Ministry for the Environment
Manatū Mō Te Taiao

New Zealand's Seventh National Communication

Fulfilling reporting requirements under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

New Zealand Government

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Ministry for the
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Manatū Mō Te Taiao

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Contents

Tables

Figures

List of abbreviations

6NC	*Sixth National Communication*
7NC	*Seventh National Communication*
ADB	Asian Development Bank
AGS	Afforestation Grant Scheme
ANDRILL	ANtarctic DRILLing
ANZLIC	Australia New Zealand Land Information Council
APEC	Asia–Pacific Economic Cooperation
AR2	*Second Assessment Report*
AR4	*Fourth Assessment Report*
ARC	Antarctic Research Centre
ASEAN	Association of South East Asian Nations
BR2	Second Biennial Report
CBIT	Capacity Building Initiative for Transparency
CCDF	Climate Change Development Fund
CCS	carbon capture and storage
CEMARS	Certified Emissions Management and Reduction Scheme
CH4	methane
CIIL	Crown Irrigation Investments Limited
CMIP5	Coupled Model Intercomparison Project 5
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
COP	Conference of Parties
CRF	common reporting format
CRI	Crown research institute
DOC	Department of Conservation
E3 programme	Equipment Energy Efficiency programme
ECFP	Erosion Control Funding Programme
ECV	Essential Climate Variable
EECA	Energy Efficiency and Conservation Authority
EEZ	Exclusive Economic Zone
EFDB	Emission factor Data Base
EmaR	Environmental Monitoring and Reporting
EPA	Environmental Protection Authority

F-gases	fluorinated gases
FAO	Food and Agriculture Organization of the United Nations
FONTAGRO	Regional Fund for Agricultural Technology (Inter-American Development Bank)
FTS	Fourier Transform Spectrometer
G20	Group of 20
GAW	Global Atmosphere Watch
GBIF	Global Biodiversity Information Facility
GCF	Green Climate Fund
GCOS	Global Climate Observing System
GDP	gross domestic product
GEF	Global Environment Facility
GEO	Group on Earth Observations
GLOSS	Global Sea Level Observing System
GNS Science	Institute of Geological and Nuclear Sciences Limited
GRA	Global Research Alliance on Agricultural Greenhouse Gases
GRUAN	GCOS Reference Upper Air Network
GSN	GCOS Surface Network
GTS	Global Telecommunication System
GUAN	Global Upper Air Network
GWP	global warming potentials
ha	hectare
HCEP	Hill Country Erosion Programme
HFC	hydrofluorocarbon
HWP	harvested wood products
IAF	Irrigation Acceleration Fund
IGPS	Institute for Governance and Policy Studies, Victoria University of Wellington
IMOS	Integrated Marine Observation System
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
ISO	International Organization for Standardization
ITL	International Transaction Log
kt CO_2-e	kilotonnes of carbon dioxide equivalent
LAWA	Land Air Water Aotearoa
LCDB	Land Cover Database
LINZ	Land Information New Zealand

LUCAS	Land Use and Carbon Analysis System
LULUCF	land use, land-use change and forestry
MBIE	Ministry of Business, Innovation and Employment
MetService	Meteorological Service of New Zealand Limited
MFAT	Ministry of Foreign Affairs and Trade
MfE	Ministry for the Environment
MPI	Ministry for Primary Industries
Mt CO_2-e	million tonnes of carbon dioxide equivalent
N_2O	nitrous oxide
NDC	Nationally Determined Contribution
NEMS	National Environmental Monitoring Standards
NGMP	National Groundwater Monitoring Programme
NIR	National Inventory Report
NIWA	National Institute of Water and Atmospheric Research
NOAA	National Oceanic and Atmospheric Administration
NPS-FM	National Policy Statement for Freshwater Management
NZ ETS	New Zealand Emissions Trading Scheme
NZ FACE	Free Air Carbon Dioxide Enrichment experiment
NZAGRC	New Zealand Agricultural Greenhouse Gas Research Centre
NZEECS	New Zealand Energy Efficiency and Conservation Strategy 2017–2022
NZGPP	New Zealand Government Procurement and Property
NZISM	New Zealand Information Security Manual
NZU	New Zealand Unit
ODA	official development assistance
OECD	Organisation for Economic Co-operation and Development
OGC	Open Geospatial Consortium
pCO_2	partial pressure of CO_2
PFC	perfluorocarbon
PFSI	Permanent Forest Sink Initiative
PGgRc	Pastoral Greenhouse Gas Research Consortium
PGP	Primary Growth Partnership
PICTs	Pacific Island countries and territories
PI-GCOS	Pacific Islands Global Climate Observing System
PJ	petajoule
Pou Taiao ILG	Pou Taiao Iwi Leaders Group
PSRM	Pastoral Supply Response Model

QA	quality assurance
QC	quality control
RCP	Representative Concentration Pathway
RICE	Roosevelt Island Climate Evolution Project
SF6	sulphur hexafluoride
SLMACC	Sustainable Land Management and Climate Change Plan of Action
SMC	Science Media Centre
SPC	Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SSIF	Strategic Science Investment Fund
SWFDDP	Severe Weather Forecasting and Disaster Risk Reduction Demonstration Project
TAPA	Technical Assistance for Pacific Access programme
TPES	total primary energy supply
UNFCCC	United Nations Framework Convention on Climate Change
VOS	Voluntary Observing Ships
VOSClim	VOS Climate Project
WIS	WMO Information System
WMO	World Meteorological Organization
WUNZ programme	Warm Up New Zealand programme
YELF	Youth Enviroleaders Forum

About this report

This *Seventh National Communication* provides a snapshot of New Zealand's progress in implementing its commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol. It covers the period from the submission of the *Sixth National Communication* in December 2014 through to the end of December 2017. This *Seventh National Communication* document also contains *New Zealand's report on the Global Climate Observing System*.

New Zealand's Seventh National Communication provides information on:

- national circumstances to provide context for New Zealand's emissions (chapter 2)
- latest trends in New Zealand's greenhouse gas emissions and removals (chapter 3)
- policies and measures in place to address climate change (chapter 4)
- projections of New Zealand's greenhouse gas emissions and removals (chapter 5)
- climate change impacts on New Zealand and vulnerability and adaptation work (chapter 6) – this chapter also serves as New Zealand's first adaptation communication under the Paris Agreement
- climate-related financial, technology transfer and capacity-building support New Zealand has provided to developing countries (chapter 7)
- research and systematic observation (chapter 8)
- education, training and public awareness (chapter 9)
- summary of greenhouse gas emissions and removals from New Zealand's 2017 national inventory report (annex A)
- supplementary information under Article 7.2 of the Kyoto Protocol (annex B)
- supplementary material for projections of emissions and removals (annex C)
- *New Zealand's report on the Global Climate Observing System* (annex D)
- *Living with Change: An Integrated National Strategy for Enhancing the Resilience of Tokelau to Climate Change and Related Hazards, 2017–2030* (annex E)
- *Companion to Living with Change: Implementation Plan, 2017–2022* (annex F).

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Minister's foreword

Climate change is the greatest challenge facing the world today and New Zealand is committed to playing its part in the global solution.

New Zealand's *Seventh National Communication* and *Third Biennial Report* are both important reports that help New Zealand fulfil its reporting obligations as a Party to the United Nations Framework Convention on Climate Change. The reports show how New Zealand is progressing in meeting our international commitments on climate change, what we're doing to reduce our emissions, and what the future might look like as the climate changes.

It is encouraging to see that New Zealand is meeting our international climate change commitments. But we know that we can, and will, do more. Our challenge is to embark on a just transition to a low emissions economy. This is an opportunity to create new, sustainable jobs.

The New Zealand Government is committed to action on climate change. We will put in place a new net-zero emissions goal for 2050 and establish an independent Climate Change Commission. The Commission will provide advice on achieving that goal across all sectors of the economy, and set five-year carbon budgets.

The Government aims for New Zealand to generate 100 per cent of its electricity using renewable sources by 2035, under normal hydrological conditions. We already generate around 85 per cent of our electricity using renewable sources. We are blessed with a wealth of clean energy options, and we intend to make the most of them.

In transport, our goal is to support more low emissions transport options. The Government will lead by example, transitioning the Government car fleet to electric vehicles. Because of our high proportion of renewable electricity generation, adoption of electric vehicles has the potential to significantly reduce overall emissions.

New Zealand's emissions profile has distinctive features, such as a very high proportion of emissions from the agricultural sector. Our work internationally through organisations such as the Global Research Alliance on Agricultural Greenhouse Gases is a promising contribution to addressing this issue.

We have ambitious plans for afforestation, with the goal of planting a billion trees in the next decade.

New Zealand was one of the first countries to institute an emissions trading scheme (ETS), and the Government plans to update the rules of our ETS to ensure it is fit for purpose and drives emissions reduction.

Underpinning all this work is a commitment to a just transition, with the Government working alongside people, communities, and businesses to achieve outcomes that are good for people, the economy, and the environment. Our approach to this is grounded in principles of transparency, participation, investment predictability, ambition, and the need to provide enduring institutional arrangements that reflect robust scientific evidence.

The *Seventh National Communication* shows that New Zealand is committed supporting climate change action in developing countries through both financial support and capacity building. We are acutely aware that our Pacific Island neighbours are in many ways on the frontline of climate change. As a Pacific country, we feel a strong sense of obligation to support our neighbours with mitigation and adaption.

We have extended our ratification under the Paris Agreement to Tokelau and included Tokelau's climate change strategy *Living with Change* as an annex in the national communication. We will continue to work with Tokelau to meet its reporting obligations under the UNFCCC and the Paris Agreement.

As detailed in the report, the effects of climate change are already being felt in New Zealand and across the world. As I write, our country is experiencing uncharacteristic weather for this time of year. With water use restrictions already in place in many of our cities, there is speculation about water shortages affecting homes and businesses, especially agricultural businesses, in coming months.

Climate change is a challenge we face together as a planet, although the impacts and the solutions may differ across countries. It is my hope that together we can deepen our international cooperation and learn from each other as we take action towards a stable climate for generations to come.

James Shaw
Minister for Climate Change, New Zealand

1 Executive summary

Climate change is the biggest environmental challenge of our time. What we do now to limit the effects of climate change and to adapt to this global issue will enable our communities and environment to prosper for generations to come.

New Zealand is committed to playing its part in the global response to climate change, and transitioning to a low-carbon and climate-resilient economy. Global momentum from the Paris Agreement continues to shape New Zealand's climate change policies within Government and the business sector. New Zealand has ratified the Paris Agreement and is committed to its Nationally Determined Contribution under that Agreement. We will work both domestically and internationally to ensure New Zealand does its fair share to take and support action on climate change.

New Zealand's small population is widely distributed across a long, narrow and mountainous country. Located in the South Pacific, the country is distant from the majority of its trading partners. New Zealand has an export-dependent economy, with a significant reliance on the agriculture sector. Some 85 per cent of New Zealand's total food production goes to the international market. New Zealand's geography and population distribution have contributed to a dependence on fossil fuel-powered transport. Because of this, and New Zealand's primary exports base, emissions are dominated by the energy and agriculture sectors, which together comprise approximately 88 per cent of gross emissions.

New Zealand has high levels of renewable energy use and a long history of renewable energy development. More than three-quarters of New Zealand's electricity generation uses renewable resources – primarily hydro generation. Continued development of geothermal and wind generation has seen the amount of electricity generated from these sources more than triple over the last two decades. New Zealand is looking to make further gains in this area. The recently released New Zealand Energy Efficiency and Conservation Strategy 2017–2022 reaffirms our commitment to a goal of generating 90 per cent of electricity from renewable resources by 2025.

In the agriculture sector, New Zealand is investing in research to improve productivity and reduce emissions from agricultural production. New Zealand has a strong domestic research programme, and internationally is a leading member of the Global Research Alliance on Agricultural Greenhouse Gases. New Zealand has made significant improvements in production efficiency across the agriculture sector. This means that, while production overall has increased, emissions per unit of sheepmeat, beef and dairy product have decreased significantly. The result is absolute emissions from agriculture have remained more-or-less stable since 2005. New Zealand's research programmes continue to seek economically viable technologies for reducing emissions.

Overall, New Zealand's emissions have increased since 1990 on the back of strong economic and population growth. While these emissions have decoupled from economic growth, meaning our economy is growing faster than emissions, New Zealand faces challenges of finding low-cost opportunities to further reduce its emissions from agriculture.

