WAM	17,489	16,578	15,909	15,306	14,580	13,929	13,344	13,037	12,992	12,940	
Total nitrogen fertiliser	thousand tonnes per year	WEM/WAM	59	151	189	355	341	429	470	450	424	398	
		WOM	59	151	189	355	341	429	470	455	456	456	

Key underlying assumptions	Unit	Scenarios	Historical								Projected	
			1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Total annual milk production	million litres per year	WEM/WAM	7,199	8,957	11,630	14,103	16,483	21,253	21,148	20,734	20,935	21,058
		WOM	7,199	8,959	11,638	14,114	16,500	21,290	21,217	20,893	21,639	22,461
Total Dairy Cows	thousand head	WEM/WAM	3,302	3,839	4,316	5,152	5,861	6,698	6,361	6,055	5,875	5,709
		WOM	3,302	3,840	4,319	5,156	5,867	6,710	6,382	6,101	6,072	6,089
Total Beef Cows	thousand head	WEM	4,526	5,048	4,644	4,447	4,101	3,670	3,890	3,710	3,448	3,273
		WOM	4,526	5,050	4,651	4,457	4,115	3,695	3,941	3,830	3,704	3,660
		WAM	4,526	5,048	4,644	4,447	4,101	3,670	3,890	3,704	3,421	3,226
Total Sheep	thousand head	WEM	60,569	49,466	45,680	39,271	32,384	29,803	26,822	23,918	22,428	21,075
		WOM	60,569	49,488	45,755	39,353	32,497	30,010	27,173	24,692	24,095	23,569
		WAM	60,569	49,466	45,680	39,271	32,384	29,803	26,822	23,881	22,255	20,775
Total Lambs	thousand head	WEM	39,997	37,018	34,840	33,226	28,152	25,833	23,172	21,466	20,537	19,683
		WOM	39,997	37,034	34,897	33,296	28,250	26,012	23,476	22,160	22,064	22,012
		WAM	39,997	37,034	34,897	33,296	28,250	26,012	23,476	21,432	20,379	19,403
Total Deer	thousand head	WEM	780	1,231	1,677	1,757	1,146	958	810	756	676	618
		WOM	780	1,232	1,680	1,761	1,150	965	821	780	726	691
		WAM	780	1,232	1,680	1,761	1,150	965	821	755	671	609
Afforestation	hectares	WEM	14,512	64,101	32,863	12,010	10,513	5,937	41,111	43,476	38,067	38,067
		WAM	14,512	64,101	32,863	12,010	10,513	5,937	41,111	55,226	50,519	50,519
		Low	14,512	64,101	32,863	12,010	10,513	5,937	41,111	51,867	46,287	46,287
		High	14,512	64,101	32,863	12,010	10,513	5,937	41,111	35,123	29,885	29,885
Deforestation	hectares	WEM/WAM	1,844	1,844	4,591	16,668	10,069	8,523	2,506	1,933	1,933	1,933
		Low	1,844	1,844	4,591	16,668	10,069	8,523	2,506	1,067	1,067	1,067
		High	1,844	1,844	4,591	16,668	10,069	8,523	2,506	3,244	3,244	3,244

Key underlying assumptions	Unit	Scenarios	Historical								Projected	
			1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Managed waste tonnage	kilotonnes	WEM	2,607	3,033	2,806	3,081	2,511	3,208	3,495	3,533	3,645	3,777
managed LFG sites only waste	kilotonnes	WEM	1,433	1,688	1,575	1,881	2,308	3,017	3,248	3,192	3,342	3,449
managed non-LFG sites only waste	kilotonnes	WEM	1,175	1,345	1,231	1,200	225	205	135	142	94	67
non-MSW landfills waste	kilotonnes	WEM	2,604	2,917	3,433	4,161	4,500	5,093	5,093	5,093	5,093	5,093
farm waste (buried)	kilotonnes	WEM	784	663	746	621	578	533	476	510	499	490
farm waste (burned)	kilotonnes	WEM	784	663	746	621	578	533	476	510	499	490
composted waste tonnage	kilotonnes	WEM	27	30	33	37	71	224	399	472	506	526
AD waste tonnage	kilotonnes	WEM	0	0	0	0	0	0	0	60	75	90
Total number of farms	number	WEM	80,904	68,776	NE	64,488	59,907	55,263	49,288	52,858	51,716	50,755
Combined Population & GDP scaling factor from 2020 projections (Waste sector)	factor	Low	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.95	0.91
Combined Population & GDP scaling factor from 2020 projections (Waste sector)	factor	High	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.05	1.09

Note: CO₂-e = carbon dioxide equivalent; GDP = gross domestic product; HFCs = hydrofluorocarbons; NA = not applicable; WAM = with additional measures; WEM = with existing measures; WOM = without measures; Low = Low emissions variation of the WEM scenario, High = High emissions variation of the WEM scenario. *Ozone Layer Protection Act 1996 regulations as at 10 December 2018, Schedules 6+1AA, relating to a High Court amendment. ^This includes numbers on native afforestation from the modelled CERF forestry initiatives.

C.2: Information on updated emissions projections

Table C.2.1: Information on updated greenhouse gas emissions (with measures) (CTF Table 6a)

GHG emissions projections	GHG emissions and removals							GHG emissions projections		
	Base year 1990 (kt CO ₂ -e)	1995 (kt CO ₂ -e)	2000 (kt CO ₂ -e)	2005 (kt CO ₂ -e)	2010 (kt CO ₂ -e)	2015 (kt CO ₂ -e)	2020 (kt CO ₂ -e)	2025 (kt CO ₂ -e)	2030 (kt CO ₂ -e)	2035 (kt CO ₂ -e)
Sector										
Energy	15,751.70	15,618.56	18,370.71	21,586.33	18,898.06	18,600.46	18,285.00	13,589.80	12,050.37	10,990.54
Transport	8,126.19	10,247.56	11,648.31	13,063.44	13,349.43	13,805.24	13,176.42	15,111.28	14,798.50	13,754.28
Industry/industrial processes	3,579.92	3,174.43	3,443.22	4,061.65	4,591.13	5,137.32	4,618.35	4,019.60	3,910.28	3,717.95
Agriculture	33,792.88	35,734.70	37,614.88	39,571.90	37,711.50	39,415.79	39,425.54	37,432.57	36,298.76	35,329.96
Forestry/LULUCF	-21,229.22	-22,445.90	-26,934.90	-25,424.54	-29,326.27	-26,610.16	-23,313.25	-9,532.97	-12,013.71	-25,476.16
Waste management/waste	3,943.11	4,234.51	4,434.56	4,378.30	3,871.67	3,487.83	3,268.87	3,137.90	2,982.49	2,884.33
Tokelau (Other)	3.17	3.14	3.49	4.49	4.52	3.42	4.18	3.56	3.51	3.46
Gas										
CO ₂ emissions including net CO ₂ from LULUCF	3,878.45	5,102.66	4,831.02	11,490.90	5,035.98	8,826.78	10,790.52	21,401.44	17,051.54	1,466.04
CO ₂ emissions excluding net CO ₂ from LULUCF	25,502.51	28,003.49	32,246.01	37,424.07	34,811.08	35,813.11	34,456.75	31,284.66	29,415.51	27,292.45
CH ₄ emissions including CH ₄ from LULUCF	33,041.22	34,314.43	36,021.62	36,633.80	34,856.74	35,066.39	34,354.60	32,657.63	31,592.07	30,762.47
CH ₄ emissions excluding CH ₄ from LULUCF	32,972.51	34,237.19	35,951.60	36,522.93	34,764.35	34,989.09	34,272.94	32,571.33	31,505.77	30,676.17
N ₂ O emissions including N ₂ O from LULUCF	6,118.17	6,947.71	7,406.82	8,328.06	8,036.12	8,485.51	8,735.10	8,381.61	8,157.57	7,948.45
N ₂ O emissions excluding N ₂ O	5,792.05	6,570.02	6,996.74	7,930.30	7,679.68	8,186.65	8,463.78	8,117.66	7,893.62	7,684.50

GHG emissions projections	GHG emissions and removals						GHG emissions projections			
	Base year 1990 (kt CO ₂ -e)	1995 (kt CO ₂ -e)	2000 (kt CO ₂ -e)	2005 (kt CO ₂ -e)	2010 (kt CO ₂ -e)	2015 (kt CO ₂ -e)	2020 (kt CO ₂ -e)	2025 (kt CO ₂ -e)	2030 (kt CO ₂ -e)	2035 (kt CO ₂ -e)
from LULUCF										
HFCs	0.00	24.52	233.65	694.01	1,100.81	1,386.17	1,480.29	1,302.98	1,209.46	1,006.70
PFCs	909.95	153.28	67.61	69.38	47.56	58.59	87.92	0.00	0.00	0.00
SF ₆	19.97	24.42	19.56	25.41	22.84	16.46	16.69	18.08	19.55	20.70
NF ₃										
Other gases										
Total with LULUCF	43,967.76	46,567.01	48,580.27	57,241.57	49,100.05	53,839.90	55,465.11	63,761.75	58,030.20	41,204.35
Total without LULUCF	65,196.98	69,012.91	75,515.17	82,666.10	78,426.32	80,450.06	78,778.37	73,294.72	70,043.91	66,680.52

Table C.2.2: Information on updated greenhouse gas emissions (without measures) (CTF Table 6b)

GHG emissions projections	GHG emissions and removals						GHG emissions projections			
	Base year 1990 (kt CO ₂ -e)	1995 (kt CO ₂ -e)	2000 (kt CO ₂ -e)	2005 (kt CO ₂ -e)	2010 (kt CO ₂ -e)	2015 (kt CO ₂ -e)	2020 (kt CO ₂ -e)	2025 (kt CO ₂ -e)	2030 (kt CO ₂ -e)	2035 (kt CO ₂ -e)
Sector										
Energy	15,751.70	15,618.56	18,370.71	21,586.33	18,898.06	18,600.46	18,285.00	15,912.53	16,052.42	15,986.22
Transport	8,126.19	10,247.56	11,648.31	13,063.44	13,349.43	13,805.24	13,176.42	15,328.82	15,232.69	14,411.54
Industry/industrial processes	3,579.92	3,181.18	3,453.29	4,043.88	4,557.14	5,127.74	4,609.13	4,246.68	4,220.83	4,100.84
Agriculture	33,792.88	35,734.70	37,614.88	39,571.90	37,711.50	39,561.83	39,821.96	38,225.91	38,346.42	38,597.10
Forestry/LULUCF	-21,229.22	-22,474.82	-26,648.51	-30,839.55	-28,206.15	-24,800.91	-17,043.47	-2,370.87	1,482.20	-4,860.59
Waste management/waste	3,943.11	4,234.51	4,434.56	4,378.30	4,298.26	4,090.63	3,846.43	3,777.36	3,707.31	3,660.03

GHG emissions projections	GHG emissions and removals						GHG emissions projections			
	Base year 1990 (kt CO ₂ -e)	1995 (kt CO ₂ -e)	2000 (kt CO ₂ -e)	2005 (kt CO ₂ -e)	2010 (kt CO ₂ -e)	2015 (kt CO ₂ -e)	2020 (kt CO ₂ -e)	2025 (kt CO ₂ -e)	2030 (kt CO ₂ -e)	2035 (kt CO ₂ -e)
Tokelau (Other)	3.17	3.14	3.49	4.49	4.52	3.42	4.18	3.56	3.51	3.46
Gas										
CO ₂ emissions including net CO ₂ from LULUCF	3,878.45	5,073.74	5,117.40	6,075.88	6,156.10	10,636.04	17,060.31	31,085.54	34,992.06	27,777.47
CO ₂ emissions excluding net CO ₂ from LULUCF	25,502.51	28,003.49	32,246.01	37,424.07	34,811.08	35,813.11	34,456.75	33,806.67	33,860.11	32,988.32
CH ₄ emissions including CH ₄ from LULUCF	33,041.22	34,314.43	36,021.62	36,633.80	35,283.33	35,797.05	35,274.02	33,974.84	33,962.43	34,114.87
CH ₄ emissions excluding CH ₄ from LULUCF	32,972.51	34,237.19	35,951.60	36,522.93	35,190.94	35,719.75	35,192.36	33,888.54	33,876.13	34,028.57
N ₂ O emissions including N ₂ O from LULUCF	6,118.17	6,947.71	7,406.82	8,328.06	8,036.12	8,503.68	8,789.66	8,515.45	8,551.33	8,595.97
N ₂ O emissions excluding N ₂ O from LULUCF	5,792.05	6,570.02	6,996.74	7,930.30	7,679.68	8,204.82	8,518.34	8,251.50	8,287.37	8,332.01
HFCs	0.00	31.27	243.72	676.24	1,066.82	1,376.59	1,471.07	1,530.06	1,520.01	1,389.59
PFCs	909.95	153.28	67.61	69.38	47.56	58.59	87.92	0.00	0.00	0.00
SF ₆	19.97	24.42	19.56	25.41	22.84	16.46	16.69	18.08	19.55	20.70
NF ₃										
Other gases										
Total with LULUCF	43,967.76	46,544.84	48,876.73	51,808.78	50,612.77	56,388.41	62,699.65	75,123.98	79,045.38	71,898.60
Total without LULUCF	65,196.98	69,019.65	75,525.24	82,648.34	78,818.92	81,189.32	79,743.12	77,494.85	77,563.18	76,759.19

Table C.2.3: Information on updated greenhouse gas emissions (with additional measures) (CTF Table 6c)