Along with exploring opportunities to reduce emissions New Zealand is prioritising work on how to adapt to the effects of climate change so our country becomes more resilient to these changes.

A general election in September 2017 resulted in a change of Government for New Zealand. Climate change is one of the new Government's priorities and they are looking at options to adopt and make progress towards the goal of a net zero emissions Economy by 2050 which includes introducing a Zero Carbon Act, and establishing an independent Climate Commission

New Zealand's emissions targets

Since the *Sixth National Communication* New Zealand has announced its Nationally Determined Contribution to reduce emissions to 30 per cent below 2005 levels by 2030 as part of the Paris Agreement, which New Zealand ratified in October 2016. This Agreement entered into force on 4 November 2016. This is the fourth national target the Government has set for reducing New Zealand's greenhouse gas emissions. The four targets are:

- a target under the Kyoto Protocol's first commitment period of reducing greenhouse gas emissions to 1990 levels between 2008 and 2012. New Zealand met this target in 2016 when its 'True-up Report' was reviewed by the United Nations Framework Convention on Climate Change (UNFCCC)[1]
- an unconditional target under the UNFCCC of reaching 5 per cent below our 1990 greenhouse gas emissions levels by 2020. Domestically New Zealand reports progress towards this target in the Net Position report.[2] New Zealand is on track to meet this target
- a Nationally Determined Contribution under the Paris Agreement of reaching 30 per cent below our 2005 greenhouse gas emissions levels by 2030 (this target is equivalent to 11 per cent below 1990 levels by 2030)
- a gazetted long-term target of 50 per cent below our 1990 greenhouse gas emissions levels by 2050.

New Zealand will meet its future targets through a mix of reducing emissions domestically and planting forests, if necessary New Zealand will supplement these reductions with high integrity international units to meet our targets. For meeting the 2020 target, New Zealand can also count the surplus of 123.7 million units we achieved during the first commitment period of the Kyoto Protocol (2008–12).[3]

New Zealand uses a multi-year 'carbon budget' approach to setting and measuring progress towards our targets. This means that progress towards our targets is not measured by looking at emissions in a single year, but includes a comparison of emissions in all the years of each target period (2008–12, 2013–20 and 2021–30), illustrated in figure 1.1. This approach was required by countries that took a first commitment period target under the Kyoto Protocol and is being used by New Zealand for its 2020 and 2030 targets as well.

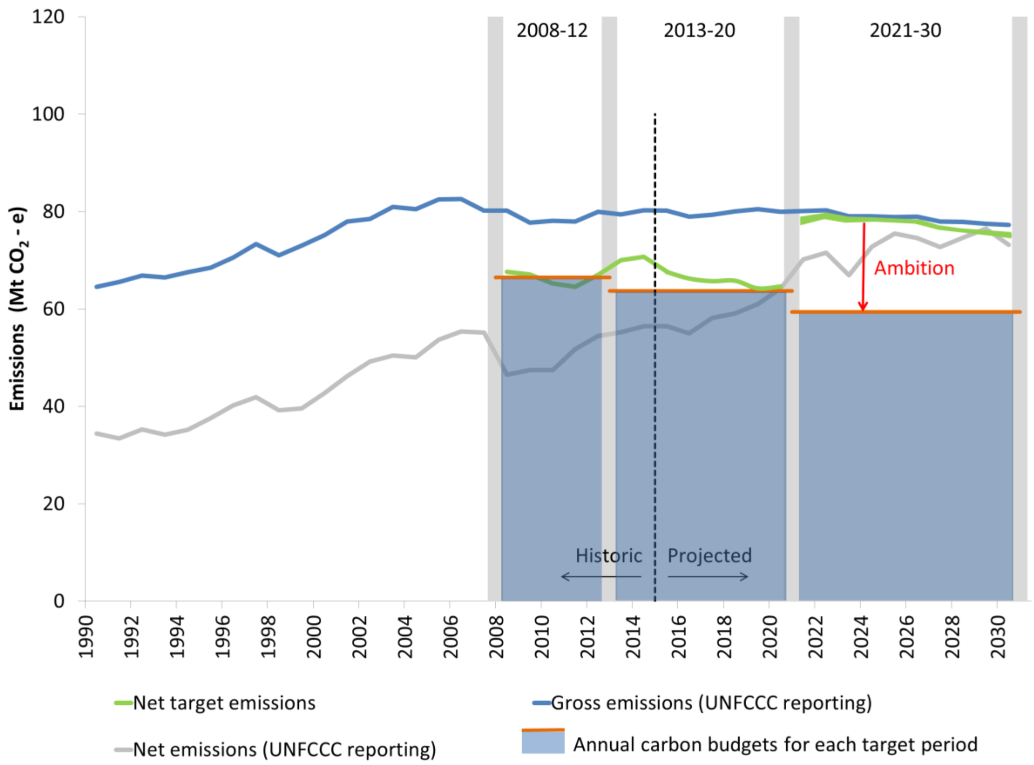
Figure 1.1 below shows New Zealand's historical and projected emissions as we head towards our 2030 target. The gap between the green and orange lines shows how much New Zealand needs to reduce emissions by to achieve its targets (the level of ambition).

1 http://unfccc.int/resource/docs/2016/tpr/nzl.pdf

2 www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/latest-2020-net-position

3 Ibid.

Figure 1.1: New Zealand's gross, net, and net target emissions with annual carbon budgets for its Kyoto Protocol and UNFCCC emissions reduction targets, 1990–2030



Note: Figure 1.1 includes three types of emissions:

- gross emissions (as reported to the UNFCCC), which include emissions from all sectors of the New Zealand economy, excluding forestry and land use emissions/removals
- net emissions (as reported to the UNFCCC), which include emissions from all sectors of the New Zealand economy, including all forestry and land-use emissions and removals
- net target emissions (what we use to measure progress towards our targets). Net target emissions include all of our gross emissions, but only a subset of our forestry and land-use emissions and removals. This subset is based on either the accounting rules under the Kyoto Protocol or for our 2030 target, a subset of our forestry and land-use emissions and removals based on rules explained in New Zealand's first Nationally Determined Contribution.[4]

Mt CO_2-e = million tonnes of carbon dioxide equivalent; UNFCCC = United Nations Framework Convention on Climate Change.

Action on climate change

The **New Zealand Emissions Trading Scheme (NZ ETS)** was introduced in 2008. It is the principal policy tool underpinning New Zealand's domestic emissions reduction action. It requires emitters that are participants in the scheme to report on their emissions and surrender emissions units that correspond to their obligations. NZ ETS participants are able to meet their NZ ETS obligations by surrendering New Zealand Units, the primary unit of trade in the scheme.

The NZ ETS is a broad-based trading scheme that enables New Zealand to meet its international targets using carbon markets. Entry to the scheme was phased by sector, with forestry the first sector to have reporting and surrender obligations. Since then, the

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4 www4.unfccc.int/ndcregistry/PublishedDocuments/New%20Zealand%20First/New%20Zealand%20first%20NDC.pdf

transport, stationary energy,[5] industrial processes, synthetic gases, and waste sectors have joined the NZ ETS. The agriculture sector faces reporting obligations, but currently there is no legislated date for when biological agricultural emissions will assume surrender obligations under the NZ ETS.

The NZ ETS is a long-term tool. The Government is committed to regularly reviewing the NZ ETS and making any modifications as needed to ensure New Zealand meets its international climate change obligations and reduces emissions.

Agricultural research: New Zealand has a strong focus on researching ways to reduce emissions from agricultural production and it is an area where New Zealand continues to provide expertise. New Zealand has an enduring commitment to providing leadership in research, innovation and technical solutions to reduce greenhouse gas emissions from agriculture, and sharing this knowledge internationally. Notable achievements since the *Sixth National Communication* include:

- progressing research on greenhouse gas mitigation, such as research to identify methane inhibitors, develop low methane-emitting sheep through genetics, progress towards a methane vaccine, and identify naturally occurring compounds that can lower nitrous oxide emissions from pasture
- establishing the Biological Emissions Reference Group, a joint government and industry reference group set up to build a robust and agreed evidence base on 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
- contributing funding and expertise to international research activities of the Global Research Alliance on Agricultural Greenhouse Gases and co-chairing its Livestock Research Group.

Financial support: Since the *Sixth National Communication*, New Zealand remains committed to supporting climate change action in developing countries. New Zealand contributed approximately NZ$455 million in climate-related support for developing countries during this reporting period (2013–16). New Zealand's contribution is an increase of approximately NZ$146 million compared with the previous reporting period.

New Zealand's climate-related support is for building stronger and more resilient infrastructure, strengthening disaster preparedness and supporting low-carbon economic growth. It includes significant contributions to improving access to affordable, reliable and clean energy, and supporting low-emissions agricultural development through the Global Research Alliance on Agricultural Greenhouse Gases.

New Zealand's co-hosting of Pacific Energy Conferences with the European Union has enabled us to mobilise finance at scale. Combined, our 2013 and 2016 events mobilised over NZ$2 billion in finance for renewable energy projects in the Pacific.

Due to the challenges Pacific Island countries face in accessing finance from multilateral funds such as the Green Climate Fund, New Zealand launched a Technical Assistance for Pacific Access programme in early 2016. Through this programme New Zealand is supporting national capacity-building workshops and providing targeted technical assistance with preparing project proposals.

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[5] The stationary energy sector includes all fossil fuels (gas and coal) used in electricity generation and in the direct production of industrial heat, as well as geothermal energy.

Public awareness: The Government actively supports initiatives that encourage public awareness of climate change. Over the past four years, the Government has run a number of public awareness campaigns, including household and vehicle energy efficiency campaigns, greenhouse gas reduction certification schemes, tools for measuring emissions, and environmental awards. In 2015 the Government consulted the public on its Intended Nationally Determined Contribution in advance of the Paris Agreement. This consultation included 15 public meetings and hui[6] across New Zealand and 17,023 written submissions. The Government has also consulted with key stakeholders as part of its NZ ETS review, which was completed in July 2017. The review assessed how the NZ ETS should evolve to support New Zealand in meeting future emissions reduction targets and its ongoing transition to a low-emissions economy. During the review period the Ministry for the Environment hosted 20 stakeholder sessions and co-hosted six hui with the Climate Change Iwi Leaders Group. Around 600 people attended these sessions.

Research on impacts, adaptation and vulnerability: The Government continues to fund research relating to the impacts and potential adaptation measures of climate change in a range of subject areas. In particular, the Deep South National Science Challenge includes a programme that aims to understand the potential impacts and implications of climate change for New Zealand in order to support planning and decision-making, and to aid adaptation efforts.

A Climate Change Adaptation Technical Working Group was set up by the Minister for Climate Change Issues in 2016 to provide advice on options for how New Zealand can adapt to the effects of climate change. The Government also updated New Zealand's climate projections based on the *Fifth Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC).

International engagement: New Zealand engages widely on addressing climate change at the international level. In addition to participating actively in IPCC working groups and UNFCCC negotiations, New Zealand contributes to a number of scientific organisations and plurilateral initiatives. For example, New Zealand is active in the Climate and Clean Air Coalition and in international efforts to phase out inefficient fossil fuel subsidies, through its membership of the Friends of Fossil Fuel Subsidy Reform.

New Zealand's greenhouse gas emissions and removals

New Zealand is committed to transparent and accurate annual reporting on the national greenhouse gas inventory as a developed country Party to the UNFCCC. New Zealand's gross greenhouse gases emissions in 2015 were 80.2 million tonnes of carbon dioxide equivalent (Mt CO_2-e). This comprises emissions from the energy (including transport), agriculture, industrial processes and product use, and waste sectors. Since 1990, New Zealand's gross emissions have increased by 24.1 per cent on the back of strong population growth and an increase in domestic production. Most of this emissions growth occurred between 1990 and 2005. Since then gross emissions have been relatively stable.

The agriculture and energy sectors are the two largest contributors to New Zealand's emissions profile (at about 47.9 per cent and 40.5 per cent respectively of gross emissions in 2015).

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6 A hui refers to a gathering or meeting. It can involve individuals, a hapū (a grouping of related families) or several hapū, an entire iwi (a larger Māori grouping, sometimes called a tribe), or several iwi.

New Zealand's net emissions under the UNFCCC were 56.4 Mt CO_2-e in 2015. Net emissions consist of gross emissions combined with emissions and removals from the land use, land-use change and forestry (LULUCF) sector. Net emissions have increased by 63.6 per cent since 1990. The reason for the increase is the combined effect of the increase in gross emissions and the higher harvesting rates in planted forests in 2015 compared with 1990. This is discussed further in chapter 3.

Greenhouse gas projections

Projections of greenhouse gases are described in chapter 5. Projections of emissions and removals are useful but inherently uncertain. Economic variables such as commodity and oil prices, the assumed carbon price, the assumed rate of afforestation and deforestation, and the harvest age of forests have significant effects on projected emissions and removals. Seasonal changes, especially variation in rainfall, can affect agriculture emissions. There is also uncertainty in the methodology to estimate emissions (and removals) from biological sources such as agriculture and forestry.

Based on current data and policies, New Zealand's gross emissions are projected to gradually decrease to 77.2 Mt CO_2-e by 2030. This is 19.6 per cent above 1990 levels and 6.4 per cent below 2005 levels. This decreasing trend in gross emissions to 2030 is due to:

- a greater amount of land-use change from agriculture to forestry
- more sustainable farm management practices
- reduced energy use, combined with less carbon-intensive fuels for energy production.

New Zealand's net emissions are projected to increase to 73.2 Mt CO_2-e by 2030. Given the influence of forests on New Zealand's emissions, net emissions at any given time will be strongly influenced by the planting and harvesting cycles of New Zealand's planted forests (figure 1.1).

The LULUCF sector is expected to remain a net source of removals over the projected time series. Removals from this sector will continue to decrease to almost become a source of emissions in the late 2020s. This is because the rate of new forest plantings increased in the late 1980s and early 1990s. These forests have begun to reach maturity and are now contributing to higher rates of harvest for timber production, as part of sustainable forest management in New Zealand. This increasing rate of harvest will steadily continue into the 2020s, before declining to the lower rates that occurred during the 2000s.

Comparing New Zealand's projected net emissions 'with measures' and 'without measures', as shown in figure 1.2, demonstrates the impact of some, but not all, of New Zealand's policies and measures.[7] 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 such contributions cannot be predicted and, as such, are not included in the emissions estimates. In total, the impact of New Zealand's policies and measures were estimated to reduce gross emissions by 6.2 Mt CO_2-e between 1990 and 2015 and by 41.8 Mt CO_2-e from 2016–30.

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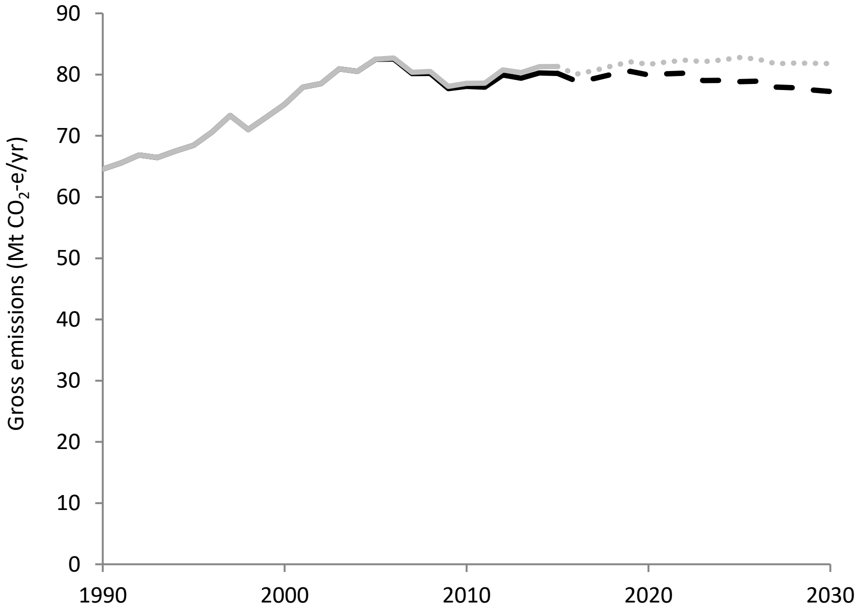
7 Government policies and measures on energy efficiency assume the same energy efficiency trends for both the 'with measures' and 'without measures' scenarios.

The impact of New Zealand's policies and measures reduced total net emissions by 31.0 Mt CO_2-e between 1990 and 2015 and by 113.2 Mt CO_2-e from 2016–30.

Figure 1.2: New Zealand's gross emissions with and without policy measures, 1990–2030



Note: New Zealand's historical (solid lines) and projected (dashed-lines) 'with measures' and 'without measures' scenarios for gross emissions (Mt CO_2-e). The black line represents net emissions from the 'with measures' scenario, while the grey line represents the 'without measures' scenarios. Mt CO_2-e = million tonnes of carbon dioxide equivalent.

Tokelau

This *National Communication* includes reporting on Tokelau's response to the challenges of climate change. Tokelau has been a dependent territory of New Zealand since 1926, and is considered "part of New Zealand" for certain purposes under the Tokelau Act 1948 (NZ). Tokelau has produced a climate change strategy, which appears in this report as 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. With the extension of New Zealand's ratification of the United Nations Framework Convention on Climate Change and the Paris Agreement to Tokelau (completed on 13 November 2017), New Zealand will also continue to work with Tokelau to meet reporting obligations under the UNFCCC and the Paris Agreement.

2 National circumstances

Key points

- New Zealand is a long, mountainous country in the Pacific Ocean with a temperate, oceanic climate.
- Due to the widely distributed population of 4.8 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.
- New Zealand's efficient agricultural system is fundamental to the economy, and 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.

2.1 Geographic profile

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° south latitude. 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. New Zealand has 17,200 kilometres of coastline,[8] and its Exclusive Economic Zone is one of the largest in the world. Combined, New Zealand's Exclusive Economic Zone (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. There are frequent earthquakes 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 ecosystems ranging from high alpine to warm temperate forests, including 72 types of naturally uncommon ecosystems.[9] After New Zealand's land mass broke away from the Gondwana supercontinent, plants and animals evolved in isolation for millions of years almost entirely without the presence of mammals. As a result, New Zealand's biodiversity is unique, with a huge diversity of birdlife and a large number of species found nowhere else in the world.

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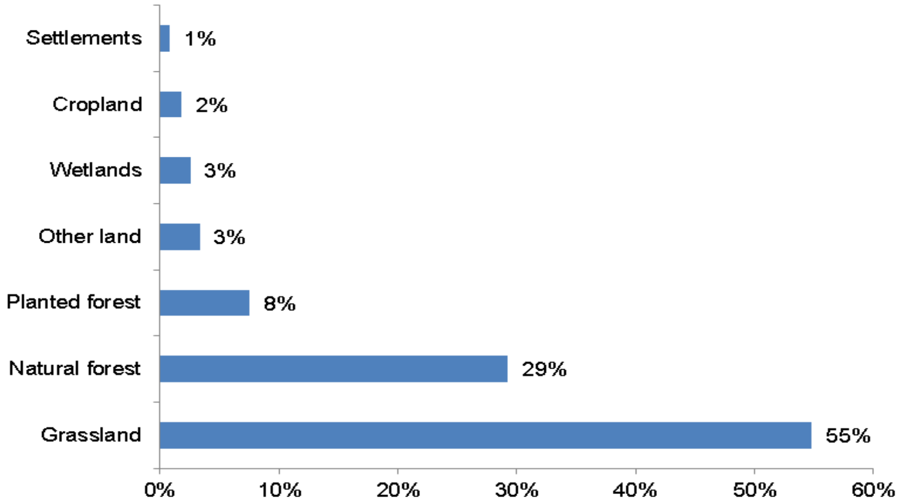
[8] United Nations Environment Programme. 2017. *The UNEP Environmental Data Explorer, as compiled from World Resources Institute (WRI)*. Retrieved from http://ede.grid.unep.ch.

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

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

Figure 2.1: Land use in New Zealand, 2015



Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

2.2 Population profile

New Zealand's population was 4.8 million at 31 March 2017.[10] The majority of the population is urbanised and 76.6 per cent live in the North Island; the largest city is Auckland, and 34.4 per cent of New Zealand's total population live within the greater Auckland area alone (as at June 2016).[11] New Zealand's population density is relatively low, with an average of 18 people per square kilometre.[10, 12]

New Zealand's population is growing, and has increased by an average of 1.4 per cent a year between 1948 and 2016. The population grew fastest in the 1950s (2.2 per cent per year on average), 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 the recent high population growth (2.1 per cent in the year ended June 2016), the population growth rate is projected to slow in the long term (figure 2.2). There is an approximately 25 per cent chance that the population will be declining by the 2060s.[13]

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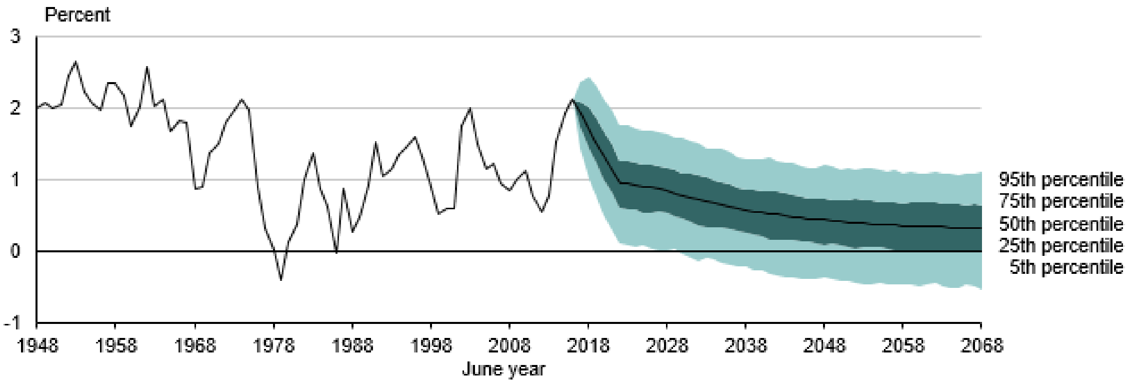
10 Statistics NZ. 2017. *Table Reference: DPE055A.* Retrieved from www.stats.govt.nz/infoshare.

11 Statistics NZ. 2017*. Subnational Population Estimates 2016.* Retrieved from http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE7502.

12 Statistics NZ. 2017. *New Zealand in Profile: 2015.* Retrieved from www.stats.govt.nz/browse_for_stats/snapshots-of-nz/nz-in-profile-2015/about-new-zealand.aspx.

13 Statistics NZ. 2017. *National Population Projections: 2016(base)–2068*. Retrieved from www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/NationalPopulationProjections_HOTP2016.aspx.

Figure 2.2: Annual population growth rate, 1948–2068



Source: Statistics New Zealand. 2017. *National Population Projections: 2016 (base) –2068*.

Net migration (the number of permanent and long-term migrants entering New Zealand, minus those leaving) has varied greatly over the years as a result of legislative and economic factors, both in New Zealand and overseas. The year ended March 2017 was a record year for migration, with a net migration of 71,900 people.[14] Net migration is projected to slow down in the future. The median long-run annual net migration assumption is for the population to increase by 15,000 people in 2022 and beyond.[13]

Census data

Many figures in chapter 2 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 2013, seven years after the previous one in 2006. Therefore some data used in this chapter fall prior to the current reporting period. The census is usually completed every five years but, due to the impacts of the Canterbury earthquake in 2011, the census scheduled for that year was postponed for two years. The next census will be conducted in 2018.

2.3 Climate

2.3.1 Current climate

New Zealand has climate zones ranging from subtropical to subantarctic. The climate is heavily influenced by New Zealand'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 urban 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 (figure 2.3).[15]

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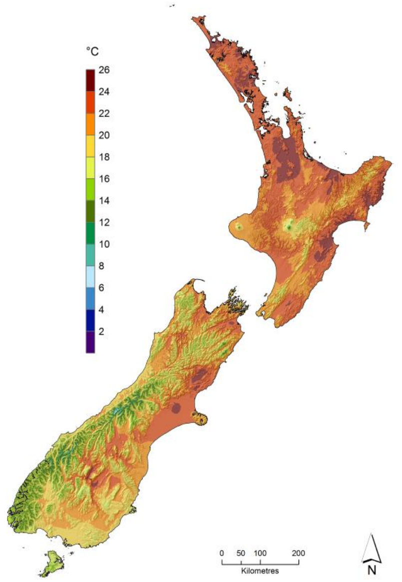
14 Statistics NZ. 2017. *International Travel and Migration: March 2017.* Retrieved from www.stats.govt.nz/browse_for_stats/population/Migration/IntTravelAndMigration_HOTPMar17.aspx.