GHG emissions projections	GHG emissions and removals							GHG emissions projections		
	Base year 1990 (kt CO ₂ -e)	1995 (kt CO ₂ -e)	2000 (kt CO ₂ -e)	2005 (kt CO ₂ -e)	2010 (kt CO ₂ -e)	2015 (kt CO ₂ -e)	2020 (kt CO ₂ -e)	2025 (kt CO ₂ -e)	2030 (kt CO ₂ -e)	2035 (kt CO ₂ -e)
Sector										
Energy	15,751.70	15,618.56	18,370.71	21,586.33	18,898.06	18,600.46	18,285.00	13,588.01	11,337.69	10,487.54
Transport	8,126.19	10,247.56	11,648.31	13,063.44	13,349.43	13,805.24	13,176.42	15,111.28	14,798.50	13,754.28
Industry/industrial processes	3,579.92	3,174.43	3,443.22	4,061.65	4,591.13	5,137.32	4,618.35	3,940.12	3,810.65	3,475.91
Agriculture	33,792.88	35,734.70	37,614.88	39,571.90	37,711.50	39,415.79	39,425.54	37,390.57	36,165.29	35,107.74
Forestry/LULUCF	-21,229.22	-22,445.90	-26,934.90	-25,424.54	-29,326.27	-26,610.16	-23,313.25	-9,637.74	-13,427.64	-28,033.03
Waste management/waste	3,943.11	4,234.51	4,434.56	4,378.30	3,871.67	3,487.83	3,268.87	3,137.78	2,840.35	2,661.09
Tokelau (Other)	3.17	3.14	3.49	4.49	4.52	3.42	4.18	3.56	3.51	3.46
Gas										
CO ₂ emissions including net CO ₂ from LULUCF	3,878.45	5,102.66	4,831.02	11,490.90	5,035.98	8,826.78	10,790.52	21,294.87	14,924.93	-1,593.83
CO ₂ emissions excluding net CO ₂ from LULUCF	25,502.51	28,003.49	32,246.01	37,424.07	34,811.08	35,813.11	34,456.75	31,282.87	28,702.83	26,789.45
CH ₄ emissions including CH ₄ from LULUCF	33,041.22	34,314.43	36,021.62	36,633.80	34,856.74	35,066.39	34,354.60	32,620.78	31,319.35	30,330.58
CH ₄ emissions excluding CH ₄ from LULUCF	32,972.51	34,237.19	35,951.60	36,522.93	34,764.35	34,989.09	34,272.94	32,534.48	31,233.05	30,244.28
N ₂ O emissions including N ₂ O from LULUCF	6,118.17	6,947.71	7,406.82	8,328.06	8,036.12	8,485.51	8,735.10	8,376.34	8,154.69	7,934.89
N ₂ O emissions excluding N ₂ O from LULUCF	5,792.05	6,570.02	6,996.74	7,930.30	7,679.68	8,186.65	8,463.78	8,112.38	7,890.73	7,670.93

GHG emissions projections	GHG emissions and removals							GHG emissions projections		
	Base year 1990 (kt CO ₂ -e)	1995 (kt CO ₂ -e)	2000 (kt CO ₂ -e)	2005 (kt CO ₂ -e)	2010 (kt CO ₂ -e)	2015 (kt CO ₂ -e)	2020 (kt CO ₂ -e)	2025 (kt CO ₂ -e)	2030 (kt CO ₂ -e)	2035 (kt CO ₂ -e)
HFCs	0.00	24.52	233.65	694.01	1,100.81	1,386.17	1,480.29	1,223.50	1,109.83	764.66
PFCs	909.95	153.28	67.61	69.38	47.56	58.59	87.92	0.00	0.00	0.00
SF ₆	19.97	24.42	19.56	25.41	22.84	16.46	16.69	18.08	19.55	20.70
NF ₃										
Other gases										
Total with LULUCF	43,967.76	46,567.01	48,580.27	57,241.57	49,100.05	53,839.90	55,465.11	63,533.58	55,528.35	37,457.00
Total without LULUCF	65,196.98	69,012.91	75,515.17	82,666.10	78,426.32	80,450.06	78,778.37	73,171.32	68,955.99	65,490.02

Appendix D: New Zealand's report on the Global Climate Observing System

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Executive summary

This report describes Aotearoa New Zealand's major observation programmes for atmospheric, terrestrial and oceanic measurements, in accordance with the revised United Nations Framework Convention on Climate Change reporting guidelines on global climate observing systems (Decision 11/CP.13).

Environmental observations related to Global Climate Observing System (GCOS) Essential Climate Variables (ECVs) are funded and carried out in New Zealand by multiple providers, including:

- sub-national and local authorities (local authorities and others)
- Crown research institutes: National Institute of Water and Atmospheric Research Ltd (NIWA), Institute of Geological and Nuclear Sciences Limited (GNS Science) and others
- state-owned enterprises: Meteorological Service of New Zealand Limited (MetService) and some of the energy companies
- public service departments: Toitū Te Whenua Land Information New Zealand (LINZ), Department of Conservation, Waka Kotahi NZ Transport Agency, Fire and Emergency New Zealand and others
- private organisations: energy companies, irrigation companies and others.

Various national initiatives are in place to ensure consistent and comprehensive environmental monitoring across New Zealand. Supported by recent advances in data management standards and tools, data providers and institutions are working on building up comprehensive institutional and cross-institutional catalogues about New Zealand observation data holdings.

New Zealand has four primary observation programmes related to ECVs, which are funded and carried out through various agencies.

1. Surface climate observations, upper air observations and atmospheric constituent measurements undertaken by MetService and NIWA are provided to the GCOS Global Observing Network.
2. Surface ocean observations are carried out by a range of organisations (eg, port companies, local authorities, NIWA, GNS Science, LINZ), with five sea-level stations included in the Global Sea Level Observing System network.
3. New Zealand contributes to the Voluntary Observing Ships and Argo programmes. Ocean water column observations are carried out by NIWA, as part of research and commercial projects and voyages that have defined scopes and timeframes, so observation locations and methods change.
4. Land observations are conducted in New Zealand by a variety of organisations, with most routine observations being carried out by local authorities. These include freshwater observations (groundwater levels and quality, lake level and quality, river levels, flows and quality) and vegetation surveys. Additional ongoing and ad hoc (project based) observations are carried out by NIWA, Manaaki Whenua Landcare Research and the Department of Conservation (among others). NIWA provides river level, flow and water quality data to the Global Runoff Data Centre (GRDC) and United Nations Environment Programme Global Environment Monitoring System for Freshwater (GEMS/Water) programme.

Introduction

Aotearoa New Zealand maintains observation programmes for atmospheric, terrestrial and oceanic measurements for a suite of Global Climate Observing System (GCOS)⁶¹³ Essential Climate Variables (ECVs).⁶¹⁴ These measurements are complemented by archives of historical observations of climate-related parameters. The New Zealand GCOS ECVs observation programmes are detailed in this report and presented in accordance with the revised United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines on global climate change observing systems.⁶¹⁵ These guidelines focus on the contribution of Parties to the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC.

⁶¹³ <https://gcos.wmo.int/>

⁶¹⁴ <https://gcos.wmo.int/en/essential-climate-variables>

⁶¹⁵ UNFCCC. 2008. *Decision 11/CP.13 Reporting on global observing systems for climate*, FCCC/CP/2007/6/Add.2. Retrieved from <http://unfccc.int/resource/docs/2007/cop13/eng/06a02.pdf> (12 September 2022).

Observations in New Zealand: Context

Data is collected by multiple agencies

In Aotearoa New Zealand, GCOS ECVs observations are funded and carried out by multiple providers, including the following:

- sub-national and local authorities: regional and local councils and others
- Crown research institutes: National Institute of Water and Atmospheric Research Ltd (NIWA), Institute of Geological and Nuclear Sciences Limited (GNS Science) and others
- state-owned enterprises: Meteorological Service of New Zealand Limited (MetService) and some of the energy companies
- public service departments: Toitū Te Whenua Land Information New Zealand (LINZ), Department of Conservation, Waka Kotahi NZ Transport Agency, Fire and Emergency New Zealand and others
- private organisations: energy companies, irrigation companies and others.

Some observations are mandated by legislation or policy or covered by agreements between institutions. Most observations are related to operational requirements and might change over time (see next section). Voluntary coordination is happening between organisations, to ensure national consistency and comprehensiveness, as outlined below.

High-quality observations versus ‘fit-for-purpose’

GCOS ECVs observations are used for many practical purposes, including regional management of environmental resources or mitigation of hazards, for example:

- local authorities operate flood warning monitoring networks on major rivers
- Fire and Emergency New Zealand operates a network of weather stations for fire warning purposes
- energy companies operate river and lake monitoring networks for hydro-energy resource and consent management
- data are collected through various private entities to support and control consented operations, such as irrigation.

Because the data are collected for different purposes, different collection standards are used, and often the data collection for a station is optimised for its purpose. For example, at a flood recording site, water level would be recorded only to a low accuracy, whereas at a site consented for water abstraction, accurate level recording is imperative, to ensure consent conditions are met. Consequently, it is often not easy to ‘reuse’ the data for a different purpose or to combine data collected in different networks. This problem has been recognised and is being addressed through national initiatives aimed at facilitating better monitoring network integration across different providers and working towards best practices in monitoring to fulfil a variety of purposes.

National coordination

National coordination and clearly defined institutional arrangements are paramount, to ensure national-scale data are collected to consistent standards and are sufficiently representative to support national-level reporting. In Aotearoa New Zealand, several legislative frameworks and programmes and projects are relevant to data collection, including the following.

Legislative frameworks

- The **Declaration on Open and Transparent Government** was approved by the New Zealand Government on 8 August 2011⁶¹⁶ and requires government agencies to commit to actively releasing high-value public data for reuse. The related **Principles for managing data and information held by the New Zealand Government** provide guidelines on principles to be used to make non-personal, government-held data and information more widely available, discoverable and easily usable. The principles help facilitate agencies' release of the non-personal, government-held data and information that people, communities and businesses want to use and reuse. The related **New Zealand Government Open Access and Licensing framework** (NZGOAL) is all-of-government guidance for agencies to follow when releasing copyright works, non-copyright and public domain material for reuse by others.
- The **Environmental Reporting Act 2015**⁶¹⁷ mandates that the Government Statistician and the Secretary for the Environment have responsibility for national environmental reporting in New Zealand. The Act further mandates that environmental reporting is conducted in line with the principles and protocols for producers of Tier 1 statistics (see below). The Act is supported through a framework that divides the environment into five environmental domains for reporting (and further into 'topics'). Under each domain, reporting is conducted on three main types of information: pressures, states and impacts. The Act has increased demand for consistently monitored data and triggered some of the national programmes and activities below.

National programmes and activities

- **Tier 1 statistics**⁶¹⁸ are compiled by Stats NZ as a set of national statistics for understanding how New Zealand is performing. Tier 1 statistics need to be relevant, authoritative and trustworthy, provide long-term continuity, and enable international comparability. Environmental Tier 1 statistics currently available cover marine protected areas, natural resource and environment accounts, and human-induced greenhouse gas emissions and removals. Environmental Tier 1 statistics under development include air quality, stratospheric ozone, soil health, freshwater quality and use, coastal and recreational water quality, marine biodiversity, terrestrial ecosystem health and atmosphere, and ocean climate change. Tier 1 statistics rely on consistent and comprehensive national data sets. For this reason, when developing new environmental Tier 1 statistics, it is necessary to increase efforts to ensure consistency, representativeness and longevity in the data collected across different agencies.

⁶¹⁶ <https://www.data.govt.nz/toolkit/policies/declaration-on-open-and-transparent-government>

⁶¹⁷ <https://www.mfe.govt.nz/more/environmental-reporting/about-act>

⁶¹⁸ <https://www.stats.govt.nz/about-us/legislation-policies-and-guidelines#tier-1-stats>

- Stats NZ maintains a programme for collecting information about **environmental indicators**. The indicators provide technical information on the state of New Zealand's: 1) air, 2) marine environment, 3) fresh water, 4) atmosphere and climate, 5) land, and 6) biodiversity (a cross-domain area).⁶¹⁹
- **National Environmental Monitoring Standards (NEMS)**⁶²⁰ is a multi-agency project, led by local authorities, NIWA and energy companies, supported by the Ministry for the Environment (MfE), to develop and implement national monitoring standards to support and ensure consistency of observation and environmental data across New Zealand. NEMS has produced several standards documents to date, mainly focusing on freshwater monitoring, and further standards are under development. In addition, NEMS champions workshops to support data collection agencies to implement those standards. An important 'backbone' of the NEMS system is the National Quality Coding Scheme⁶²¹ that ensures data coming from multiple agencies are annotated with a consistent data quality code.
- **Environmental monitoring and reporting (EMaR)** is a multi-agency project by local authorities and MfE, with the goal of developing a standardised national framework to support national environmental state of the environment reporting. The project has developed a framework for national monitoring, based on institutionally operated (but nationally optimised) monitoring networks.⁶²²

As part of EMaR, **Land, Air, Water Aotearoa (LAWA)**⁶²³ is an initiative by local authorities to provide a national mechanism and presentation layer for combining regional environmental monitoring data sets. The project has successfully demonstrated this collaborative approach by collating land, fresh water, coastal and air quality information, and displaying it on the LAWA website.

National data archives and data centres

Various data management and data archive facilities exist in Aotearoa New Zealand and are maintained by agencies, typically based on institutional and cross-institutional initiatives. A set of 'nationally significant databases' has been maintained over the past decades by individual institutions, and supported by the Government, as archives of important data sources.⁶²⁴ Contribution to these data sets is voluntary. Table D.1 lists GCOS-relevant New Zealand data archives.

⁶¹⁹ <https://www.stats.govt.nz/tools/environmental-indicators>

⁶²⁰ <https://www.nems.org.nz>

⁶²¹ <https://www.nems.org.nz/documents/quality-code-schema>

⁶²² <https://environment.govt.nz/facts-and-science/environmental-reporting/improving-environmental-reporting-data>

⁶²³ <https://www.lawa.org.nz>

⁶²⁴ <https://www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/strategic-science-investment-fund/funded-infrastructure/nationally-significant-collections-and-databases>

Table D.1: GCOS-relevant data sets and archives in New Zealand (not a comprehensive list)

Data archive / facility	Organisation	Support / context	Content
Atmosphere			
Climate database	NIWA	Nationally Significant Database / Collection	Data from historical and operating climate stations; about 10,000 stations
Greenhouse gas surface observations	NIWA	Supported by NIWA	Trace gases are measured continuously at Baring Head, Lauder and Arrival Heights (Antarctica) and submitted to international data archives
Upper atmosphere constituents' observations	NIWA	Supported by NIWA	Trace gases measured at Lauder and Arrival Heights (Antarctica) and submitted to international data archives
Ocean			
Sea-level data	NIWA	Supported by NIWA	Data collated from 17 sea-level monitoring sites (operated by various organisations)
Sea-level data	LINZ	Supported by LINZ	Data archived from port companies, regional councils and NIWA
New Zealand Ocean Data Network	NIWA	Supported by NIWA	Data archive for ocean physical and chemical observations; more than 2 million observations
National Invertebrate Collection	NIWA	Nationally Significant Database / Collection	Marine invertebrate specimen collection from New Zealand region, the southwest Pacific and the Ross Sea, Antarctica; more than 100,000 observations
Southwestern Pacific Ocean Biogeographic Information System Node	NIWA	Supported by NIWA	Marine biological observations from New Zealand, provided to the Ocean Biogeographic Information System and the Global Biodiversity Information Facility (GBIF); more than 2 million observations
Bathymetry data	NIWA	Supported by NIWA, delivered through the NIWA Geospatial Data Service	Bathymetry model of New Zealand as a 250 metre resolution raster; a compilation of data digitised from published coastal charts, digital soundings archive, navy collector sheets and digital multibeam data sourced from surveys
Bathymetry data	LINZ	Supported by LINZ, delivered through the LINZ Data Service	Various bathymetry data sets for areas around New Zealand, Pacific and Antarctica
Land			
Water Resources Archive	NIWA	Nationally Significant Database / Collection	Data from historical and operating river flow, lake level and water quality observations; about 1000 stations
National Groundwater Database	GNS Science	Nationally Significant Database / Collection	Reference data set of groundwater quality data from about 100 stations
Freshwater Fish Database	NIWA	Nationally Significant Database / Collection	Freshwater fish observations; more than 100,000 observations

Data archive / facility	Organisation	Support / context	Content
Land Cover Database	Manaaki Whenua Landcare Research	Funded by MfE, generated by MWLR, delivered through MWLR LRIS	The LCDB is a multi-temporal, thematic classification of New Zealand's land cover
National Soils Database	Manaaki Whenua Landcare Research	Supported by MWLR, delivered through MWLR LRIS and NZDR	'Point' database containing descriptions of about 1500 New Zealand soil profiles, together with analytical data on their chemical, physical and mineralogical characteristics
S-map	Manaaki Whenua Landcare Research	Supported by MWLR, delivered through S-MAP Online and LRIS	Ongoing project to map New Zealand's soil resources at a nominal 1:50,000 scale
National Vegetation Survey Databank	Manaaki Whenua Landcare Research	Nationally Significant Database / Collection	Physical archive and electronic databank containing records of more than 120,000 vegetation survey plots, including more than 25,000 permanent plots
National biodiversity monitoring	Department of Conservation	Supported by Department of Conservation	Data archive for terrestrial monitoring programme for about 1400 biodiversity survey plots
Land, Air, Water Aotearoa	Local authorities	Supported by local authorities, MfE	Consolidation and portal for local authorities' environmental observations
New Zealand Digital River Network	NIWA	Supported by NIWA, delivered through the NIWA Geospatial Data Service	Database of digital river segments and related catchments for New Zealand
Elevation Aotearoa	LINZ	Supported by LINZ, delivered through the LINZ Data Service	Various high-resolution elevation data sets for New Zealand derived from LIDAR surveys
Lake Submerged Plant Indicators	NIWA	Supported by NIWA	Database of ecological conditions of over 200 lakes across New Zealand, described by observations and derived indicators
New Zealand Land Resource Inventory	Manaaki Whenua Landcare Research	Supported by MWLR, delivered through LRIS	National spatial database of physical land resource information. It comprises an inventory of five physical factors (rock type, soil, slope, present type and severity of erosion, and vegetation)
Other / generic			
LINZ Data Service	LINZ	Supported by LINZ	Various geospatial and related data from LINZ
MfE Data Service	MfE	Supported by MfE	Various environmental datasets published by MfE
NIWA Geospatial Data	NIWA	Supported by NIWA	Various geospatial datasets, including environmental classifications
Land Resource Information System (LRIS)	Manaaki Whenua Landcare Research	Nationally Significant Database / Collection	Geospatial data repository holding over 200 land resource data layers for Aotearoa – New Zealand

Note: LCDB = Land Cover DataBase; LIDAR = light detection and ranging; LINZ = Toitū Te Whenua Land Information New Zealand; LRIS = Land Resource Information System; MfE = Ministry for the Environment; MWLR = Manaaki Whenua Landcare Research; NIWA = National Institute of Water and Atmospheric Research; NZDR = National Soils Data Repository.

Data standards, catalogues and registers

As noted, environmental data are collected and managed in New Zealand by multiple data providers and agencies. Data integration and access is supported through standards and tools. This includes approaches for consistent data collection and quality assurance (eg, through the NEMS initiative, see above), data management, data discovery and data delivery.

The development of standards and tools is often supported through international organisations, such as the International Organization for Standardization (ISO), the World Meteorological Organization (WMO), the Open Geospatial Consortium (OGC), the Global Biodiversity Information Facility (GBIF),⁶²⁵ the Integrated Marine Observing System (IMOS),⁶²⁶ the Group on Earth Observations (GEO), and others. Data standards support the WMO Information System (WIS) through improving the availability of consistent environmental data.⁶²⁷

This area of work also includes catalogues contributing to international archives, such as the GBIF and IMOS.

To support improved data discovery, a variety of data providers are working on building up catalogues of data holdings; for example, the: LINZ Data Service,⁶²⁸ MfE Data Service,⁶²⁹ GNS Science Dataset Catalogue,⁶³⁰ NIWA Data Catalogue,⁶³¹ Manaaki Whenua Landcare Research Land Resource Information System (LRIS)⁶³² and Manaaki Whenua Landcare Research Datastore.⁶³³

Efforts have been made to aggregate these catalogues into national registries, for example, the: New Zealand Government Data Catalogue,⁶³⁴ National Environmental Data Centre (NEDC)⁶³⁵ and LAWA.⁶³⁶

Pacific Island region coordination and capacity building

Under a joint partnership of the Secretariat of the Pacific Regional Environment Programme (SPREP) and Met Office UK Pacific Trust Fund, the MetService helps in the management and operation of the GCOS Upper Air Network (GUAN) stations in Tuvalu (Funafuti) and Kiribati (Tarawa). Help is in the form of annual in-country maintenance trips and the provision of remote technical assistance (pandemic restrictions have meant no travel to the Pacific since late 2019, and the maintenance trips will be resumed once restrictions are lifted). MetService

⁶²⁵ <https://www.gbif.org>

⁶²⁶ <https://imos.org.au>

⁶²⁷ <https://community.wmo.int/activity-areas/wis>

⁶²⁸ <https://data.linz.govt.nz>

⁶²⁹ <https://data.mfe.govt.nz>

⁶³⁰ <http://data.gns.cri.nz/metadata>

⁶³¹ <http://dc.niwa.co.nz>

⁶³² <https://lris.scinfo.org.nz>

⁶³³ <https://datastore.landcareresearch.co.nz>

⁶³⁴ <https://data.govt.nz>

⁶³⁵ <https://nedc.nz>

⁶³⁶ <https://www.lawa.org.nz>

manages the Wellington Regional Telecommunications Hub as part of the WMO Information System, through which weather observation data from the Pacific are disseminated to global modelling and climate centres. Pacific Island countries and territories' national meteorological centres have access to many GCOS ECVs data, information and products through the MetConnect Pacific website, which is hosted by MetService. The MetConnect Pacific website is the hub for the WMO-led Severe Weather Forecasting Programme for the South Pacific.

NIWA works with the United Nations Development Programme under the Global Environment Facility, and with other bilateral arrangements and partner agencies, to support climate adaptation work in several Pacific Island countries and territories, including Fiji, Kiribati, Samoa and Solomon Islands. NIWA has collaborated with the Australian Bureau of Meteorology to develop and install a Pacific climate database (Climate Data for the Environment, CliDE) and associated support for data rescue, quality assurance and climate services. NIWA supports national meteorological and hydrological services in the region with enhancing their national observation networks, related cellular or satellite-based telemetry, and in-country data archiving.

NIWA and MetService are currently working with the United Nations Environment Programme under the Green Climate Fund on "Enhancing Climate Information and Knowledge Services for resilience in 5 island countries of the Pacific Ocean", which includes the provision or upgrade of 58 automatic weather stations (AWS) and 4 shipboard AWS.⁶³⁷

Palaeoclimate data

Several Aotearoa New Zealand Crown research institutes and universities are collecting palaeoclimate archives and generating climate reconstructions from them. Their goals are to provide evidence about how the Earth's past environment was different from the present, including quantification of past warm periods, variability and climate extremes. These archives provide evidence about natural climate changes over time and enlighten us about climate dynamics, climate processes and their drivers. The environmental change signals in these archives extend the context for historical records of limited temporal scope.

Several high-level international palaeoclimate initiatives are coordinated from New Zealand that contribute toward research frameworks of the International Quaternary Union (INQUA) and Past Global Changes (PAGES),⁶³⁸ a core project of the 'Future Earth'⁶³⁹ initiative and a partner of the World Climate Research Programme. The New Zealand contributions include the Southern Hemisphere Assessment of PalaeoEnvironments (SHAPE) international focus group and the Southern Hemisphere glacial maximum (SHeMax) project under the INQUA Palaeoclimate Commission. Several PAGES '2k Network Projects'⁶⁴⁰ also contribute, including climate reconstructions over the past 2000 years in the Aus2k, Iso2k and CoralHydro2k, and over longer time scales in the Speleothem Isotopes Synthesis and Analysis (SISAL) working group.

New Zealand was actively involved in the (now discontinued) international Antarctic Drilling (ANDRILL) programme. ANDRILL retrieved two cores from deeper than 1200 metres in the McMurdo region, providing a unique record of the history of the Ross Ice Shelf and Antarctic

⁶³⁷ <https://www.greenclimate.fund/project/fp147>

⁶³⁸ <https://www.pastglobalchanges.org>

⁶³⁹ <https://futureearth.org>

⁶⁴⁰ <https://pastglobalchanges.org/science/wg/2k-network/projects>

ice sheets spanning the past 20 million years and comprising numerous cycles of ice advance and retreat under various climatic conditions. Some data may represent extended periods when the climate was a few degrees warmer and atmospheric carbon dioxide (CO₂) higher than at present, much like that projected for the future under many current climate change scenarios. ANDRILL palaeoclimate data are used with the latest ice sheet models to better predict the future response of Antarctic ice sheets to global warming.

We have a good understanding of palaeoclimatology in specific marine regions (eg, the Chatham Rise, Campbell Plateau, eastern North Island), however, knowledge is sparse in other areas of national and international importance (eg, western New Zealand, south of the Campbell Plateau towards Antarctica, and north of New Zealand to the Tasman Front). Decadal and century-scale records are sparse, except for a few spatially restricted localities along the East Cape of the North Island. For example, core MD97-2121, which shows a rapid sedimentation rate of up to 42 centimetres per 1000 years, yields a detailed record of southwest Pacific Ocean conditions over the last glacial cycle. Recent work in the SHAPE and SHeMax projects has focused on shoring up the spatial and temporal coverage for the past 60,000 years around New Zealand, the Tasman Sea and Southern Ocean.

New Zealand is leading the international Roosevelt Island Climate Evolution (RICE) Project.⁶⁴¹ RICE is a collaboration between New Zealand, Australia, China, Denmark, Germany, Italy, Sweden, the United Kingdom and United States. The project recovered one ice core to a depth of 764 metres from Roosevelt Island in Antarctica to help understand the stability of the Ross Ice Shelf and West Antarctica in a warming world. The RICE core was processed in the New Zealand National Ice Core Research Facility at GNS Science and has produced paleoclimate reconstructions with sub-annual resolution for the past 2700 years and at least decadal resolution for the past 60,000 years. The data provide records of near-instrument quality time series of temperature, snow accumulation, sea-surface temperature, sea-ice extent, marine primary productivity, and atmospheric greenhouse gas concentrations of methane (CH₄) and CO₂. The paleoclimate reconstructions are used in earth system and ice sheet models to quantify the sensitivity of the Ross Ice Shelf and West Antarctica to warming, and to assess the potential contribution of this region to future sea-level rise.

Over the past decade, a rigorous assessment of available temperature reconstructions for the past 2000 years (through PAGES2k) has supported the production of a robust global data set and temperature synthesis. This data set is an important evaluation tool for the performance of climate models providing future projections. Only records with excellent age control, sufficient resolution and a demonstrated robust temperature proxy were included in the global data base, after careful assessments by the team. New Zealand's contributions to this data set are three ice core records from the Ross Sea region and several tree ring records. The New Zealand national tree ring network included multiple species with other climatic sensitivities that were gathered for but ultimately not included, due to the focus on temperature.

Collectively, these records provide important historic high-resolution baselines for the South Pacific and the southern mid and high latitudes. Significant advances have also been made in the development of a globally unique ancient kauri tree ring archive at NIWA that contains wood discontinuously spanning parts of the last glacial cycle, which is not available anywhere else in the world.

⁶⁴¹ <https://www.victoria.ac.nz/antarctic/research/research-prog/rice>

Ongoing high-resolution palaeoclimatology continues to update the national tree ring network and is adding new annually banded coral records from the southwest Pacific. In addition, several high-resolution (multi-annual to decadal) records are being developed from speleothems and sedimentary archives (including peats and lakes) that are adding more detail from the New Zealand region to the view of continuous climate changes through time. Precise chronologies of glacier changes in the past, from which temperature reconstructions can be derived, have also emerged from New Zealand's Southern Alps based on cosmogenic surface exposure dating. These emergent data have helped to define the ages of moraine sequences along with ice retreat and advances. These data are being used to challenge long-held views about the causes of Quaternary ice ages.

Essential Climate Variables: Atmosphere

Atmospheric ECVs that can be feasibly measured and are relevant to the UNFCCC (according to GCOS⁶⁴²) relate to surface measurements, upper atmosphere measurements and atmospheric composition measurements:

- **surface:** air temperature, wind speed and direction, water vapour, air pressure, precipitation, radiation budget
- **upper atmosphere:** earth radiation budget (including solar irradiance), upper-air temperature (including microwave sounding unit (MSU) radiances), wind speed and direction, water vapour, cloud properties, number of lightnings
- **atmospheric composition:** aerosol properties (optical depth; single-scattering albedo; layer height; extinction profiles for the troposphere and the lower to middle stratosphere); CO₂, CH₄ and other greenhouse gases; ozone; precursors (nitrogen dioxide tropospheric column; sulfur dioxide, formaldehyde (HCHO) tropospheric columns; carbon monoxide tropospheric column; carbon monoxide tropospheric profile).

General situation: National data collection and support

Three primary observation programmes are ongoing for Aotearoa New Zealand GCOS atmospheric ECVs:

- surface weather observations undertaken by MetService and NIWA
- upper atmosphere weather observations undertaken by MetService and NIWA
- atmospheric constituent measurements undertaken by NIWA.

In addition, New Zealand local authorities, research institutes and private agencies operate several thousand surface meteorological observations for regional and local purposes, especially rainfall and river monitoring for flood hazard management, and air quality monitoring. Observations are often carried out for specific purposes. Instrument and data quality may vary, and station locations can change due to local requirements.