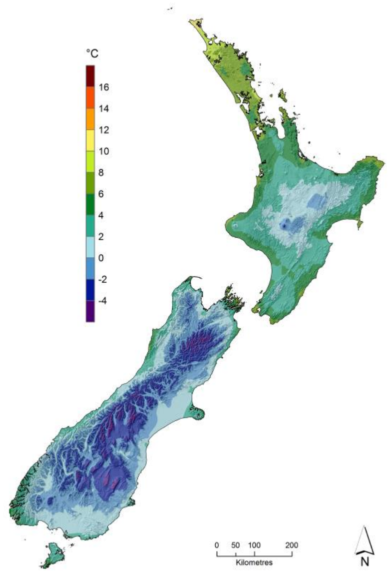
15 National Institute of Water and Atmospheric Research. 2017. *Overview of New Zealand Climate*. Retrieved from www.niwa.co.nz/education-and-training/schools/resources/climate/overview.

Average annual temperatures range from 10°C in the southern part of New Zealand to 16°C in the north. Temperatures fluctuate up to 14°C between seasons inland and to the east of the ranges, but generally the changes between summer and winter temperatures are small. On average, most of New Zealand receives at least 2000 sunshine hours annually (figure 2.3).[16] New Zealand's average annual temperature has increased approximately 1°C over the past 100 years.[16]

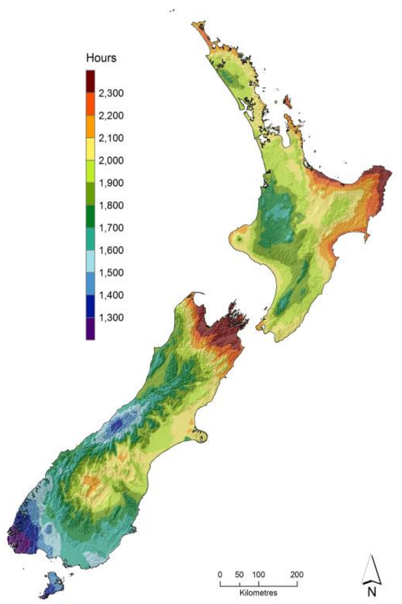
Figure 2.3: Median values for New Zealand's climate, 1981–2010*



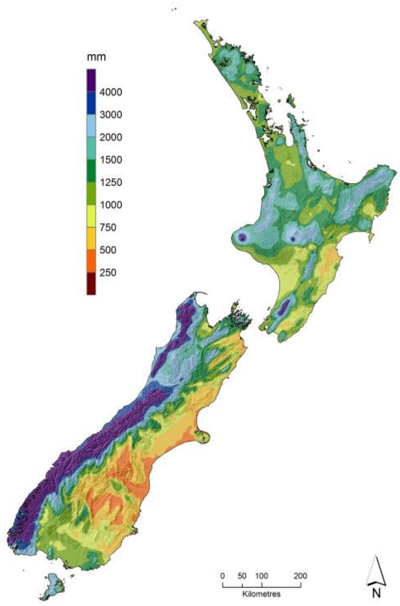
Maximum daily temperature (mid-summer median)



Minimum daily temperature (mid-winter median)



Sunshine hours (annual median)



Rainfall (annual median)

Note: * These are the latest available maps, updated every 10 years.

Source: National Institute of Water and Atmospheric Research. 2010.

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16 National Institute of Water and Atmospheric Research. 2017. *'Seven-station' Series Temperature Data*. Retrieved from www.niwa.co.nz/our-science/climate/information-and-resources/nz-temp-record/seven-station-series-temperature-data.

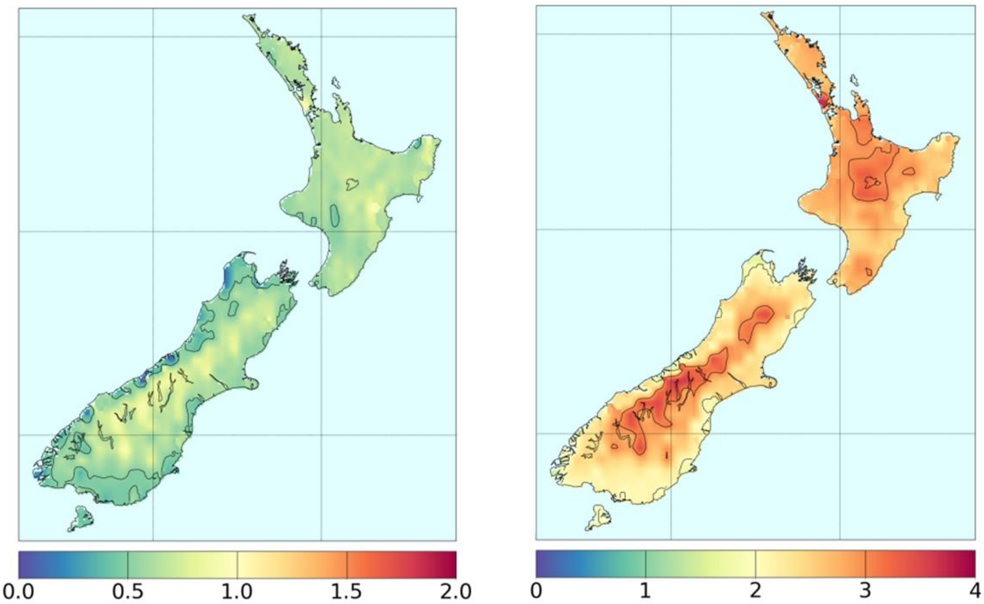
2.3.2 Projected changes in climate

The following projections are based on two different scenarios, known as Representative Concentration Pathways (RCPs). One is a low-emissions mitigation pathway that requires removal of some of the carbon dioxide (CO_2) presently in the atmosphere (RCP2.6), and the other is a pathway with very high greenhouse gas emissions (RCP8.5).

According to the projections, by 2090 the temperatures will increase by about 0.7°C under the low-emissions scenario, and by about 3.0°C under the high-emissions scenario in relation to the 1995 baseline. The pattern of annual average warming is expected to be relatively uniform across New Zealand, with slight gradients from north to south and from east to west. The North Island is predicted to warm more than the South Island (figure 2.4).[17]

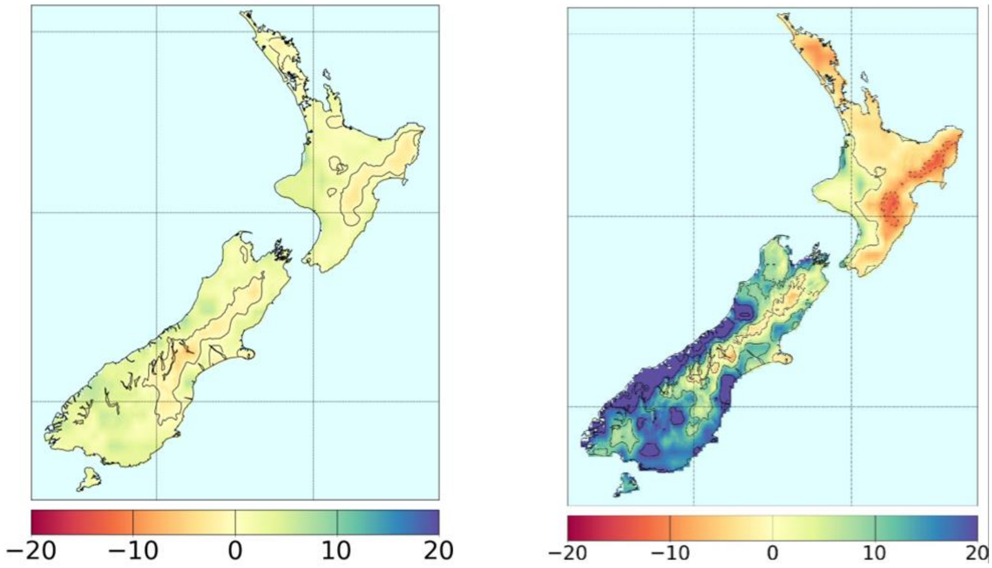
Projections of annual precipitation are highly variable by region and by season. The largest rainfall changes by the end of the century will be for particular seasons rather than annually. The overall pattern for changes in annual precipitation is a reduction in the north and east of the North Island, and increases almost everywhere else (figure 2.5), especially for the South Island's West Coast (up to a 40.0 per cent increase of rainfall during winter under RCP8.5 by 2090). Seasonally, decreased rainfall in the spring is expected in the north and east of the North Island, and in the south and east of the South Island. During summer, increased rainfall is projected in the north and east of the North Island, and increased winter rainfall is expected in many parts of the South Island.[17]

Figure 2.4: Projected annual average temperature changes by 2090 under the RCP2.6 low-emissions scenario (left) and the RCP8.5 high-emissions scenario (right), relative to the 1995 baseline*



[17] Ministry for the Environment. 2016. *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment*. Wellington: Ministry for the Environment.

Figure 2.5: Projected annual average rainfall changes (%) by 2090 under the RCP2.6 low-emissions scenario (left) and the RCP8.5 high-emissions scenario (right), relative to the 1995 baseline*



Note: * The colour scales are different, in order to show each scenario more clearly.

Source: National Institute of Water and Atmospheric Research. 2016.

2.4 Government structure

2.4.1 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, Queen Elizabeth II (the Sovereign). The Queen 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 Queen is represented in New Zealand by a Governor-General, currently Her Excellency The Right Honourable Dame Patsy Reddy.[18]

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 52nd Parliament.[19]

18 See www.gg.govt.nz

19 See www.parliament.nz/en/mps-and-electorates/political-parties. This information was accurate as at 10 November 2017.

2.4.2 Local government

New Zealand has 78 local authorities comprising 11 regional councils, 61 territorial authorities and 6 unitary councils (which are territorial authorities with regional council responsibilities). 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, derived from taxes on land and property and council-owned enterprises.

The purpose of the Local Government Act 2002 is for local government to promote the social, economic, environmental and cultural well-being of communities and to enable democratic decision-making. A sustainable development approach and community planning are cornerstones of the Local Government Act. This Act requires local authorities to consult communities on their desired outcomes and prepare Long-term Council Community Plans. The activities of local government include the provision of utility services, recreational assets, transportation services, and land and resource management.[20]

Local authorities have the primary responsibility for regulating resource use in New Zealand. The mandate for this derives from a range of legislation, but in particular the Resource Management Act 1991. This Act integrated the provisions of more than 75 earlier laws and is founded on the principle of sustainable management of natural and physical resources. The Resource Management Act has undergone several reviews and amendments to keep up with changing needs and circumstances. The latest major review was in 2017.

2.5 Buildings and urban structure

The 2013 census recorded 1.6 million occupied dwellings (about 8700 of which were public dwellings and the rest were private) and approximately 185,500 unoccupied dwellings. That year the average number of people per dwelling was 2.7. The majority (81.1 per cent) of occupied dwellings were separate houses, 18.1 per cent were two or more flats or apartments joined together, and the remaining 0.7 per cent were a mixture of other types of dwellings, including holiday homes, mobile homes and improvised dwellings.[21] In March 2017 the number of private dwellings was estimated to be 1.8 million.[22] The number of private dwellings and households in New Zealand has historically been increasing at a rate exceeding the population growth rate, but since 2013 that trend has reversed. The proportion of households who rent their dwelling has increased from 23 per cent in 1991 to 32 per cent in 2015. The proportion of households who own their dwelling (with or without a mortgage) has decreased from 74 per cent in 1991 to 64 per cent in 2015.[23]

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20 For more information on the role of local government bodies, see www.localcouncils.govt.nz.

21 Statistics NZ. 2013. *QuickStats about Housing.* Retrieved from www.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-about-housing/types-occupied-dwellings.aspx.

22 Statistics NZ. 2017. *Dwelling and Household Estimates: March 2017 quarter*. Retrieved from www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/DwellingHouseholdEstimates_HOTPMar17qtr.aspx.

23 Statistics NZ. 2017. *Dwelling and Household Trends: 1991–2015.* Retrieved from www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/dwellings-household-trends-1991-2015.aspx.

2.6 Economy

New Zealand has an export-dependent economy operating on free market principles. In the year ended March 2017, New Zealand's nominal gross domestic product (GDP) was NZ$230.5 billion (US$167.7 billion) and the nominal GDP per capita was NZ$56,073.[24,25] The economy has grown at an average annual rate of 2.6 per cent since 1990.[26]

The economy is based on the provision of services (roughly two-thirds of the total GDP) and the manufacturing and primary sectors (figure 2.6). The primary sector (agricultural, horticultural, forestry, mining and fishing industries) plays a fundamental role in the export sector and in employment. Overall, the primary sector directly accounts for around 8 per cent of real GDP (figure 2.6) and contributes just over half of New Zealand's total export earnings.[27] In 2013 the primary sector employed 135,297 people, with the agriculture industry being the second-largest employer (at 5.5 per cent of total people employed) after the professional, scientific and technical services industry (7.2 per cent).[28]

Tourism is another important source of income for New Zealand, directly contributing NZ$12.9 billion (5.6 per cent) to New Zealand's GDP. International tourist expenditure accounted for NZ$14.5 billion or 20.7 per cent of New Zealand total export earnings in 2016. In the same year there were 3.6 million overseas visitor arrivals. The most important sources of visitors to New Zealand over this period were Australia, China, the United Kingdom, the United States and Japan. Total visitor numbers and expenditure are forecast to increase annually at around 5.8 and 6.2 per cent respectively between 2017 and 2023.[29]

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24 Statistics NZ. 2017. *Table Reference: SNE053AA*. Retrieved from: www.stats.govt.nz/infoshare.

25 Statistics NZ. 2017. *Regional Gross Domestic Product: Year ended March 2017*. Retrieved from www.stats.govt.nz/browse_for_stats/economic_indicators/GDP/GrossDomesticProduct_HOTPMar17qtr.aspx.

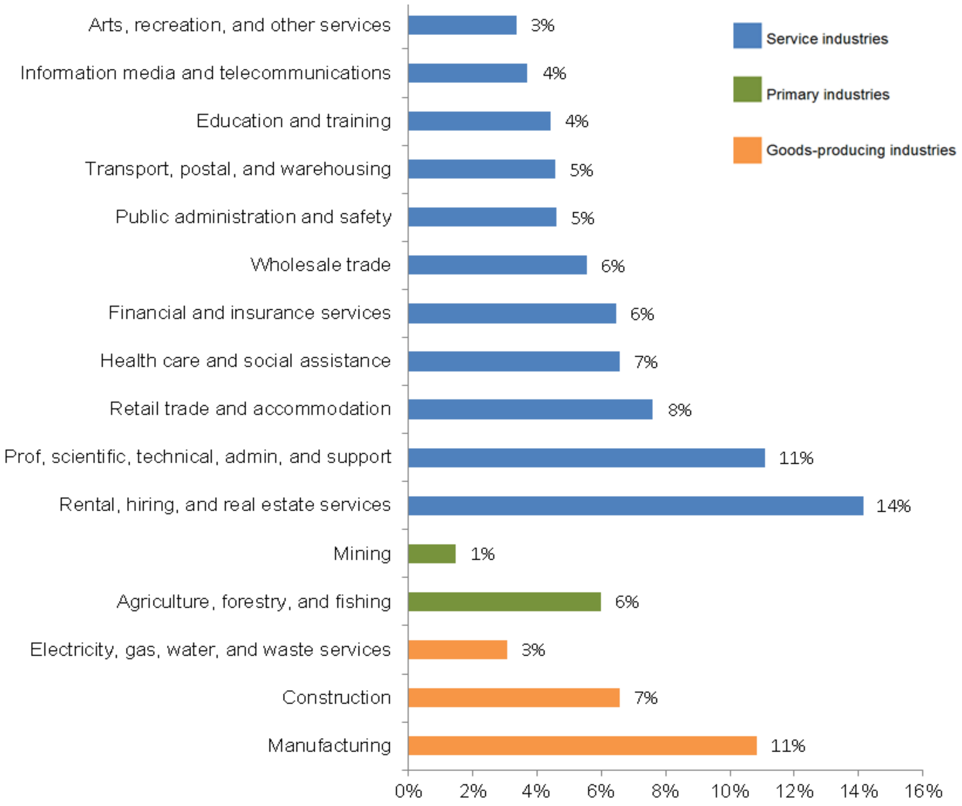
26 Annual average calculated based on percentage change from same quarter previous year, ie, 2015Q3 vs 2016Q3. Statistics NZ. 2017. *Table Reference: SNE181AA.* Retrieved from: www.stats.govt.nz/infoshare.

27 The Treasury. 2016. *New Zealand Economic and Financial Overview 2016.* Retrieved from www.treasury.govt.nz/economy/overview/2016.

28 Statistics NZ. 2013. *QuickStats about Work and Unpaid Activities.* Retrieved from www.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-work-unpaid.aspx.

29 Ministry of Business, Innovation and Employment. 2017. *Key Tourism Statistics*. Retrieved from www.mbie.govt.nz/info-services/sectors-industries/tourism/key-tourism-statistics.

Figure 2.6: Contribution of different sectors to New Zealand's GDP*



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

Source: Statistics New Zealand. 2017. Gross Domestic Product: March 2017 quarter.

New Zealand's economy was affected by widespread drought in the first half of 2013. This drought was unusual due to its severity and how it affected the whole country, rather than only one area. It had a major impact on the agriculture industry, in particular dairy farming, where the volume of milk produced fell dramatically. The economic impact from the drought was offset by increased demand for milk powder from China, which caused whole-milk powder prices to increase significantly resulting in 44.0 per cent growth in GDP for the agriculture sector between 2013 and 2014.[30]

A significant contributor to New Zealand's economic growth since 2012 has been the construction industry, mainly because of two factors. First, population growth has averaged about 1.3 per cent annually between 2012 and 2016. This has increased demand for housing and other infrastructure. The second contributor to construction growth was a series of earthquakes, in particular the Canterbury earthquakes in 2010 and 2011. These earthquakes caused significant damage to housing, other buildings and infrastructure. Real average annual growth for construction has been 5.1 per cent since 2012.[25] The value of building consents attributed to the Canterbury earthquakes and issued in the Canterbury region between September 2010 and May 2017 was NZ$4.1 billion, with approximately NZ$2.6 billion from residential construction and NZ$1.5 billion from non-residential construction.[31]

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30 Statistics NZ. 2017. *National Accounts (Industry Production and Investment)*. Retrieved from www.stats.govt.nz/browse_for_stats/economic_indicators/GDP/GrossDomesticProduct_HOTPMar17qtr.aspx.

31 Statistics NZ. 2017. *Earthquake-related building consents in Canterbury*. Retrieved from www.stats.govt.nz/browse_for_stats/industry_sectors/Construction/canterbury-earthquake-building-consents.aspx.

Another severe earthquake (magnitude 7.8) occurred near Kaikōura in November 2016. This has had an impact on transport around the country, due to disruption to the main road and rail route through the South Island. It is expected the road and rail network repair work will skew GDP estimates in the near future. It is unclear how this disruption in transport infrastructure will affect New Zealand's greenhouse gas emissions.

2.6.1 Exports

New Zealand's total exports of goods and services were valued at NZ$70.1 billion for the year ended December 2016. Australia continued to be New Zealand's primary export market, worth NZ$12.8 billion, followed by China (NZ$12.3 billion), the European Union (NZ$8.3 billion) and the United States (NZ$8.1 billion).[32]

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).[33] It is also a significant player in the kiwifruit, pip fruit and wool industries. Dairy products were New Zealand's largest export earner in the year ending December 2016, accounting for 16.0 per cent of exports at NZ$11.2 billion. In the same year meat products, wood products and fruit were New Zealand's next three largest groups of export goods, accounting for 8.4 per cent, 5.9 per cent and 3.9 per cent of total exports respectively. The largest service export was the business and other personal travel category, which contributed NZ$10.1 billion (14.4 per cent) of total export goods and services.

2.6.2 Imports

New Zealand's goods and services imports were valued at NZ$66.4 billion in the year ending December 2016. The European Union was New Zealand's largest source of imports, accounting for 17.7 per cent of the total, followed by Australia (16.9 per cent) and China (15.8 per cent). In the same year, the vehicles, parts and accessories category contributed the most to New Zealand's total imports at 10.9 per cent, followed by the mechanical machinery and equipment category at 10.0 per cent.

2.7 Energy

New Zealand's total primary energy supply (TPES) was 907 petajoules in 2015, an increase of 0.6 per cent on the 2014 calendar year.[34] This is calculated as domestic production plus imports, less exports and energy used for international transport. Renewable energy contributed 40.1 per cent of the 2015 TPES, the highest level on record. The remainder of the TPES was dominated by oil (32 per cent) and gas (21 per cent) (figure 2.7).[35]

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32 Statistics NZ. 2016. *Goods and Services Trade by Country: Year ended December 2016.* Retrieved from www.stats.govt.nz/browse_for_stats/industry_sectors/imports_and_exports/GoodsServicesTradeCountry_HOTPYeDec16.aspx.

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

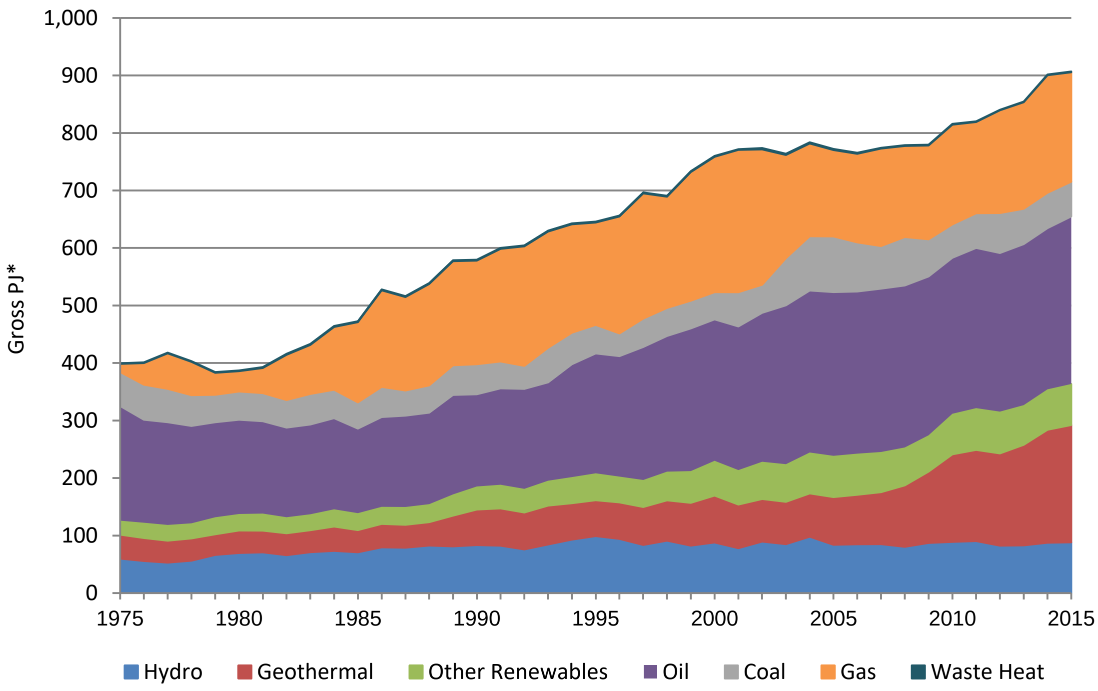
34 1 petajoule = 10^{15} Joules.

35 Unless otherwise specified, all information in this section is provided by the Ministry of Business, Innovation and Employment (MBIE): *Energy in New Zealand 2016.* Retrieved from www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/publications/energy-in-new-zealand.

The energy sector (including transport) is the second-largest contributor to New Zealand's gross greenhouse gas emissions, at approximately 40.5 per cent in 2015.[36] Since 1990, New Zealand's GDP has grown at a greater rate than the amount of energy used by consumers and as a result the overall energy intensity of the economy has improved 1.2 per cent on average per year between the years 1990 and 2015.

New Zealand's total energy self-sufficiency was 81.0 per cent in 2015.[37] Energy self-sufficiency peaked in 2010 at 92.0 per cent due to historically high oil, gas and coal production. The minimum self-sufficiency occurred in 2005 at 75 per cent. New Zealand meets all of its gas, renewables and waste heat needs through indigenous production.

Figure 2.7: Total primary energy supply by fuel, 1975–2015



Note: * PJ = petajoules.