MetService and NIWA both pay particular attention to quality control. NIWA's climate monitoring and archiving programme carries ISO9001 certification, and MetService has ISO9001 certification for the operation of its observing programmes. NIWA is helped by voluntary observers, especially for rainfall monitoring.

⁶⁴² <https://public.wmo.int/en/programmes/global-climate-observing-system/essential-climate-variables> and <https://gcos.wmo.int/en/essential-climate-variables>

NIWA supports its observational programmes and the related quality assurance and archiving systems through government funding from the Ministry of Business, Innovation and Employment for 'Nationally Significant Collections and Databases'⁶⁴³ and its own (government and commercially sourced) funding as part of the New Zealand Crown Research Institutes Act 1992.⁶⁴⁴

MetService supports its data collection, storage and processing operations through a contract with the New Zealand Ministry of Transport.

Surface weather observations

An overview of Aotearoa New Zealand surface meteorological observation history can be found in the 60th anniversary publication of the New Zealand Hydrological Society from 2021.⁶⁴⁵ Currently, 223 stations are operated by NIWA and MetService, as the New Zealand National Climate Station Network (NCSN), and based on various network design criteria. The NCSN aims to cover climate regions, agricultural regions and urban areas, as well as including the National Reference Climate Station Network (NRCSN). The NRCSN is a subset of the national climate network and was established in the late 1980s. It consists of 66 stations (including back-up stations) located across mainland New Zealand, some of the outlying islands (Raoul, Chathams, and Campbell) and the Ross Dependency (Scott Base). This resulted from a recommendation from the 10th session of the WMO Commission for Climatology.

MetService, on behalf of New Zealand, is providing data from 33 weather stations to the Regional Basic Synoptic Network (RBSN) and data from 10 weather stations to international data centres, as part of the GCOS Surface Network (GSN). The GSN stations at Paraparaumu Aerodrome, Hokitika Airport and Invercargill Aerodrome are operated automatically but also have observers on contract providing observations. The other seven stations are automatic and owned and operated by MetService. Detailed metadata for these stations are compiled and site inspections are regularly carried out by NIWA and MetService staff. Copies of inspection reports are available through NIWA's Instrument Systems group in Christchurch. New Zealand is in the process of adding nine more stations to the GSN (ratification through WMO pending).

Pyranometers, pyrgeometers and photometers at NIWA's Lauder Atmospheric Research Station record radiation data submitted to the Baseline Surface Radiation Network (BSRN).⁶⁴⁶

Upper atmosphere observations

As part of the GUAN, Aotearoa New Zealand operates four GUAN stations. New Zealand GUAN stations are at Paraparaumu Aerodrome, Invercargill Aerodrome, Raoul Island and the Royal New Zealand Air Force base Whenuapai. Raoul Island releases one balloon a day, while the three remaining stations each release two balloons a day. All four stations measure

⁶⁴³ <https://www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/strategic-science-investment-fund/funded-infrastructure/nationally-significant-collections-and-databases>

⁶⁴⁴ <https://www.legislation.govt.nz/act/public/1992/0047/latest/DLM264292.html>

⁶⁴⁵ Harper A, Elley G, Pearson, C. 2021. Hydrometeorological monitoring in the last ten years. *Journal of Hydrology New Zealand* 60(2): 3–10. <https://www.hydrologynz.org.nz/journal/volume-60-2021>

⁶⁴⁶ <https://bsrn.awi.de/products/quality-code/comparisons/lauder-lau>

air temperature, humidity, wind speed and wind direction. All stations deploy the Vaisala RS-41SG radiosonde, which uses a global positioning system (GPS) module to calculate wind speed and direction. Currently, the Raoul Island station is out of service due to COVID-19 pandemic-related access constraints, and services will resume once pandemic restrictions allow site access.

The Lauder Atmospheric Research Station is part of the GCOS Reference Upper Air Network (GRUAN). Lauder's radiosonde data, ozonesonde data, frost-point hygrometer data and global navigation satellite system (GNSS) receiver data are all being submitted to GRUAN as part of official data streams. The operational GRUAN radiosondes launched at Invercargill are also being submitted to GRUAN through a partnership between NIWA and MetService. NIWA has provided the Invercargill site with a standard humidity chamber to incorporate into its ground-check operations. The chamber allows the radiosonde humidity sensor to make a measurement in 100 per cent relative humidity. Normally, the radiosonde relative humidity sensors only undergo a 0 per cent relative humidity test. This high humidity calibration point helps to constrain the sensors and identify biases, thereby improving the quality of the water vapour measurements. This partnership between a research GRUAN site and an operational GRUAN site was the first of its kind in the world and is being credited as a great way to pass the best practices of GRUAN sites on to GRUAN sites.

Ross Island, Antarctica, is another GRUAN site that is managed by NIWA as a partnership with the United States Antarctic Program (USAP) and LINZ. Routine radiosonde data from McMurdo Station and GNSS data from a LINZ GNSS receiver near Scott Base, Antarctica, are submitted to GRUAN as active data streams. The distributed site is called the Ross Island GRUAN site, to avoid confusion, because McMurdo Station is already an actively submitting GRUAN site.

Atmospheric constituents measurements

Aotearoa New Zealand has three surface stations (Baring Head, Lauder and Arrival Heights, Antarctica) providing atmospheric constituent data to the World Data Centre for Greenhouse Gases (WDCGG), as part of the Global Atmosphere Watch (GAW) programme.⁶⁴⁷ In situ concentrations of CO₂, methylene (CH₂), carbon monoxide (CO), ozone (O₃) and nitrous oxide (N₂O) are routinely measured at all three stations, either with discrete flask samples or continuous measurements. Stable carbon isotope ratios and radiocarbon content of carbon-bearing gases ($\delta^{13}\text{CO}_2$, $\delta^{13}\text{CH}_4$) are measured at Baring Head and Arrival Heights. Measurements of atmospheric constituents at the NIWA Lauder Atmospheric Research Station are used to validate data from the Greenhouse Gases Observing Satellite (GOSAT),⁶⁴⁸ Orbiting Carbon Observator 2 & 3 (OCO-2 and OCO-3),⁶⁴⁹ the TROPOspheric Monitoring Instrument (TROPOMI),⁶⁵⁰ and form part of the Total Carbon Column Observing Network (TCCON).⁶⁵¹ They will be used in MethaneSAT validation, after its planned launch in 2022/23.⁶⁵²

⁶⁴⁷ <https://gaw.kishou.go.jp>

⁶⁴⁸ <https://www.gosat.nies.go.jp/en>

⁶⁴⁹ https://www.nasa.gov/mission_pages/oco2/index.html and
https://www.nasa.gov/mission_pages/oco3/index.html

⁶⁵⁰ <http://www.tropomi.eu>

⁶⁵¹ <http://www.tcccon.caltech.edu>

⁶⁵² <https://www.methanesat.org>

In collaboration with the United States National Oceanic and Atmospheric Administration (NOAA), continuous in situ ozone measurements at Arrival Heights and Lauder were initiated in 2002 and 2003, respectively. In situ ozone has also been measured at Baring Head since 1991. In August 2006, an in situ Fourier transform spectrometer (FTS) greenhouse gas analyser (CO₂, ¹³CO₂, CH₄, CO and N₂O) was installed, initially to support TCCON measurements; now it is an integral part of the New Zealand CarbonWatch project.⁶⁵³ A Licor-7000 CO₂ analyser was installed in 2008, along with weekly flask sampling (CO₂, ¹³CO₂, CH₄, CO and N₂O), to provide additional measurement redundancy and as part of in situ FTS validation activities. Flask measurements are ongoing, and the Licor-7000 measurements stopped in April 2022 having generated 15 years of overlap validation data. The in situ FTS CO, CH₄ (and CO₂ since 2015) data and CH₄ flask measurements are submitted regularly to the GAW WDCGG database.

Monthly frost-point hygrometer flights are made from Lauder in collaboration with NOAA to measure water vapour profiles into the stratosphere. Complementing the water vapour column data, a GNSS–GPS system was installed at Lauder that started in May 2012.

Vertical ozone profile measurements have been made at Lauder using ozonesondes, a stratospheric ozone LIDAR, a mid-infrared Fourier transform spectrometer (MIR-FTS), a microwave radiometer, and the Umkehr technique using a Dobson instrument. Total column ozone measurements are made at Lauder and Arrival Heights using Dobson spectrophotometers and MIR-FTSs. Such remotely sensed data are routinely submitted to the Network for the Detection of Atmospheric Composition Change (NDACC).⁶⁵⁴

Between 2003 and 2013 (through NOAA, GCOS and NIWA support), New Zealand collected air samples in the data-sparse western Pacific in collaboration with the Japanese National Institute of Environmental Studies (NIES), on a vessel travelling between Nelson (New Zealand) and Osaka (Japan) to analyse the principal greenhouse gases and their latitudinal and inter-hemispheric trends. The data have been submitted to the GAW database. Aerosol measurements made on these transects include high-volume sampling of nutrient species (nitrogen, phosphorus and iron) and continuous condensation nuclei measurements. Microtops sun-photometer readings of aerosol optical depth and ozone were made when sky conditions allowed, and these data are available as part of the National Aeronautics and Space Administration (NASA) Aeronet Maritime Aerosol Network. This programme was discontinued in 2013, when safety regulations reduced the number of berths on the ship, leaving no room for a researcher.

GNS Science holds a 25-year (and ongoing) record of atmospheric black carbon and an 18-year (and ongoing) record of atmospheric multi-site particulate matter elemental composition (sodium to uranium) for filter-based aerosol observations across New Zealand. While these records are directed at air quality management, they also form a record of background atmospheric composition due to the significant marine influence on New Zealand boundary layer aerosol and occasional trans-boundary incursions of aerosol from Australia. The results have been reported regionally (local authorities), nationally (Ministry for the Environment, Ministry of Transport, Ministry of Health) and internationally. Because the analytical techniques are non-destructive, GNS Science maintains a physical archive of the aerosol samples. The aerosol compositional data are held on the National Air Particulate Matter Speciation Database and the metadata are accessible through the GNS Science Data Catalogue.⁶⁵⁵

⁶⁵³ <https://niwa.co.nz/climate/research-projects/carbon-watch-nz>

⁶⁵⁴ <https://www.ndaccdemo.org>

⁶⁵⁵ <https://data.gns.cri.nz/metadata>

Satellite-based measurements

A support and science programme was established in Aotearoa New Zealand in 2021 for the new global MethaneSAT, with a planned satellite launch in late 2023. The satellite, owned by the United States Environmental Defense Fund, aims to monitor and detect major leaks from most of the main global oil and gas infrastructure. The Mission Operations and Control Centre is being developed by Rocket Lab in Auckland. A science programme, including NIWA, University of Auckland, University of Waikato and Manaaki Whenua Landcare Research, is planning to assess capability for detection of agricultural emissions (eg, from ruminant livestock farming and rice cultivation).⁶⁵⁶

Several New Zealand ground-based measurement programmes contribute data for the validation and interpretation of satellite-based measurements. MetService radiosonde observations are used extensively by global (and NIWA's) numerical weather prediction centres to remove forward model biases from radiative transfer models.

In New Zealand, several agencies operate satellite receiver stations and data archives, as outlined below.

MetService operates two satellite reception systems, both of which were relocated from Wellington to Paraparaumu in early 2022. The first receiver ingests imagery for all channels provided by the Japan Meteorological Agency's (JMA's) geostationary satellite Himawari-8. This receiver acts as the back-up to MetService's primary feed from Himawari-8, received through JMA's Himawari Cloud service. The second receiver ingests X- and L-band data (all instruments) from polar orbiter satellites, currently NOAA18, NOAA19, MetOp-B, Terra, Aqua and Suomi NPP. Visible 7 micron and 11 micron imagery, covering the New Zealand area of responsibility for marine forecasts, is kept in a long-term archive at MetService.

NIWA operates two polar orbiting satellite reception systems, one in Wellington and one in Lauder. In Wellington, an L-band receiver has acquired data from all available NOAA satellites from 1992 to the present (starting with N10, but currently only N18 and 19 remain operational), along with SeaWiFS data from SeaStar (Orbview2) from May 2000 until mission end in 2011. Following a receiver upgrade in mid-2018, data from MetOp-B and MetOp-C (since 2019) are also acquired. At Lauder, a dual X/L-band receiver was installed in August 2007. It acquires data from all available NOAA satellites (currently only N18 and N19), MetOp-B (since April 2014) and MetOp-C (since early 2019), Terra (MODIS only), Aqua (all instruments) and Suomi NPP (since April 2014, all instruments). All raw (level-0) data and many derived products from these satellites are held in long-term archival storage (from 1992 to present). NIWA also operated a geostationary satellite receiver from August 1998 to March 2008, receiving data from JMA's GMS-5 and MTSAT-1R satellites (also NOAA's GOES-9 while deployed as replacement for GMS-5 before MTSAT-1R). All data are held in long-term archival storage. NIWA currently receives AHI imager data from JMA's latest geostationary satellite, Himawari-8 via the Himawari Cloud service (all channels, full resolution, full scan every 10 minutes, since mid-2016). All data are held in long-term archival storage.

NIWA has developed several data products from these data streams, including 1-kilometre resolution sea-surface temperature analyses, cloud mask, cloud type and estimated rain rate. These derived data products have been collocated with MetService meteorological radar (three radars), an advanced microwave sounder unit (20 spectral intervals), a high-resolution infrared sounder (20 spectral channels), and an advanced, very high-resolution radiometer

⁶⁵⁶ <https://www.methanesat.org/>

(5/6 channels), for NOAA14, NOAA15, NOAA16, NOAA17 and NOAA18. Called the NIWA ATOVS Collocation Archive, it is being used to develop algorithms that could be used to monitor the hydrological cycle over an area within a radius of 2000 kilometres from Wellington. The archive is also being used to improve the value of satellite sounder radiances in numerical weather prediction through improved detection of unmodelled, radiative transfer processes. NIWA has also developed high-resolution (1 kilometre) daily and weekly snow-cover analyses for the New Zealand region using a Bayesian method. Visible (including pseudo true colour) and infrared band imagery covering areas of interest around New Zealand are routinely generated and saved in long-term archival storage. Infrared and microwave atmospheric sounder data are forwarded to the WMO Direct Broadcast Network programme with minimal latency and are being used within NIWA's weather forecast system data assimilation processes. Ocean colour products derived from the Moderate Resolution Imaging Spectroradiometer (MODIS), and more recently Visible Infrared Imaging Radiometer Suite (VIIRS), imager data are important inputs to science programmes and are being used by local authorities.

Measurements of stratospheric trace gases and aerosols at Lauder and Arrival Heights support several satellite-based measurement programmes in the United States, Europe and Japan. This includes making correlative measurements of ozone and other atmospheric gases using spectrometers, LIDARs, and ozonesondes during satellite overpasses.

Response to GCOS implementation plan

The following actions have been initiated in response to the recommendations on atmospheric ECVs in the GCOS implementation plan.

Applying the GCOS climate monitoring principles to all surface climate networks

NIWA and MetService have taken necessary action to ensure their surface climate networks are operating according to GCOS climate monitoring principles.

Incorporating atmospheric pressure sensors into drifting buoy programmes

All of Aotearoa New Zealand's drifting buoy programmes include atmospheric pressure as a measurement.

Ensuring availability of three-hourly mean sea-level pressure and wind speed and direction data from GSN stations

NIWA and MetService have worked towards ensuring that at least three-hourly data are available from GSN stations.

Operating the World Weather Watch / Global Observing System radiosonde network in full compliance with the GCOS climate monitoring principles and coding conventions

NIWA and MetService have taken the necessary action to ensure all their radiosonde observations are operating according to GCOS monitoring principles.

Submitting metadata records and inter-comparisons for radiosonde observations to the specified international data centres

Although metadata records are collected and forwarded to international data centres, it is not yet practical to conduct inter-comparisons for radiosonde observations on site in New Zealand. New radiosonde implementations and operations are assessed by international panels before they are set up.

Developing a network of ground-based GPS receivers for measuring water vapour

Initial discussions between the GPS industry and research sector did occur, but so far New Zealand is not in a position to actively pursue the development of a ground-based network of GPS receivers to measure water vapour.

Sustained measurements of the atmospheric composition ECVs

NIWA conducts project-based (ie, not sustained) investigations into measurements of other atmospheric variables.

Data rescue

NIWA has been collating a searchable database of historical severe weather events for New Zealand going back to the 1840s, including information on impacts, damage, casualties and disruption.⁶⁵⁷

NIWA also works on several projects focusing on Pacific Island climate data rescue and provides training, in-kind staff and facilities for data rescue, through joint collaborations between NIWA, the United States NOAA GCOS Program, and the Australian Bureau of Meteorology.

⁶⁵⁷ <http://hwe.niwa.co.nz>

Essential Climate Variables: Ocean

Ocean ECVs that can be feasibly measured and are relevant to the UNFCCC (according to GCOS⁶⁵⁸) relate to physical, biochemical, biological and ecological properties, obtained through surface, subsurface and ocean water column measurements, as follows:

- **physical:** sea ice; sea level; sea state; surface heat flux; surface salinity; surface temperature; surface currents; surface stress; subsurface currents; subsurface salinity; subsurface temperature
- **biogeochemical:** inorganic carbon; N₂O; nutrients; ocean colour; oxygen; transient tracers
- **biological and ecosystems:** marine habitat; phytoplankton; zooplankton.

Physical ocean measurements

In Aotearoa New Zealand, various agencies are operating sea-level gauges. GeoNet (GNS Science) is operating a tsunami warning and monitoring network consisting of 18 pressure sea-level gauges, funded by LINZ.⁶⁵⁹ GeoNet is also operating a network of deep-ocean instruments. This Deep-Ocean Assessment and Reporting on Tsunami (DART) network⁶⁶⁰ consists of 10 pairs of ocean bottom pressure sensors that record water height and associated surface buoys. The data provide information on whether a tsunami has been generated, and more accurate estimates on wave size and velocity. The sensors are particularly valuable for monitoring potential tsunami from earthquakes in the southwest Pacific that may be unfelt on the New Zealand mainland. The network also provides monitoring and detection information for Cook Islands, Niue, Samoa, Tokelau and Tonga.

NIWA operates four sea-level gauges for monitoring long-term, sea-level changes. Port companies and local authorities operate 16 sea-level gauges at major ports (standard ports), and around 30 more permanent gauges are operated by local authorities or other agencies around New Zealand's coastline. LINZ regularly collects and archives these data. In terms of ocean tides, storm surges and long waves, the open-coast gauges in the NIWA network provide a valuable data set. The earliest site started in 1971. NIWA coordinates and archives an informal network of 17 coastal sea-level recorders, including the Global Sea Level Observing System (GLOSS) site at Scott Base.⁶⁶¹ In addition, long-term tide gauge records since around 1900 are held by LINZ for the ports of Auckland, Wellington, Lyttelton and Dunedin. Shorter records are held from several other ports and open-coast gauges (also held by LINZ and NIWA, in some cases). Records from six long-term sites have been provided by NIWA to MfE and Stats NZ for the national State of the Environment Report released in October 2020.

New Zealand has four sea-level sites registered in GLOSS,⁶⁶² those at Wellington, Auckland and Bluff (Southland) are operated by port companies (or the local authority on behalf of the port

⁶⁵⁸ <https://public.wmo.int/en/programmes/global-climate-observing-system/essential-climate-variables> and <https://gcos.wmo.int/en/essential-climate-variables>

⁶⁵⁹ <https://www.linz.govt.nz/sea/tides/sea-level-data>

⁶⁶⁰ <https://www.geonet.org.nz/tsunami/dart>

⁶⁶¹ <https://www.niwa.co.nz/our-science/coasts/tools-and-resources/sea-levels>

⁶⁶² <https://www.gloss-sealevel.org>

company). The site at Waitangi, Chatham Islands, formerly operated by the Pacific Tsunami Warning Center, is no longer operational. The site at Scott Base, Antarctica, is operated by LINZ and Antarctica New Zealand. Only the Wellington and Bluff sites have full records in GLOSS.

Twenty-one New Zealand sea-level sites are registered in the Permanent Service for Mean Sea Level (PSMSL).⁶⁶³

Sea-surface temperature is measured in New Zealand at seven of the sea-level stations.

Ocean waves are routinely monitored around the New Zealand coast at five sites operated by NIWA and/or local authorities, and at a further six sites are operated by ports. Since 2016, NIWA has collaborated with local authorities on environmental monitoring of Wellington Harbour (Te-Whanganui-a-Tara). Data include both physical, biological and ecosystem health observations: temperature, salinity, ocean currents, waves and atmospheric data.

Remote coastal video cameras have been installed by NIWA for long-term monitoring of beach conditions and erosion at seven sites.⁶⁶⁴

Since the mid-1980s, MetService has maintained a network of free-drifting buoys in the Tasman Sea. Until around 2002, the network consisted of buoys like the first Global Atmospheric Research Programme's Global Experiment type buoys, which measured air temperature and sea-level pressure, with a few buoys measuring wind speed and direction. Since 2002, a combined meteorological and oceanographic drifting buoy, of the Surface Velocity Programme with Barometer (SVPB) type, has been deployed. SVPB buoys measure sea-surface temperature and sea-level pressure, and ocean current is derived from their drift. All buoys report via the Iridium satellite network. As of April 2022, MetService has 11 operational drifting buoys in the waters surrounding New Zealand. MetService also works collaboratively with the Global Drifter Center in Miami to deploy buoys under the Southern Ocean Buoy Programme in the Pacific Ocean south of 40°S. These buoys are of the SVPB type, and nine were deployed in the Southern Ocean and Ross Sea area in January 2022.

Under MetService's WMO Voluntary Observing Ships (VOS) Scheme, New Zealand seeks to upgrade or recruit new ships to make climate quality observations under the VOS Climate Project (VOSCLIM). Around 30 ships are operating under this programme per year. Extensive metadata are collected for each VOSCLIM ship, which detail instrument type, location, exposure and other parameters. The real-time observations are monitored by the United Kingdom's Real Time Monitoring Centre, and the observations, metadata, co-located model data and delayed mode data are all supplied to the United States' Data Assembly Center for archiving for future research and climate applications.

Since 2001, NIWA has annually purchased and deployed two profiling floats under the Argo programme. Of the 40 Argo floats purchased and deployed, 15 are still active. The data from the New Zealand floats (temperature, salinity, currents) are administered by the Scripps Institution of Oceanography (United States) and are available from the Argo Global Data Assembly Centers.⁶⁶⁵ NIWA intends to continue to purchase and deploy Argo floats at the rate of two per year. NIWA has also collaborated in the development and deployment of deep Argo floats, which profile to 6000 metres, undertaking two dedicated research voyages targeting sensor development, and deploying 72 deep solo floats from RV *Tangaroa* and RV *Kaharoa*.

⁶⁶³ <https://www.psmsl.org/>

⁶⁶⁴ <https://www.niwa.co.nz/our-services/online-services/cam-era>

⁶⁶⁵ <https://argo.ucsd.edu/>

NIWA is deploying floats and buoys in the southern hemisphere from the research vessel *RV Kaharoa* as an ongoing collaboration with the University of Washington and the Scripps Institution of Oceanography. These voyages, dating back to 2004, have deployed over 1370 floats, primarily in the South Pacific but also in the eastern tropical Pacific Ocean and Indian Ocean. *RV Kaharoa* has deployed globally more Argo floats than any other vessel.⁶⁶⁶ In addition, over 75 deployments have been made from the research vessel *RV Tangaroa*, mainly in the Southern Ocean.

Since 2010, NIWA has maintained a sequence of hydrographic moorings in the Ross Sea, supported through science projects, to capture data for a better understanding of ocean dynamics. At present, this includes three moorings off Cape Adare and three in Terra Nova Bay. Further, four ice shelf cavity moorings have been operated for periods of more than a year. In addition, a new hydrographic mooring was deployed beneath the sea ice in Haskell Strait, McMurdo Sound, in November 2021.

Since 2015, NIWA has completed 30 ocean glider missions around New Zealand's Exclusive Economic Zone (EEZ) and territorial seas. These autonomous platforms measure ocean properties, such as: salinity, temperature, oxygen, chlorophyll, turbidity, light and organic matter. A regular transect has been established along the northeast region of New Zealand to monitor variability of the East Auckland boundary current.

Biochemical ocean measurements

Between 2002 and 2012, Aotearoa New Zealand maintained two global reference mooring network sites in deep waters (about 3000 metres) to the east of the country. These provided long-term, time-series biophysical data (currents, temperature, salinity, fluorometry and particle flux) from the subtropical and subantarctic waters on either side of the Subtropical Front, north and south of Chatham Rise. Measurements included a repeated, across-front transect measuring currents, nutrients, fluorometry and, in more recent years of the time series, bio-optics. These moorings have now been removed, and the data have yet to be quality checked and made available. A third site to the northeast of New Zealand, which is not part of the global reference mooring network, supplied current and temperature data in the subtropical inflow region of the East Auckland Current, and was in place for six-and-a-half years (1998–2005).

Time series data of currents, temperature, salinity, light and fluorometry have been collected at two shallow mooring sites in the Firth of Thames, in the Hauraki Gulf, since 1998. More recently, oxygen and nutrients have also been measured. Meteorological and water column observations (wind speed and direction, barometric pressure, air and sea temperature, salinity, turbidity, waves and currents) have been made since 2007 at a site located in the centre of Golden Bay, at the northern tip of the South Island. This is a joint project funded by NIWA and local government.

Surface ocean CO₂ is measured using an underway system on the *RV Tangaroa*, and data are submitted annually to the Surface Ocean CO₂ Atlas (SOCAT).⁶⁶⁷

Measurements of partial pressure of CO₂ (pCO₂), ocean acidity, and supporting data are routinely taken on cruises out of Dunedin as part of the Munida Microbial Observatory Time

⁶⁶⁶ <https://sites.google.com/view/argofloats/rv-kaharoa>

⁶⁶⁷ <https://www.socat.info/>

Series programme.⁶⁶⁸ These surface measurements, undertaken in accordance with the GCOS climate monitoring principles, have been made since 1998, and data are submitted as part of New Zealand's reporting towards Sustainable Development Goal 14.3.

NIWA has established, together with other agencies, the New Zealand Ocean Acidification Observing Network (NZOA-ON), comprising 14 pristine and urban monitoring sites located around New Zealand, where pH, pCO₂, carbonate ion concentration and saturation states are monitored.⁶⁶⁹ This network is linked into the GOA-ON.⁶⁷⁰ The data are submitted as part of New Zealand's reporting towards Sustainable Development Goal 14.3. These data have also been included in the WMO Statement of the State of the Global Climate (2018).

NIWA, collaborating with IMOS, has set up the New Zealand Ocean Data Network (NZODN),⁶⁷¹ a data platform for archiving and making ocean data available.

Biological and ecosystems ocean measurements

NIWA collects marine biogeochemical, physical and other environmental data as part of research and commercial voyages. Data includes: conductivity, temperature and depth (CTD) based temperature, salinity, dissolved oxygen, and nutrients, nitrate, nitrogen dioxide, ammonium, dissolved reactive phosphorus, dissolved reactive silica, chlorophyll-a, particulate organic carbon, particulate organic nitrogen, particulate phosphorus, bacteria biomass and abundance (flow cytometry), picophytoplankton biomass and abundance (flow cytometry) and microzooplankton biomass and abundance. Scope, location and length of observational records depend on voyage objectives.

Of interest is the *Ross Sea Life in a Changing Climate (ReLiCC) 2021* voyage (code: TAN2101) that measured essential climate variables between Aotearoa New Zealand the Ross Sea, 4 January to 17 February 2021. The overarching purpose of this multi-disciplinary research voyage was to increase knowledge about significant environmental and biological processes in the Ross Sea region of Antarctica and the Southern Ocean, and thereby improve understanding of ecosystem function and likely responses to future change.

Twice-yearly measurements of the zooplankton assemblage in the near surface have been made since 2008 between New Zealand and the Ross Sea.⁶⁷² Samples are collected by the Continuous Plankton Recorder (CPR) and analysed in New Zealand as part of the Southern Ocean CPR project.⁶⁷³

⁶⁶⁸ <https://www.otago.ac.nz/mots>

⁶⁶⁹ <https://niwa.co.nz/coasts-and-oceans/research-projects/new-zealand-ocean-acidification-observing-network-nzoa-on>

⁶⁷⁰ <http://www.goa-on.org/>

⁶⁷¹ <https://nzodn.nz/>

⁶⁷² Pinkerton MH, Decima M, Kitchener J, Takahashi K, Robinson K, Stewart R, Hosie GW. 2020. Zooplankton in the Southern Ocean from the continuous plankton recorder: Distributions and long-term change. *Deep Sea Research Part I, Oceanographic Research Papers* 162: 103303. DOI: 10.1016/j.dsr.2020.103303.