Source: Ministry of Business, Innovation and Employment. 2017. *Energy in New Zealand 2016.* 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 (80.8 per cent in 2015). For the 2015 calendar year, hydro generation provided 55.5 per cent of New Zealand's electricity. A further 17.8 per cent came from geothermal, 5.3 per cent from wind, 1.4 per cent from biomass and 0.2 per cent from solar. The remaining 19.8 per cent was provided by fossil fuel thermal generation plants using gas, coal and oil.

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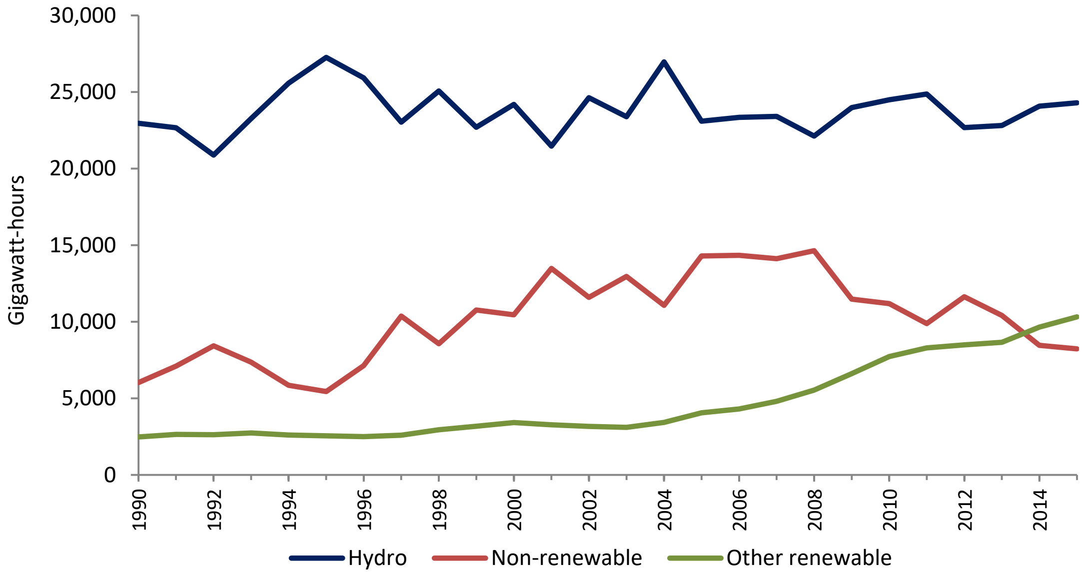
36 All greenhouse gas emissions data in this section are from: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015*. Wellington: Ministry for the Environment.

37 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.

Electricity consumption grew by 2.0 per cent between 2014 and 2015. The industrial sector accounted for the largest share of consumption in 2015 at 36.9 per cent, followed closely by the residential sector at 31.7 per cent. The wider Auckland region has the highest share of national electricity demand (28.6 per cent) due to its large population. In 2015 the public electricity and heat production category contributed 5.0 per cent of New Zealand's gross greenhouse gas emissions, an increase of 15.8 per cent since 1990. 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 the 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 2.8 shows the close inverse relationship between non-renewable and hydro generation. This relationship has historically influenced the yearly fluctuations seen in New Zealand's total energy and gross greenhouse gas emissions. Figure 2.8 also shows that the amount of electricity generated by renewable sources other than hydro power has more than tripled since 1990.

Figure 2.8: New Zealand's hydro-electric, other renewable and non-renewable electricity generation, 1990–2015



Source: Ministry of Business, Innovation and Employment. 2017. *Energy in New Zealand 2016.* Wellington: MBIE.

The electricity industry has gone through a long process of reform. Competition in the generation sector was first 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 are now administered by the Electricity Authority, an independent Crown entity.[38]

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

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[38] For a detailed account, see: MBIE. 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.

Aluminium Smelter. There are 29 local distribution network companies in New Zealand, with a variety of ownership models. Economic regulation of Transpower and 17 distribution businesses that are not consumer-owned is administered by the Commerce Commission. Electricity consumers can choose between competing retailers of electricity. There are currently five main generation companies, which in 2015 provided around 91.0 per cent of New Zealand's total electricity generation.

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 2015 New Zealand produced 182 petajoules of gas from 17 gas fields. Of New Zealand's total consumption in 2015 (185 petajoules), the great majority was used by the industrial sector. The remainder was consumed by the commercial and residential sectors, and the agriculture, forestry and fishing industries.[39] In 2015 combustion of natural gas contributed approximately 9.5 per cent of New Zealand's gross greenhouse gas emissions, when in 1990 the corresponding figure was 18.3 per cent.

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 2015 New Zealand produced 87.6 petajoules (14.9 million barrels) of crude oil from 16 fields in the Taranaki region. The same year, crude oil production was at its highest level since 2011, with an average of 40,900 barrels produced per day.[40] In 1990 oil production and use (including liquid petroleum gas) contributed 5.0 per cent of New Zealand's gross greenhouse gas emissions; by 2015 the contribution had increased to 23.3 per cent.

While New Zealand is a net importer of oil, crude oil extracted in New Zealand is of high quality and fetches a premium price on the international market. Cheaper foreign oil is imported and refined at the Marsden Point refinery. The domestic oil sector consists of a number of oil-producing companies, one refinery, five wholesalers, a range of independent distributors and five main oil retailers.

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. The estimated in-ground resources for all coal types are over 15 billion tonnes. Approximately 80 per cent of this is lignite (low grade). Bituminous and sub-bituminous in-ground resources are around 4 billion tonnes. Most of New Zealand's bituminous coal production is exported, accounting for 97.0 per cent of total coal exports in 2015. In 2015 New Zealand exported 1.4 million tonnes (43 petajoules) of coal.

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[39] MBIE. 2017. *Data Tables for Gas*. Retrieved from www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/gas.

[40] MBIE. 2017. *Data Tables for Oil*. Retrieved from www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/oil.

In 2015 New Zealand consumed 2.8 million tonnes of coal, a decrease of 1.3 per cent from the previous year. The coal was mainly used for industrial purposes (37.0 per cent) and electricity generation (33.0 per cent). The proportion of New Zealand's gross greenhouse gas emissions from the consumption of coal has decreased from 10.9 per cent in 1990 to 4.4 per cent in 2015. Because of the small size of New Zealand's coal-mining industry, local changes in mining operations can lead to a variation in emissions from year to year.[41] The closing of two coal mines resulted in a 30.0 per cent decrease in emissions from coal mining between 2010 and 2011.[42]

2.8 Transport

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 New Zealand's 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. As a result, transport in New Zealand is energy intensive and relies on fossil fuels. In 2015 transport contributed 18.4 per cent of New Zealand's gross domestic greenhouse gas emissions, an increase of 68.4 per cent from 1990.[43] The great majority (90.0 per cent) of these emissions are from road transport (table 2.1 and figure 2.9).

Table 2.1: Transportation emissions, 2015

Category	Emissions (kilotonnes of carbon dioxide equivalent)	Percentage of total transport emissions	Percentage of total energy sector
Road transportation	13,282.3	90.0%	40.9%
Domestic aviation	856.4	5.8%	2.6%
Domestic navigation	434.7	2.9%	1.3%
Railways	154.7	1.0%	0.5%
Other transportation	33.8	0.2%	0.1%
Total	**14,761.9**	**100%**	**45.5%**

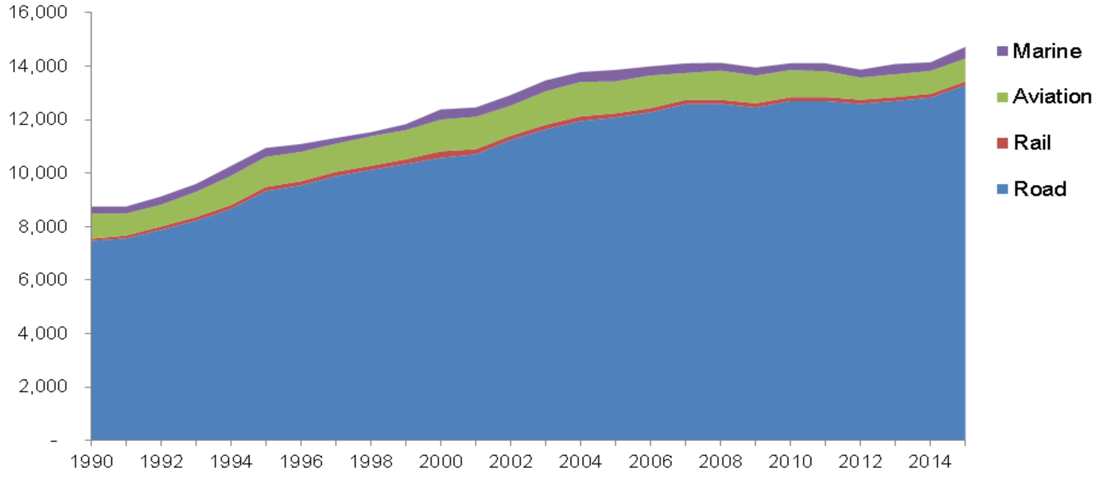
Note: * Columns may not total due to rounding.

41 Emissions from coal mining are 'fugitive emissions' – those emissions that arise from the production, processing, transmission and storage of fuels, and from non-productive combustion.

42 Pike River Mine was sealed in January 2011 due to explosions in November 2010. Spring Creek Mine suspended its coal production from November 2010 to May 2011 to accelerate work on a safety improvement programme.

43 All greenhouse gas emissions data in this section are from: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

Figure 2.9: Domestic transport emissions by mode (Mt CO_2-e), 1990–2015



Source: Ministry of Business, Innovation and Employment. 2017. *Energy Greenhouse Gas Emissions: 2015 Calendar Year Edition.* Wellington: MBIE.

2.8.1 Road transport

The majority of vehicles in New Zealand (over 90 per cent) are light vehicles (those that have a gross vehicle mass of less than 3.5 tonnes). In 2015, 82.6 per cent of the light fleet was powered by petrol and 17.4 per cent by diesel. New Zealand has a relatively old vehicle fleet: in 2015 the light vehicle fleet was 14.2 years and the truck fleet 17.6 years on average.[44] Most New Zealanders (more than 80 per cent) travel to work using private road transport.[45] Road transport also carries most of the domestic freight in tonne-kilometres (70.3 per cent).[46]

In 2015 there were approximately 3.5 million light vehicles in New Zealand, which is the equivalent of 767 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 (figure 2.10). There was a decrease of light vehicles per person after the 2007 peak until 2011, but the number has been increasing significantly since 2011 (figure 2.10). The total annual distance travelled by all vehicles on roads grew by 13.9 per cent from 2001–15. The major causes of this increase were economic and population growth.

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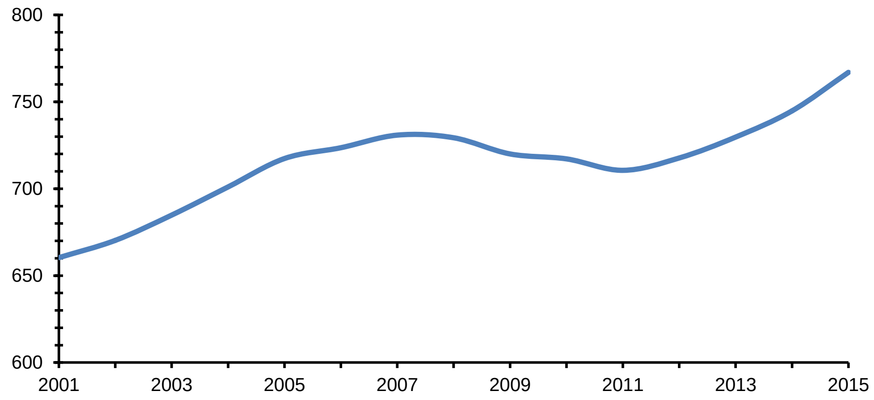
[44] Unless otherwise specified, all data in this section are from: Ministry of Transport. 2015. *New Zealand Vehicle Fleet Annual Statistics*. Retrieved from www.transport.govt.nz/research/newzealandvehiclefleet statistics.

[45] Ministry of Transport. 2017. *Mode Share of Journeys to Work TP006.* Retrieved from www.transport.govt.nz/ourwork/tmif/travelpatterns/.