⁶⁷³ Takahashi K, Hosie G, Cowen T, Hunt B, Kitchener J, McLeod D, Meilland J, Pinkerton M, Raymond B, Robinson K, Swadling, K. 2021. *Report on the Status and Trends of Southern Ocean Zooplankton based on the SCAR Southern Ocean Continuous Plankton Recorder (SO-CPR) Survey*. Cambridge: Scientific Committee on Antarctic Research. Retrieved from <https://www.scar.org/scar-news/so-cpr-eg-news/so-zp-status-2020/> (12 September 2022).

NIWA maintains the Southwestern Pacific Ocean Biogeographic Information System Node,⁶⁷⁴ which contributes biological ocean data (collected during voyages and projects) to the international Ocean Biodiversity Information System (OBIS)⁶⁷⁵ and the GBIF.⁶⁷⁶

Satellite-based measurements

See the section ‘Satellite-based measurements’ in ‘ECVs: Atmospheric’, for information about satellite receiving stations and products.

Aotearoa New Zealand is actively involved in the acquisition, processing and application of satellite data for essential ocean climate variables. New Zealand research expertise and use of satellite data includes: 1) local scale (New Zealand territorial waters, EEZ); 2) Southern Ocean; and 3) global scale. Significant variables considered and developed in New Zealand include sea surface temperature, chlorophyll-a (as a proxy for phytoplankton biomass), primary production, suspended sediment, light attenuation, particulate organic matter flux (benthopelagic coupling), sea-ice concentration and primary production by sea-ice algae.⁶⁷⁷ Coastally, locally tuned processing of satellite data has led to a 20-year time series of inherent optical properties (absorption, backscattering, beam attenuation), apparent optical properties (diffuse attenuation, underwater visibility, irradiance at the seabed) and biogeochemical properties (total suspended particulate matter concentration, detrital absorption, phytoplankton absorption). These data have been disseminated and applied using a new satellite-based data portal for remotely sensed data (SCENZ⁶⁷⁸). For example, coastally, the satellite data have been used to look at the effects of climate change on aquaculture⁶⁷⁹ and, on the ocean scale, to track changes in the New Zealand EEZ⁶⁸⁰ and Southern Ocean.⁶⁸¹

The NIWA sea-surface temperature archive contains 1-kilometre resolution sea-surface temperatures retrieved from all NOAA orbits over the southwest Pacific region (1993 to the present). NIWA has acquired Aqua MODIS imager data covering the oceans around New Zealand going back to 2002 (received at Lauder since 2007, downloaded from NASA for preceding years) from which various ocean colour data products have been derived (including chlorophyll concentration). It is planned to extend this data set using data from the VIIRS satellites (acquired at Lauder). Since 2005, daily chlorophyll concentration maps of New Zealand coastal waters have been routinely generated and held in long-term archival storage.

⁶⁷⁴ <https://niwa.co.nz/our-science/coasts-and-oceans/tools-and-resources/southwestern-pacific-obis-node>

⁶⁷⁵ <https://obis.org/node/6c17c09e-5cc2-4d5a-8463-e866731d35a1>

⁶⁷⁶ <https://www.gbif.org/installation/f0d34585-ddcb-4915-9332-6043585e831a>

⁶⁷⁷ Pinkerton MH, Hayward A. 2021. Tracking variability and long-term change in potential sea ice primary productivity using a novel light penetration index. *Journal of Marine Systems* 221: 103576.

⁶⁷⁸ <https://data-niwa.opendata.arcgis.com/documents/NIWA::niwa-scenz-ocean-colour-application/explore>

⁶⁷⁹ Broekhuizen N, Plew DR, Pinkerton MH, Gall MG. 2021. Sea temperature rise over the period 2002–2020 in Pelorus Sound, New Zealand – with possible implications for the aquaculture industry. *New Zealand Journal of Marine and Freshwater Research* 55(1): 46–4.

⁶⁸⁰ Pinkerton MH, Sutton P, Wood S. 2018. *Satellite indicators of phytoplankton and ocean surface temperature for New Zealand*. NIWA report 2018180WN. Prepared for Ministry for the Environment by the National Institute of Water and Atmospheric Research. Wellington: Ministry for the Environment.

⁶⁸¹ Pinkerton MH. 2019. *Change in environmental conditions of the Southern Ocean observed by satellites and data-assimilating models to 2019*. Paper prepared for the Commission for the Conservation of Antarctic Marine Living Resources, WG-EMM-19. Tasmania: Commission for the Conservation of Antarctic Marine Living Resources. Pinkerton MH, Boyd P, Deppeler S, Hayward A, Hofer J, Moreau S. 2021. Evidence for the impact of climate change on primary producers in the Southern Ocean. *Frontiers of Marine Science*. DOI: 10.3389/fevo.2021.592027.

Response to GCOS implementation plan

The following actions have been initiated in response to the recommendations on ocean essential climate variables in the GCOS implementation plan.

Improving metadata acquisition and data management for the VOSClm subset of the VOS

The observations made by VOSClm ships adhere to the GCOS climate monitoring principles. The collection of metadata for VOSClm is well documented under the VOSClm project, and MetService collects the full range of variables for its VOSClm ship. MetService's VOSClm ship is regularly inspected, to maintain instrument standards. Monthly monitoring of the real-time reports is carried out by the Regional Specialised Monitoring Centre in the United Kingdom, with feedback provided to the ship on any variables that are flagged as suspect.

Ensuring high-frequency (hourly or less) sea-level observations are available for all coastal sea-level gauges (including historical records), corrected for sea-level pressure and submitted to the specified international data centres

Quality-assured, sea-level data from GLOSS sites 101 and 129 are submitted by LINZ each month to the University of Hawaii Sea Level Center (UHSLC). Data have not been submitted from GLOSS site 127 (Auckland) for several years. Data from other sea-level gauges are made available to UHSLC and Permanent Service for Mean Sea Level annually, by LINZ. Real-time data from the tsunami warning and monitoring network is provided via the WMO global telecommunication system to the UNESCO/IOC Sea Level Station Monitoring Facility.⁶⁸²

Including sea-level objectives in the capacity-building programmes of GOOS,⁶⁸³ JCOMM,⁶⁸⁴ WMO, other related bodies and the system-improvement programme of GCOS

NIWA has been carrying out several aid projects in the Pacific Island region (most notably the Cook Islands and Kiribati extreme sea-level projects) to help Pacific islands develop capabilities for assessing impacts of future sea-level changes and to develop mitigation strategies.

⁶⁸² <https://www.ioc-sealevelmonitoring.org/index.php>

⁶⁸³ Global Ocean Observing System.

⁶⁸⁴ Joint WMO/ Intergovernmental Oceanographic Commission Technical Commission for Oceanography and Marine Meteorology.

Developing a robust programme to observe sea-surface salinity that includes VOS ships, research ships, reference moorings and drifting buoys

NIWA's larger research vessel, *RV Tangaroa*, is equipped to make underway measurements of sea-surface temperature and salinity. Ongoing efforts are being made to maintain and calibrate the sensors so the data are accurate, stable and archived.

MetService VOS and drifting buoy programmes are robust and operational with proven track records. VOS ships are issued with calibrated instruments (which are traceable to WMO and international standards). An ongoing programme of inspection is in place, and data quality is monitored according to VOS quality-control guidelines. Delayed mode data are collected and submitted to the global climate centres at three-monthly intervals under the Marine Climatological Summaries Scheme. Extensive metadata are collected for each VOS ship and submitted to WMO quarterly. MetService's Drifting Buoy programme is a national programme of the Data Buoy Cooperation Panel, and so MetService buoys comply with international specifications for instrument types and standards. Metadata are submitted to the WMO and Intergovernmental Oceanographic Commission's Joint Technical Commission for Oceanography and Marine Meteorology for each buoy. Real-time buoy data are monitored using international buoy quality-control tools, with bad data removed from the global telecommunication system as required.

Implementing a programme for measuring surface pCO₂

Surface pCO₂ is measured as part of the ongoing Munida Time Series programme on a 60-kilometre-long transect that includes the Southland Current and subantarctic waters. These measurements have been made every two months since 1998. Surface pCO₂ has also been measured during eight ocean cruises in Aotearoa New Zealand's EEZ and the southwest Pacific, but this open ocean work has been discontinued due to resource constraints.

Implementing a wave measurement component as part of the Surface Reference Mooring Network

Several wave buoys are operating in New Zealand for specific projects, but no national effort has been made to include wave measurements in long-term measurement programmes.

Improving in situ sea-ice observations from buoys, visual surveys (Ship of Opportunity Programme (SOOP) and aircraft) and upward-looking sonars, and implementing observations in the Arctic and Antarctic

Data have been collected on an opportunistic basis, with no routine contributions to Antarctic sea-ice observations from buoys, visual surveys or upward-looking sonar. However, in the future, the intention is to contribute land-fast sea-ice data from McMurdo Sound to the Antarctic Fast Ice Network.

Conducting the systematic global full-depth water column sampling of 30 sections repeated every 10 years (including ocean carbon inventory change)

Currently, no systematic long-term full-depth water column observations are being conducted in New Zealand.

Performing the 41 SOOP XBT/XCTD trans-oceanic sections

NIWA helps Australian (Commonwealth Scientific and Industrial Research Organisation) and United States (Scripps Institution of Oceanography) research institutions to maintain three high-resolution expandable bathythermograph (XBT) sections in the Tasman–Coral Sea area to monitor ocean temperature changes in the upper 800 metres. The lines are PX34, PX06 and PX31.⁶⁸⁵

Developing capability for systematic measurement of biogeochemical and ecological ECVs

As part of research and commercial voyages, NIWA collects marine biogeochemical, physical and other environmental data. Data includes CTD temperature, CTD salinity, CTD dissolved oxygen, nutrients, nitrate, nitrogen dioxide, ammonium, dissolved reactive phosphorus, dissolved reactive silica, chlorophyll-a, particulate organic carbon, particulate organic nitrogen, particulate phosphorus, bacteria biomass and abundance (flow cytometry), picophytoplankton biomass and abundance (flow cytometry) and microzooplankton biomass and abundance. NIWA, collaborating with IMOS, has set up the New Zealand Ocean Data Network (NZODN) platform for making these ocean data available (as permitted and funded).

Supporting data rescue projects and implementing regional, specialised and global data and analysis centres

A project at NIWA is under way to rescue historical oceans data, where paper copies are available. This includes seismic and sediment records from voyages going back 50 years, covering New Zealand's EEZ and the wider Southern Ocean.

⁶⁸⁵ <https://www-hrx.ucsd.edu>

Essential Climate Variables: Land

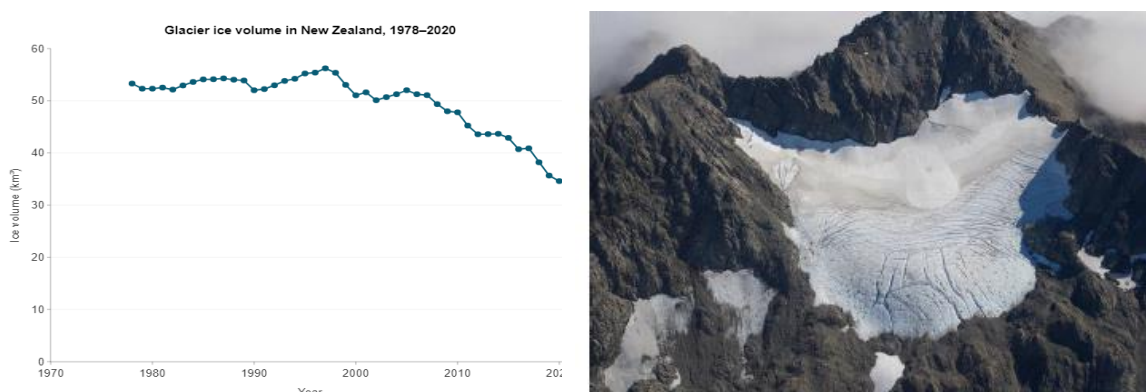
Land ECVs that can be feasibly measured and are relevant to the UNFCCC (according to GCOS⁶⁸⁶) relate to the observations for cryosphere, hydrosphere, biosphere and anthroposphere, as follows:

- **cryosphere:** snow; glaciers; ice; permafrost
- **hydrosphere:** river discharge; groundwater; lakes; soil moisture
- **biosphere:** albedo; land cover; leaf area index; fraction of absorbed photosynthetically active radiation; biomass; soil carbon; land surface temperature; fire; evaporation
- **anthroposphere:** anthropogenic greenhouse gas fluxes; anthropogenic water use.

Cryosphere observations

End-of-summer snowline elevations and photographic images of more than 50 index glaciers captured from low altitude aircraft flights in March each year are available annually, dating from 1978 (see figure D.1). These data are being used to estimate equilibrium line altitude changes and mass balance change through time.⁶⁸⁷ In addition, several of the index glaciers that have much greater photographic coverage have been paired with ground control points to evaluate changes in glacier ice volume each year, using structure from motion photogrammetry (since 2015). Three-dimensional photogrammetry methods are also paired with ground-based, biannual mass balance measurements at Brewster Glacier (Mount Aspiring National Park) and Rolleston Glacier (Arthur's Pass) (the former since 2005 and the latter since 2010), using snowstakes. LIDAR has also been used on Rolleston Glacier since 2021 to track surface elevation changes. Thermal imagery has been used on several index glaciers since 2018 in conjunction with standard photography. Limited term, fixed position timelapse photographs are available for Fox, Franz Josef, Tasman and Brewster glaciers that have been captured in recent years. Terminus positions of some larger glaciers in the Southern Alps are available with aperiodic observations from the mid-19th century to the present.⁶⁸⁸

Figure D.1: Modelled glacier ice volume change, 1978–2020, and end of summer snowline of Rolleston Glacier, Arthurs Pass area, March 2016



⁶⁸⁶ <https://public.wmo.int/en/programmes/global-climate-observing-system/essential-climate-variables> and <https://gcos.wmo.int/en/essential-climate-variables>

⁶⁸⁷ <https://www.stats.govt.nz/indicators/annual-glacier-ice-volumes>

⁶⁸⁸ <https://www.sirg.org.nz>

NIWA operates two climate stations in Antarctica: Scott Base and Arrival Heights. Scott Base has one of the longest continuous climate records in Antarctica (back to 1957). NIWA also established the national Snow and Ice Monitoring Network in 2008. It constitutes nine high-elevation (above bush line) and four lower elevation stations. This network is complemented by three snow-monitoring sites operated for commercial clients at Rose Ridge, Panorama Ridge, and Franz Josef Glacier (West Coast). NIWA and MetService are planning to increase snow depth and solid precipitation measurements in low elevation regions.

Although Aotearoa New Zealand has no permafrost measurement sites, it is supporting measurements in Antarctica conducted by the United States Department of Agriculture and the University of Insubria (Italy). Seven soil climate monitoring stations that monitor temperature to about 1.2 metres in depth are operated in the McMurdo Dry Valleys and Ross Sea coast by Manaaki Whenua Landcare Research in collaboration with the United States Department of Agriculture. Continuous monitoring data go back as far as 1999. Two permafrost boreholes are equipped with continuous temperature monitoring to a depth of 30 metres.

Hydrosphere observations

An overview of Aotearoa New Zealand surface water observation history can be found in the 60th anniversary publication of the New Zealand Hydrological Society from 2021.⁶⁸⁹ River flow and lake level monitoring are conducted in New Zealand by local authorities, which operate about 900 river flow gauging and lake level stations, energy companies (at about 400 sites, a significant number of which are operated by NIWA), and NIWA, which has a national benchmark network of about 50 stations. Data collection is of varying length and carried out to varying standards. For example, flood monitoring sites are often monitored to lesser standards.

Freshwater and coastal water quality is observed at over 1000 sites in New Zealand by local authorities and NIWA. These agencies are currently working on implementing a National Standard for discrete water quality to increase data consistency.⁶⁹⁰

Local authorities, MfE and NIWA are working on various national monitoring and quality coding protocol initiatives (eg, environmental monitoring and reporting, NEMS and LAWA projects, see the section 'National programmes and activities' above). They are also working on data aggregation standard systems, to ensure local data collection is done consistently and data can be easily integrated. New Zealand local authorities have set up the LAWA website as an integrated access portal to local authorities' land, freshwater, air quality and coastal data.⁶⁹¹

NIWA submits river flow data from 40 gauging stations to the Global Runoff Data Centre (GRDC).⁶⁹²

NIWA submits river water quality data from about 50 sites to the Global Environment Monitoring System for Freshwater (GEMS/Water).⁶⁹³

⁶⁸⁹ Pearson C, Ede M, Haddadchi A, Hudson N. 2021. Developments in surface water monitoring in the last ten years. *Journal of Hydrology New Zealand* 60(2): 11–17.
<https://www.hydrologynz.org.nz/journal/volume-60-2021>.

⁶⁹⁰ <https://www.nems.org.nz/documents/>

⁶⁹¹ <https://www.lawa.org.nz>

⁶⁹² https://www.bafg.de/GRDC/EN/Home/homepage_node.html

⁶⁹³ <https://www.unep.org/gemswater>

Soil moisture is measured across the country by local authorities and NIWA at several hundred sites, typically in conjunction with climate stations. NIWA compiles a database of about 100 sites across the country and uses the data for regular reporting of the country's soil moisture status, as part of the New Zealand Climate Summaries.⁶⁹⁴

At the national scale, groundwater quality is monitored through the National Groundwater Monitoring Programme (NGMP).⁶⁹⁵ This programme is a collaboration between GNS Science and local authorities. In addition to the monitoring operations, the NGMP has dedicated research and database objectives, which are essential to ensure the network remains relevant to current freshwater management issues. The NGMP network comprises around 110 monitoring sites, which are sampled quarterly by local authorities. At the regional scale, state of the environment groundwater monitoring programmes are operated by local authorities. However, the sampling frequency, analytical suite, sampling protocol, monitoring objectives and site selection criteria vary between monitoring agencies.

NGMP samples have been collected using a national protocol since 2006 and are analysed for a consistent suite of major cations, anions and silica, and selected minor elements such as iron, manganese, bromide and fluoride since 1998. Depth to groundwater is typically measured before sampling. Parameters such as pH, water temperature and electrical conductivity are measured in the field at the time of sampling.

Although regional networks are typically denser than the NGMP network, with an amalgamated number of sites close to 1000, the NGMP network has been shown to be representative of New Zealand groundwaters. The programme uses multivariate statistics conducted on an amalgamated state of the environment data set and the NGMP data set, respectively. The unique consistency of NGMP monitoring at the national scale means the data set can be used as a training data set when using machine-learning techniques, as shown through a study from 2021 to infer baseline for groundwater quality on an amalgamated (NGMP and state of the environment) data set.⁶⁹⁶

National-scale evaluations of groundwater quality state and trends have been reported by MfE since 1995 and have covered 5-, 10- and 20-year periods. The most recent assessment covers data collected from 2009–18⁶⁹⁷ using an aggregated data set (NGMP and state of the environment).

Biosphere observations

The Land Cover Database (LCDB) is a national compilation of land cover status in Aotearoa New Zealand using satellite imagery⁶⁹⁸ and is a multi-temporal, thematic classification of New Zealand's land cover. So far, five data sets have been compiled as part of the LCDB, representing New Zealand land cover layers for 1996/97, 2000/01, 2007/08, 2012/13 and 2018/19.

⁶⁹⁴ <https://niwa.co.nz/climate/summaries>

⁶⁹⁵ <https://ggw.gns.cri.nz/>

⁶⁹⁶ Moreau M, Daughney C. 2021. Defining natural baselines for rates of change in New Zealand's groundwater quality: Dealing with incomplete or disparate datasets, accounting for impacted sites, and merging into state of the environment reporting. *Science of The Total Environment* 755(2): 143292. DOI: 10.1016/j.scitotenv.2020.143292.

⁶⁹⁷ <https://www.stats.govt.nz/indicators/groundwater-quality/>

⁶⁹⁸ <https://iris.scinfo.org.nz/search/?q=lcdb>

To meet its Kyoto Protocol commitments, New Zealand developed the Land Use and Carbon Analysis System (LUCAS).⁶⁹⁹ LUCAS comprises components for measuring and reporting the carbon stock changes occurring from land use, land use change and forestry through a combination of permanent forest sample plots and remote sensing-based mapping. LUCAS has so far established four snapshots of land use using Landsat, SPOT and Sentinel-2 satellite data. These include the 1990, 2008, 2012 and 2016 land use databases required to track land use. Carbon stock changes in vegetation and soils are calculated and reported from 1990 onwards with the help of these time-sequence measurements.

The Ministry for Primary Industries maintains several databases related to plantation forestry schemes, including mapping of forestry entered in New Zealand's Emissions Trading Scheme. Data is shared between the Ministry for Primary Industries and LUCAS programme to ensure accurate monitoring of afforestation and deforestation is maintained in both systems.

To help those national databases, national research programmes are in progress to understand patterns and processes involved in current soil and forest carbon storage.⁷⁰⁰

Manaaki Whenua Landcare Research has established a national soil carbon benchmarking and monitoring system across a range of soil types and land use classes. By the end of 2023, 330 sites are expected to be sampled. The overall plan is to monitor changes in soil carbon at 500 sites across the country within each of five broad land use classes: cropland, horticulture, dairy pasture, flat rolling drystock pasture and hill country drystock pasture, and to revisit sites every three to five years to monitor changes.⁷⁰¹

The CarbonWatch New Zealand programme⁷⁰² is a collaborative programme that has been established to assess land-carbon exchange from major land use regions in New Zealand using 'top-down' methodologies, including both micrometeorological and atmospheric inverse modelling methods. Micrometeorological sites have been established on high-producing (Canterbury) and low-producing (Lauder) grassland to provide validation for grassland land-use models that provide priors for inverse modelling assessments. The network of atmospheric measurements across New Zealand includes monitoring stations for CO₂ established at Manukau Heads (Auckland), Manga Kakaramea (Bay of Plenty), Baring Head, Winchmore (Canterbury) and Lauder. The system being developed in New Zealand is helping development in other countries through the WMO Integrated Global Greenhouse Gas Information System (IG³IS) framework.

The National Vegetation Survey Databank maintained by Manaaki Whenua Landcare Research⁷⁰³ holds records from over 120,000 vegetation survey plots around New Zealand, including over 25,000 permanent plots. Vegetation observations span over 70 years. Local authorities are carrying out regular vegetation surveys to varying standards, depending on local stressors and needs.

⁶⁹⁹ <https://www.mfe.govt.nz/more/data/available-datasets/land-use-map>

⁷⁰⁰ <https://www.nzagrc.org.nz/soil-carbon.html>

⁷⁰¹ <https://www.landcareresearch.co.nz/news/a-new-national-soil-carbon-monitoring-system-for-agricultural-land/>

⁷⁰² <https://niwa.co.nz/climate/research-projects/carbon-watch-nz>

⁷⁰³ <https://nvs.landcareresearch.co.nz/>

The national biodiversity monitoring programme was established in 2011, through the Department of Conservation, to support annual reporting of ecological integrity and change. The programme is based on the existing network and protocols, expanded to include additional biotic indicators. It incorporates 1400 plots evenly spaced across public conservation land, which are remeasured on a five-year rotation cycle, around 280 plots are measured each year.⁷⁰⁴

A national monitoring programme designed to enable unbiased estimates of carbon stock and change for New Zealand's natural forests was developed between 1998 and 2001. Permanent plots were installed systematically on the 8-kilometre grid across New Zealand's natural forests and these were first measured over five years between 2002 and 2007. Re-measurement of the plot network provides repeat data suitable for calculating carbon stock change in natural forest. The first re-measurement of the plot network was completed between 2009 and 2014. For the third round of measurement, the programme is continuing at a reduced rate, with around 120 plots being measured each year on a 10-year cycle. Measurement of plots for this round began in 2014 and is scheduled for completion in 2024.

The National Soils Database (NSD) is a 'point' database maintained by Manaaki Whenua Landcare Research. It contains descriptions of about 8000 New Zealand soil profiles, together with analytical data on their chemical, physical and mineralogical characteristics (including soil carbon).⁷⁰⁵ The information is obtained from physically sampling and observing the soil on site.

As part of the S-map project, Manaaki Whenua Landcare Research is working on an ongoing project to map New Zealand's soil resources at a nominal 1:50,000 scale, currently with around 30 per cent coverage.⁷⁰⁶ The products include soil factsheets with physical soil characteristics.

Anthropogenic observations

A representative daily background CO₂ measurement (carbon count) for Aotearoa New Zealand is provided to media with comparison to values measured 1 year and 10 years ago.⁷⁰⁷

In conjunction with biospheric assessment, a component of CarbonWatch New Zealand, led by GNS Science, is assessing carbon exchange in the urban landscape. In coming years, the research is likely to develop to look at a range of sectoral emissions (eg, CH₄ from waste). Standards for urban emission assessment are currently under consideration as part of the Integrated Global Greenhouse Gas Information System (IG³IS) initiative.⁷⁰⁸

Because of recent changes in New Zealand legislation,⁷⁰⁹ an increasing number of water takes (for agriculture and other uses) are now being monitored by natural resource users that have consents for water takes, for example, by irrigation companies or individual farmers. Local authorities and MfE are working to ensure national consistency and national collection and

⁷⁰⁴ <https://www.doc.govt.nz/our-work/monitoring-reporting/plot-level-report>

⁷⁰⁵ <https://soils.landcareresearch.co.nz/tools/national-soils-database>

⁷⁰⁶ <https://iris.scinfo.org.nz/layer/48440-s-map-a-new-soil-spatial-information-system-for-new-zealand-current>

⁷⁰⁷ <https://niwa.co.nz/climate/research-projects/carbonwatchnz/dailyco2measurements>

⁷⁰⁸ <https://ig3is.wmo.int/en/news/towards-international-standard-urban-ghg-monitoring-and-assessment>

⁷⁰⁹ <https://environment.govt.nz/publications/measuring-and-reporting-water-takes-an-introduction-to-the-resource-management-measurement-and-reporting-of-water-takes-regulations-2010/measuring-and-reporting-water-takes-an-introduction-to-the-resource-management-measurement-and-reporting-of-water-takes-regulations-2010>

accessibility of these data. It is expected that, over the coming years, more than 10,000 surface and groundwater takes will be being monitored by various agencies (water take consent holders) and archived by local authorities in New Zealand.

Satellite-based measurements

See the section 'Satellite-based measurements' in 'ECVs: Atmospheric' for information about satellite receiving stations and products.

Aotearoa New Zealand does not have a dedicated satellite-based measurement programme of terrestrial ECVs.

However, glaciers in the Southern Alps are monitored as part of the international satellite project Global Land Ice Mapping from Space (GLIMS).⁷¹⁰ Satellite data are used for several mentioned national products, including the LCDB and New Zealand Land Use Map produced through LUCAS.

MfE maintains a register of some important national remote sensing products, including Landsat, SPOT and Sentinel imagery products.⁷¹¹

Response to GCOS implementation plan

The following actions have been initiated in response to the recommendations on terrestrial ECVs within the GCOS implementation plan.

Developing a global network of around 30 sites based on a progressive evolution of existing reference sites to monitor key biomass and provide the observations required for the calibration and validation of satellite data

Aotearoa New Zealand maintains a national plot-based monitoring system for the assessment of biodiversity status and change, and assessment of carbon pools. The National Vegetation Survey Databank contains data on 120,000 plots over a 70-year period, including more than 25,000 remeasured permanent plots. In addition, the national biodiversity monitoring programme, established in 2011 through the Department of Conservation, monitors a range of biotic indicators for about 1400 plots evenly spaced across public conservation land.⁷¹² Data from these resources are used as ground truthing and input, together with satellite imagery, for the creation of national mapping products, including the LCDB, ecosystem categorisation (EcoSat), environmental domains (Land Environments of New Zealand) and national carbon reporting (LUCAS).

⁷¹⁰ <http://glims.colorado.edu>

⁷¹¹ <https://environment.govt.nz/facts-and-science/science-and-data/satellite-data-search>

⁷¹² <https://www.doc.govt.nz/our-work/monitoring-reporting/plot-level-report>

Maintaining and expanding programmes for monitoring groundwater and aquifers

Local authorities maintain extensive groundwater measurement programmes. GNS Science is compiling a national database of about 110 groundwater sites with consistent data.

Archiving and disseminating information related to irrigation and water resources

New Zealand is introducing consistent observations for monitoring water takes and water use for agriculture. Currently, local authorities are overseeing the instrumentation across the country, including adequate data dissemination technologies like telemetry, and are archiving the data.

Strengthening existing sites for observing snow cover and snowfall, and recovering and submitting historical data to the specified international data centres

A new focus in recent years has been on infilling remote data-poor regions and regions sensitive to change. The development of the National Snow and Ice Monitoring Network for New Zealand has led this drive and has resulted in the upgrading of selected existing stations to measure snow that is very sensitive to change. NIWA operates nine high-elevation (above bush line) stations and four lower elevation stations with specialised climate and snow monitoring.