[46] Ministry of Transport. 2017. *Freight tonne-km by Mode Share FT008.* Retrieved from www.transport.govt.nz/ourwork/tmif/freighttransportindustry.

Figure 2.10: Light vehicle fleet ownership in New Zealand, 2001–15



Source: Ministry of Transport. 2017. *New Zealand Vehicle Fleet Annual Statistics.* Wellington: Ministry of Transport.

2.8.2 Aviation

Domestic aviation has increased, in part due to a reduction in the real cost of airfares. 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 6,296,900 air passenger arrivals into New Zealand in the year ended April 2017, an increase of 46.2 per cent in 10 years (since the year ended April 2007).[47] Of the total arrivals, 55.7 per cent were overseas visitors, 42.3 per cent were returning New Zealanders and the remaining 2.0 per cent were permanent and long-term migrants.

Aviation is also essential for the export and import of time-sensitive goods, such as horticultural products and medical supplies. Freight movements by air made up 15.3 per cent of exports by value in 2016. The corresponding figure for imports was 22.1 per cent.

2.8.3 Maritime

Domestic shipping is relied on for transporting some freight within New Zealand, including across the Cook Strait between the North and South Islands. Daily ferry services are operated by two competing companies using a total of five vessels. These ferries transport passengers and freight across the Cook Strait, with a journey time of around three hours. A small number of passenger ferries operate in the coastal cities (predominantly in Auckland and Wellington), which provide commuter and recreational services.

International shipping is crucial to New Zealand's trading. In the year to March 2016, 36.6 million tonnes (the real value of NZ$40.4 billion) were exported from New Zealand by sea. In the same year, imports by sea totalled 20.7 million tonnes, worth NZ$53.3 billion.[48]

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[47] Statistics NZ. 2017. *International Travel and Migration: April 2017.* Retrieved from www.stats.govt.nz/browse_for_stats/population/Migration/IntTravelAndMigration_HOTPApr17/Related%20links.aspx.

[48] Ministry of Transport. 2017. *Freight Information Gathering System & Container Handling Statistics April 2015 – March 2016.* Retrieved from www.transport.govt.nz/sea/figs.

2.8.4 Rail

The national rail network totals approximately 4000 kilometres. 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 provide approximately 26.1 million passenger trips annually, comprising 12.1 million trips in Wellington and 13.9 million trips in Auckland.[49] Rail carries 16.0 per cent of freight in tonne-kilometres within New Zealand.[50]

2.9 Agriculture

Agriculture in New Zealand is dominated by pastoral farming of dairy cattle, beef cattle, sheep and deer. As at June 2016 the country had 6.6 million dairy cattle, 3.5 million beef cattle, 27.6 million sheep and 0.84 million deer.[51] New Zealand also produces a number of different horticultural products, including kiwifruit, pip fruit, wine, and fresh and processed vegetables.

Because of New Zealand's temperate climate, the majority of animals are fed on grass outside all year round and are rarely housed inside. New Zealand's pastures have four primary sources of nitrogen: nitrogen fixed by legumes, nitrogen fertiliser, nitrogen from external supplementary feeds and nitrogen from atmospheric sources.

New Zealand farming systems are highly adaptable and have changed over the past few decades. For example, the use of synthetic nitrogen-containing fertiliser on agricultural soils increased by approximately seven-fold (623 per cent) between 1990 and 2015.

The climate is generally favourable for agriculture, but droughts do occur. Droughts can result in reduced pasture production, lower livestock performance and the need to reduce livestock numbers, and consequently lower greenhouse gas emissions.

In 2015 emissions from the agriculture sector decreased slightly (1.1 per cent) from 2014 because of a decline in production. This has been attributed to the combination of a drought in 2014–15 and a fall in milk prices. The most recent drought occurred in the Northland region in summer 2016–17.

2.9.1 Agricultural exports

Agricultural exports accounted for over half of the total value of New Zealand's goods exported in 2016. The highest-earning exports were dairy products, worth NZ$11.2 billion, and meat products, worth NZ$5.9 billion. Fruit and vegetables were worth NZ$2.7 billion, and wine was worth NZ$1.6 billion.[52]

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49 Ministry of Transport. 2016. *Transport Volumes: Public Transport Volume: Data from 2011/12*. Retrieved from www.transport.govt.nz/ourwork/TMIF/Pages/TV020.aspx.

50 Ministry of Transport. 2016. *National Freight Demand Study.* Retrieved from www.transport.govt.nz/research/nationalfreightdemandsstudy.

51 Statistics NZ. 2016. *Agricultural Production Statistics – June 2016.* Retrieved from www.stats.govt.nz/browse_for_stats/industry_sectors/agriculture-horticulture-forestry/AgriculturalProduction_final_HOTPJun16final.aspx.

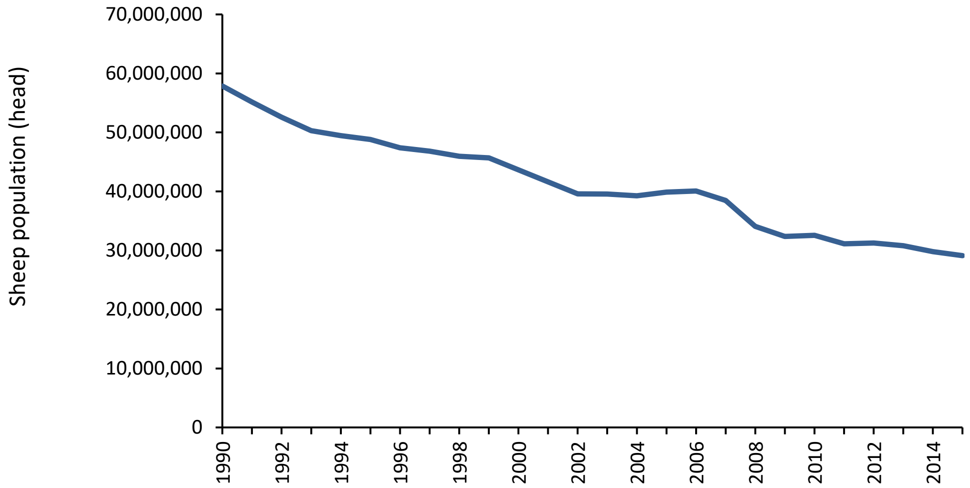
52 Statistics NZ. 2017. *Global New Zealand – International Trade, Investment and Travel Profile*. Retrieved from www.stats.govt.nz/browse_for_stats/industry_sectors/imports_and_exports/global-nz-jun-16.aspx.

The top five export destinations for 2016 by value for dairy products, in order, were China, the United States, Australia, Algeria and Japan. Over the past decade there has been a shift in the composition of New Zealand's dairy export market due to greater demand for dairy products from countries in Asia, the Middle East and Africa. Global price recovery, particularly for whole milk and butter, and growing demand for whole-milk powder from Brazil, Indonesia, Algeria and Russia are predicted to increase New Zealand's dairy export revenue in the next five years.[53]

2.9.2 Changes in the agricultural industry

Agriculture in New Zealand has undergone a transformation to become the highly competitive and efficient sector it is today. This transformation was triggered by the removal of agricultural subsidies in 1984.[54] New Zealand's agriculture sector is now the least subsidised in the OECD.[55] Agricultural productivity has increased due to advances in technology and animal breeding, the expansion of the average size of farms and improved animal health and plant nutrition. There have also been changes in the proportions of the main livestock species farmed in New Zealand. From the early 1990s to the present, sheep numbers have declined sharply (figure 2.11) due to low sheep meat and wool prices, and subsequent sheep farm conversions to dairying, viticulture and cropping. Dairy cattle numbers have grown significantly (88.5 per cent since 1990) due to the relatively high profitability of dairy products compared with sheep and beef products (figure 2.12).

Figure 2.11: Changes in New Zealand's sheep population, 1990–2015



Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

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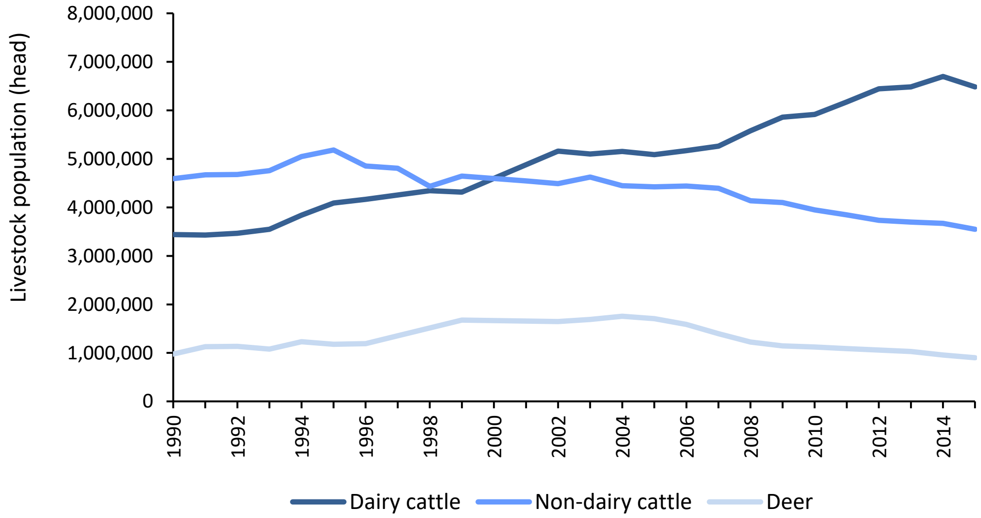
53 Ministry for Primary Industries. 2017. *Situation and Outlook for Primary Industries 2017.* Retrieved from www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/situation-and-outlook-for-primary-industries-data.

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

55 OECD. 2017. *Agricultural Support*. Retrieved from https://data.oecd.org/agrpolicy/agricultural-support.htm.

Figure 2.12: Changes in New Zealand's dairy, beef and deer populations, 1990–2015



Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

2.9.3 Emissions

High levels of agricultural activity mean almost half of New Zealand's gross greenhouse gas emissions come from agriculture, compared with an average of 12 per cent in other developed countries. Most of those emissions (73.1 per cent of agriculture emissions in 2015) come from enteric fermentation. Livestock numbers have a significant effect on New Zealand's gross emissions. Greenhouse gas emissions from the agriculture sector increased by 16.0 per cent between 1990 and 2015. The increase was mainly due to the 88.5 per cent increase in the national dairy herd population within that period. Since 1990, New Zealand pastoral farmers have consistently made production efficiency improvements in farming systems. Without these improvements, agricultural emissions would have increased by almost 40 per cent to produce the same amount of food.[56]

2.10 Fisheries

Approximately 600,000 tonnes of seafood (excluding aquaculture) is harvested from New Zealand waters each year. The seafood industry employs over 20,000 people. New Zealand earned $1.79 billion in seafood exports in 2016. In the same year 287,864 tonnes of seafood was exported.

New Zealand's marine fisheries waters (Exclusive Economic Zone and territorial sea) measures 4.4 million square kilometres, and is the world's fourth-largest EEZ. New Zealand 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 Commercial Catch for fish stocks and sets limits.

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56 New Zealand Agricultural Greenhouse Gas Research Centre. 2017. *The Structure of Agricultural Greenhouse Gas Research Funding in New Zealand*. Retrieved from www.nzagrc.org.nz/policy,listing,258,the-structure-of-agricultural-greenhouse-gas-research-funding-in-new-zealand.html.

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. New Zealand net primary productivity levels in the sea are high compared with most of Australasia, but are lower than most coastal upwelling systems around the world. The ocean surrounding New Zealand plays a major role in moderating the climate on land, and there is emerging evidence that the chemistry of seawater is changing (eg, ocean acidification) in line with other parts of the globe.[57]

2.11 Forestry

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 New Zealand as it is the third-biggest export earner at 5.9 per cent of total exports, and directly employs around 20,000 people.[58]

New Zealand had 7.8 million hectares of natural (indigenous) forest in 2015, which covered around 29.1 per cent of its total land area (figure 2.1). Two-thirds of New Zealand's natural forest is protected within public conservation land. The two main types of natural forest in New Zealand 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.[59]

Planted forests covered around 7.7 per cent of total land area in 2015 (figure 2.1). This includes forests planted for timber production and for conservation purposes, for example, for soil conservation and erosion control. Only a small proportion (0.1 per cent) of New Zealand's total timber production is derived from natural forests, and the timber industry is now based almost entirely on planted forests.[60] Total planted production forests covered just under 2.1 million hectares in 2015. *Pinus radiata* makes up 90.0 per cent of the planted forest estate, followed by Douglas-fir at 6.0 per cent.[61]

New Zealand's forests are currently a net carbon sink. Forests offset nearly 30.0 per cent of New Zealand's gross emissions in 2015. Net emissions have increased by 63.6 per cent since 1990.[62] The reason for the increase is the combined effect of the increase in gross emissions and the currently high harvesting rates occurring in planted forests compared with 1990. 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.