Maintaining sites for observing glaciers and adding additional sites and infrastructure in Africa, the Himalayas, New Zealand and South America

The end-of-summer snowline elevations and photographic images of 50 glaciers from special aircraft flights will continue for the foreseeable future. Some new index glaciers will be added.

Adding the 150 additional permafrost sites identified by GTN-P⁷¹³ to cover the high mountains of Asia, Europe and the southern hemisphere, and the North American alpine lands and lowlands, and providing data to the specified international data centres

Due to the low percentage of permafrost in the country, New Zealand does not maintain or intend to develop a network of permafrost sites.

⁷¹³ Global Terrestrial Network for Permafrost.

Reanalysing historical data concerning the terrestrial ECVs

NIWA has worked on a project for compiling a large database of historical weather events for New Zealand, including flooding, landsliding and large snowstorms.⁷¹⁴

Building a national surface and groundwater observation programme

New Zealand is working towards a more nationally comprehensive and consistent freshwater monitoring programme. This will include river flows, river water quality, lake water quality, groundwater quantity and quality, and water use. This will benefit national state of the environment reporting and New Zealand's water resources management in light of increased water- and land-use pressures.⁷¹⁵ Components of this initiative are NEMS⁷¹⁶ and increasing the availability of data through LAWA.⁷¹⁷

⁷¹⁴ <https://hwe.niwa.co.nz>

⁷¹⁵ <https://environment.govt.nz/facts-and-science/environmental-reporting/improving-environmental-reporting-data>

⁷¹⁶ <https://www.nems.org.nz>

⁷¹⁷ <https://www.lawa.org.nz>

Appendix D1: Lists of observations

Contributing networks specified in the GCOS implementation plan	Essential climate variables	Number of stations or platforms operating currently (estimate) ⁷¹⁸	Number of stations or platforms operating in accordance with the GCMPs (estimate) ⁷¹⁹	Number of stations or platforms expected to be operating in 2024 (estimate) ⁷²⁰	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with a complete historical record available in international data centres
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National contributions to surface-based atmospheric essential climate variables

GCOS Surface Network (GSN)	Air temperature, precipitation	>700	>150	>500	10 ⁷²¹	10
Full WWW/GOS surface network	Air temperature, air pressure, wind speed and direction, water vapour, precipitation	>500	>130	>500	>130	100
Baseline Surface Radiation Network (BSRN)	Surface radiation	1	1	1	1	1
Solar radiation and radiation balance data	Surface radiation	>100	19	>100	10	10
Ocean drifting buoys	Air temperature, air pressure	20	20	20	20	20
Moored buoys	Air temperature, air pressure	0	0	0	0	0
Voluntary Observing Ship Climate Project (VOSCLim) ⁷²²	Air temperature, air pressure, wind speed and direction, water vapour	0	0	0	0	0
Ocean Reference Mooring Network and sites on small isolated islands	Air temperature, wind speed and direction, air pressure	8	8	8	8	8
	Precipitation	7	7	7	7	7

⁷¹⁸ Estimated total number of relevant stations operated through various New Zealand agencies (with no quality constraints).

⁷¹⁹ Estimated total number of relevant stations operated through various New Zealand agencies (complying with GCOS climate monitoring principles (GCMPs)).

⁷²⁰ Estimated total number of relevant stations operated through various New Zealand agencies in 2024 (with no quality constraints).

⁷²¹ Currently, nine more stations are being added, WMO ratification pending.

⁷²² <https://www.vos.noaa.gov/vosclim.shtml>

Contributing networks specified in the GCOS implementation plan	Essential climate variables	Number of stations or platforms currently operating (estimate) ⁷¹⁸	Number of stations or platforms operating in accordance with the GCMPs (estimate) ⁷¹⁹	Number of stations or platforms expected to be operating in 2024 (estimate) ⁷²⁰	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with a complete historical record available in international data centres
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National contributions to upper-air atmospheric essential climate variables

GCOS Upper Air Network (GUAN)	Upper-air temperature,	3	3	4	3	3
Full WWW/GOS Upper Air Network	upper-air wind speed and direction, upper-air water vapour	4	4	4	4	4

National contributions to atmospheric composition observations

WMO/GAW Global Atmospheric CO ₂ and CH ₄ Monitoring Network	Carbon dioxide	1	1	1	1	1
	Methane	3	3	3	2	2
	Other greenhouse gases	4	4	4	3	3
WMO/GAW ozonesonde network	Ozone	1	1	1	1	1
WMO/GAW column ozone network	Ozone	2	2	2	2	2
WMO/GAW aerosol network	Aerosol optical depth	3	3	3	3	3
	Other aerosol properties	4	4	4	4	4

National contributions to the oceanic essential climate variables – surface

Global Drifter Program ⁷²³ (surface drifting buoy array)	Sea-surface temperature, sea-level pressure, position-change based current	20	20	20	20	20
GLOSS Core Sea-level Network	Sea level	78	10	70	3	2
Voluntary observing ships (VOS) ⁷²⁴	All feasible surface essential climate variables	13	13	13	13	13

⁷²³ <https://www.aoml.noaa.gov/global-drifter-program>

⁷²⁴ https://www.vos.noaa.gov/vos_scheme.shtml

Contributing networks specified in the GCOS implementation plan	Essential climate variables	Number of stations or platforms currently operating (estimate) ⁷¹⁸	Number of stations or platforms operating in accordance with the GCMPs (estimate) ⁷¹⁹	Number of stations or platforms expected to be operating in 2024 (estimate) ⁷²⁰	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with a complete historical record available in international data centres
Ship of Opportunity Programme (SOOP) ⁷²⁵	All feasible surface essential climate variables	0	0	0	0	0
National contributions to the oceanic essential climate variables – water column						
Global reference mooring network	All feasible surface and subsurface essential climate variables	0	0	0	0	0
Global tropical moored buoy network	All feasible surface and subsurface essential climate variables	0	0	0	0	0
Argo network	Temperature, salinity, current	15	15	10	15	40
Carbon inventory survey lines	Temperature, salinity, ocean tracers, biogeochemistry variables	2	2	2	2	2
National contributions to the terrestrial domain essential climate variables						
Global Terrestrial Network for River Discharge (GTN-R) ⁷²⁶	River flow	>1,000	>400	>1,000	40	40
Global Terrestrial Network for Lakes (GTN-L) ⁷²⁷	Lake level	>50	>10	>50	0	0
WWW/GOS synoptic network	Snow cover	13	13	13	0	0

⁷²⁵ <https://community.wmo.int/ship-opportunity-programme>

⁷²⁶ https://www.bafg.de/GRDC/EN/04_spcldtbss/44_GTNR/gtnr_node.html

⁷²⁷ <https://gcos.wmo.int/en/networks/terrestrial>

Contributing networks specified in the GCOS implementation plan	Essential climate variables	Number of stations or platforms currently operating (estimate) ⁷¹⁸	Number of stations or platforms operating in accordance with the GCMPs (estimate) ⁷¹⁹	Number of stations or platforms expected to be operating in 2024 (estimate) ⁷²⁰	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with a complete historical record available in international data centres
Global Terrestrial Network for Glaciers (GTN-G) ⁷²⁸	Glaciers' mass balance and length; ice sheet mass balance	50	50	50	50	50
Global Terrestrial Network for Permafrost (GTN-P) ⁷²⁹	Permafrost borehole temperatures and active-layer thickness	9 (Note: All platforms are in Antarctica)	9	9	7	7

Note: CH₄ = methane; CO₂ = carbon dioxide; GCMPs = GCOS climate monitoring principles; GCOS = Global Climate Observing System; GLOSS = Global Sea Level Observing System; WMO/GAW = World Meteorological Organization / Global Atmosphere Watch; WWW/GOS = World Weather Watch / Global Observing System.

⁷²⁸ <https://www.gtn-g.ch/>

⁷²⁹ <https://gtnp.arcticportal.org/>

Appendix D2: List of permanent stations

Station name	Latitude	Longitude	Responsible agency or agencies	GCOS system	Notes
Kaitia Observatory	-35.133	173.263	NIWA	GSN	
Gisborne Aero AWS	-38.659	177.985	MetService	GSN	
New Plymouth Aero AWS	-39.008	174.184	MetService	GSN	
Paraparaumu Aero AWS	-40.905	174.985	MetService	GSN	
Hokitika Aero AWS	-42.713	170.984	MetService	GSN	
Tara Hills AWS	-44.526	169.889	MetService	GSN	
Invercargill Aero AWS	-46.413	168.317	MetService	GSN	
Campbell Island AWS	-52.550	169.150	MetService	GSN	
Chatham Island Aero AWS	-43.817	-176.475	MetService	GSN	
Raoul Island AWS	-29.245	-177.929	MetService	GSN	
Paraparaumu Observatory	-40.905	174.985	MetService	GUAN	
Raoul Island	-29.245	-177.929	MetService	GUAN	Not operating due to COVID-19 pandemic, operations, will resume once restrictions allow
Royal New Zealand Air Force Base Whenuapai	-36.794	174.619	MetService	GUAN	Full GUAN status pending WMO ratification
Lauder Research Station	-45.05	169.683	NIWA	GRUAN	
Invercargill Observatory	-46.417	168.330	MetService	GRUAN	Paired with Lauder
Baring Head	-41.41	174.87	NIWA	GAW	
Lauder Research Station	-45.04	169.68	NIWA	GAW	
Arrival Heights	-77.83	166.66	NIWA	GAW	
Auckland – Waitemata Harbour	-36.51	174.46	Ports of Auckland Ltd	GLOSS	
Chatham Islands	-43.95	-176.55	Pacific Tsunami Warning Center	GLOSS	Closed February 2016 due to wharf redevelopment
Wellington	-41.17	174.47	Greater Wellington Regional Council	GLOSS	
Bluff	-46.6	168.35	South Port Ltd	GLOSS	
Scott Base	-77.51	166.46	LINZ / Antarctica New Zealand	GLOSS	

Note: AWS = automatic weather station; GAW = Global Atmosphere Watch; GCOS = Global Climate Observing System; GLOSS = Global Sea Level Observing System; GRUAN = GCOS Reference Upper Air Network; GSN = GCOS Surface Network; GUAN = Global Upper Air Network; LINZ = Toitū Te Whenua Land Information New Zealand; MetService = Meteorological Service of New Zealand Limited; NIWA = National Institute of Water and Atmospheric Research.

Appendix D3: Other international data contributions

The following table presents a compilation of other relevant (to GCOS ECVs) Aotearoa New Zealand contributions of data to international archives and projects (not a comprehensive list).

Data archive / facility	ECVs	Organisations	Content / purpose
Atmosphere			
Regional Basic Synoptic Network (RBSN)	Surface atmosphere measurements	MetService	Weather observations from 33 stations
Total Carbon Column Observing Network (TCCON)	Carbon dioxide, methane and other greenhouse gases	NIWA	Measurements from the NIWA atmospheric research station at Lauder, NZ. TCCON is a network of ground-based Fourier transform spectrometers recording direct solar spectra in the near infrared spectral region. From these spectra, accurate and precise column-averaged abundances of CO ₂ , CH ₄ , N ₂ O, HF, CO, H ₂ O and HDO ⁷³⁰ are retrieved and reported here.
Network for the Detection of Atmospheric Composition Change (NDACC)	Carbon dioxide, methane and other greenhouse gases	NIWA	Measurements from the NIWA atmospheric research station at Lauder, NZ, and the Antarctica New Zealand research station at Arrival Heights, Antarctica. Includes total column and profile measurements of greenhouse gases, ozone, other trace gases, aerosols, water vapour and ultraviolet (UV) radiation. Records dating from 1980s to present.
Collaborative Carbon Column Observing Network (COCCON)⁷³¹ atmospheric data for Lauder, NZ, and Arrival Heights, Antarctica	Carbon dioxide, methane and other greenhouse gases	NIWA	Ground-based remote sensing of atmospheric trace gases, CO ₂ , CH ₄ , CO, H ₂ O and HDO.
World Ozone and Ultraviolet Radiation Data Centre (WOUDC) measurements of ozone and UV at Lauder, NZ	Ozone	NIWA	WOUDC is one of six world data centres that are part of the Global Atmosphere Watch programme of the World Meteorological Organization.
World Radiation Monitoring Center–Baseline Surface Radiation Network (WRMC–BSRN) measurements of radiation from Lauder, NZ	Surface radiation	NIWA	WRMC–BSRN measurements of radiation, UV and aerosols.

⁷³⁰ Water isotope H²HO, also called semiheavy water.

⁷³¹ <https://www.imk-asf.kit.edu/english/COCCON.php>

Data archive / facility	ECVs	Organisations	Content / purpose
Ocean			
Data from sea level tide gauges and bottom pressure recorders submitted to Permanent Service for Mean Sea Level (PSMSL)	Sea level	LINZ	PSMSL is the global databank for long-term sea-level change information from tide gauges and bottom pressure recorders.
Carbon dioxide observations from voyages submitted to the Surface Ocean CO₂ Atlas (SOCAT)	Biochemical	NIWA	The SOCAT is a synthesis activity for quality-controlled, surface ocean fugacity of carbon dioxide (fCO ₂) observations by the international marine carbon research community (more than 100 contributors).
Data from 14 sites submitted to the Global Ocean Acidification Observing Network (GOA-ON)	Biochemical	NIWA	GOA-ON is a collaborative international network to detect and understand the drivers of ocean acidification in estuarine-coastal-open ocean environments, the resulting impacts on marine ecosystems, and to make the information available to optimise modelling studies.
Ocean biological data submitted to the International Ocean Biodiversity Information System (OBIS) and the Global Biodiversity Information Facility (GBIF)	Biological/ecosystems	NIWA	International database of biological observations.
Land			
Water quality observations provided to the Global Environment Monitoring System for freshwater (GEMS/Water)	Hydrosphere	NIWA	GEMS/Water provides the community with sound data on freshwater quality to support scientific assessments and decision-making on the subject.
Various freshwater biological data submitted to GBIF	Biosphere	NIWA	International database of biological observations.
Various biological data submitted to GBIF	Biosphere	Manaaki Whenua Landcare Research	International database of biological observations.

Note: CH₄ = methane; CO = carbon monoxide; CO₂ = carbon dioxide; ECVs = Essential Climate Variables; HDO = semiheavy water; HF = hydrogen fluoride; H₂O = water; LINZ = Toitū Te Whenua Land Information New Zealand; NIWA = National Institute of Water and Atmospheric Research; N₂O = nitrous oxide.

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