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57 For more information, see the chapter on ocean and climate conditions in: Ministry for Primary Industries. 2017. *Aquatic Environment and Biodiversity Annual Review 2016*. Retrieved from www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/fisheries.

58 Ministry for Primary Industries. 2017. *New Zealand's Forests.* Retrieved from: www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/forestry.

59 Under the UNFCCC, the figures collected for exotic 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.

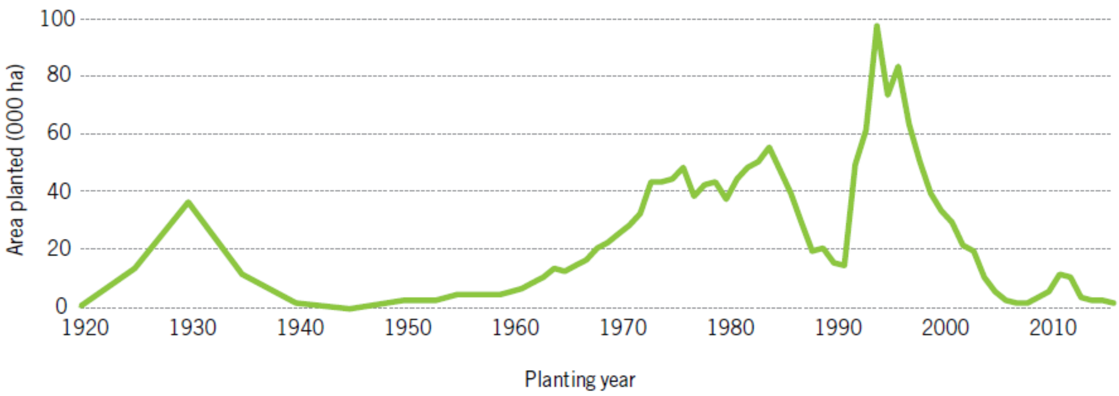
60 Ministry for Primary Industries. 2016. *Wood Processing.* Retrieved from www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/forestry/wood-processing.

61 Ministry for Primary Industries. 2017. *National Exotic Forest Description, as at 1 April 2016*. Retrieved from www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/forestry/new-zealands-forests.

62 Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015*. Wellington: Ministry for the Environment.

Forest planting rates were particularly high in the 1980s and 1990s (figure 2.13). 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 alternatives.[63] After the late 1990s the rate of planting declined. The subsequent increase in planting between 2008 and 2012 is largely attributable to the first Afforestation Grant Scheme and market-based measures for forest carbon (the Emissions Trading Scheme 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.

Figure 2.13: New Zealand's historical new production forest planting, 1920–2016



Note: ha = hectares.

Source: Ministry for Primary Industries. *National Exotic Forest Description, as at 1 April 2016*. Wellington: Ministry for Primary Industries.

Since 2012 the new forest planting rates have again dropped back to the pre-2008 levels. These current low rates are likely to be due to the relative profitability of other forms of land use, high rural land prices and, for most of the period, the low price of carbon in the NZ ETS. The exclusion of international units from the NZ ETS in May 2015 and the commencement of the NZ ETS review have both contributed to higher carbon prices, and this is expected to increase economic incentives for afforestation in future. A second Afforestation Grant Scheme is under way and aims to establish about 15,000 hectares of new forest between 2015 and 2020.

Rates of deforestation are influenced by the comparative economics between land uses, government policy and the carbon emissions unit price. The trend for decreasing forest area that has been observed since 2004 continued to 2015, but there was a slight reduction in deforestation in 2015 compared with 2014 levels. The reduction in net emissions resulting from deforestation since 2014 was likely influenced by higher carbon prices, driven by the exclusion of international units from the NZ ETS in May 2015. Higher carbon prices in recent times (at around NZ$17–18 per New Zealand Unit), and greater restrictions on livestock access to water and the discharge of nutrients are expected to reduce the level of deforestation further.

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

2.12 Waste

Solid waste in New Zealand either is disposed of at landfills or is recycled. Around 2.5 million tonnes of waste is sent to municipal landfills every year in New Zealand.[64,65] Twenty-four of these landfills (which collectively receive approximately 90.0 per cent of the waste sent to landfill) had methane recovery systems in 2011. There is no incineration of municipal waste in New Zealand, 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 (44.0 per cent) and food waste (17.0 per cent) (figure 2.14).

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. There are approximately 300 municipal wastewater treatment plants in New Zealand. In addition, there are around 50 government or privately owned treatment plants serving populations of between 100 and 1000 people. 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.[66]

In 2015 the waste sector contributed 5.0 per cent of New Zealand's gross greenhouse gas emissions. The emissions downtrend observed since 2005 continued between 2014 and 2015. This is despite ongoing population growth and the resulting increases in the amount of municipal waste generated. Improved landfill management practices, particularly landfill gas recovery, have contributed to this downward trend. In 2015 waste emissions were below the 1990 levels for the third year in a row. Emissions in the waste sector were from solid waste disposal to land (90.6 per cent), wastewater (9.3 per cent) and incineration (0.1 per cent).

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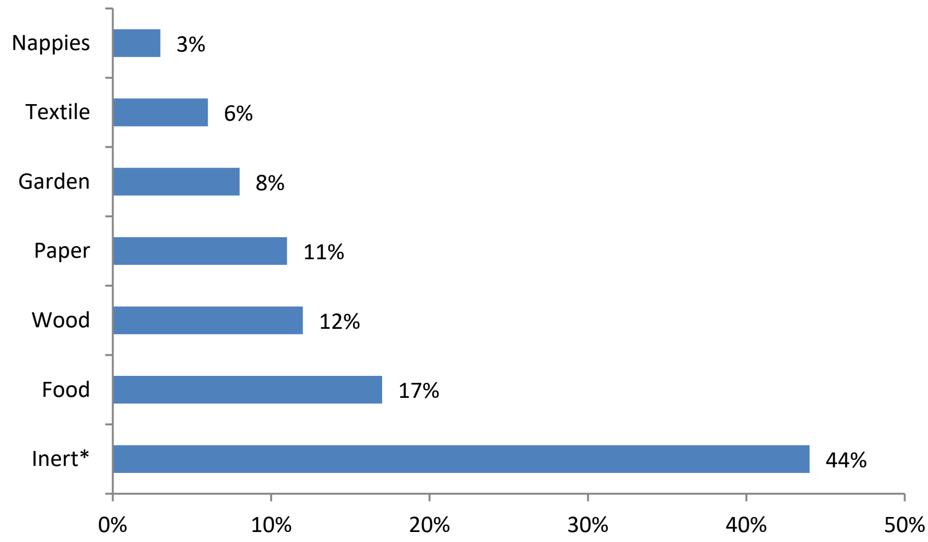
64 This is the quantity of waste that the waste disposal levy was collected on. The waste disposal levy is applied to waste received by disposal facilities, as defined by the Waste Minimisation Act 2008. It excludes diverted (recovered, reused or recycled) materials.

65 Municipal landfills are landfills where waste disposed of includes some household waste and that operate, at least in part, as a business to dispose of waste.

66 SCS Wetherill Environmental. 2002. *National Greenhouse Gas Inventory from the Waste Sector 1990–2020.* A report prepared for the Ministry for the Environment.

Figure 2.14: Estimate of New Zealand's waste composition, 2013–15



Note: * Non-greenhouse gas-producing waste that does not decompose.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015*. Wellington: Ministry for the Environment. Estimates based on survey conducted in 2012.

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 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 completed on 13 November 2017. New Zealand 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 Exclusive Economic Zone. 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.

Tokelau's population is spread over three small coral atolls (Atafu, Fakaofo and Nukunonu), which lie some 500 kilometres to the north of Samoa. The population of Tokelau is about 1500. 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, 7176 New Zealand residents identified as Tokelauan in the 2013 census.

Tokelau's economy is dominated by economic assistance from New Zealand and fisheries revenue (NZ$41 million from 2013–16). New Zealand provides general budget support to assist the delivery of essential services, consistent with our constitutional and United Nations Charter obligations.

New Zealand's total bilateral allocation to Tokelau for the period 2013–16 was NZ$83.8 million, comprising budget support, capital projects such as the new passenger ferry, and activities to improve education and transport. In addition to the bilateral funding, New Zealand commits funding for scholarships and a wide range of agencies that support the Government of Tokelau in areas such as policing, disaster preparedness, biosecurity, maritime safety and telecommunications. In the current New Zealand aid budget triennium (2015/16–2017/18), the Governments of New Zealand and Tokelau are working closely on rehabilitation of the reef passages and wharves in four locations on the atolls to increase the safety and efficiency of the transfer of passengers and cargo from ship to shore.

Tokelau's low-lying atolls are extremely sensitive to climate change and related hazards. The islands that make up Tokelau's atolls are typically no more than 200 metres wide and no point on Tokelau is higher than 5 metres above sea level. Tokelau is vulnerable to coastal erosion and inundation damage caused by rising sea levels and extreme events, including tropical cyclones, storm surges, droughts and flooding. New Zealand aid programme activities are therefore also supporting a range of climate-related projects in Tokelau. During the reporting period, New Zealand's support related to climate change has included:

- NZ$200,000[67] for the Tokelau Renewable Energy Project, as a result of which solar photovoltaics power generation is meeting almost 100 per cent of the territory's electricity needs
- Tokelau in the New Zealand Pacific Partnership on Ocean Acidification, which the Secretariat of the Pacific Regional Environment Programme (SPREP) is leading to help raise awareness of the impacts of ocean acidification and build resilience to it in the Pacific
- Tokelau in the multi-country Pacific Disaster Risk Management and Resilience activity supporting disaster risk reduction, readiness, response and recovery efforts
- Tokelau in the Pacific Community-led regional Strengthening Water Security in Pacific Island States project to build resilience to drought and water shortages.[68]

A New Zealand-funded activity to build coastal resilience to the impacts of climate change and manage coastal inundation risks is currently being scoped and will be reflected in the next reporting period.

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) (annex E) and its companion the *LivC Implementation Plan, 2017–22* (annex F) are Tokelau's response to the challenges posed by climate change and related hazards. 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

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[67] Total activity spend was NZ$7.5 million, including outside of the reporting period.

[68] See chapter 7 for further financial details of these multi-country Pacific regional activities.

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.

3 Greenhouse gas inventory

Key points

- New Zealand's gross greenhouse gas emissions in 2015 were 80.2 million tonnes of carbon dioxide equivalent (Mt CO_2-e). This comprises emissions from the energy (including transport), agriculture, industrial processes and product use, and waste sectors.
- Since 1990 New Zealand's gross emissions have increased by 24.1 per cent.
- Gross emissions in 2015 were 0.1 per cent lower than emissions in 2014.
- The agriculture and energy sectors are the two largest contributors to New Zealand's emissions profile (at approximately 48.0 per cent and 40.0 per cent respectively of gross emissions in 2015).
- The five emissions sources that contributed the most to the increase since 1990 were:
  - road transport (carbon dioxide)
  - chemical industry and food processing (carbon dioxide)
  - enteric fermentation (methane)
  - agricultural soils (nitrous oxide)
  - industrial and household refrigeration and air-conditioning systems (fluorinated gases).
- New Zealand's net emissions under the United Nations Framework Convention on Climate Change were 56.4 Mt CO_2-e in 2015. Net emissions consist of gross emissions combined with emissions and removals from the land use, land-use change and forestry sector.
- Net emissions have increased by 63.6 per cent since 1990. The reason for the increase is the combined effect of the increase in gross emissions and the higher harvesting rates in planted forests in 2015 compared with 1990.

3.1 Introduction

New Zealand has transparent, accurate and regular national greenhouse gas inventory reporting, which forms one of the building blocks for effective climate change mitigation. As a Party to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, New Zealand has an obligation to prepare, publish and update greenhouse gas inventories on an annual basis. New Zealand is also required to build and maintain the national inventory system for estimating greenhouse gas emissions and removals.

For the period 2013–20, New Zealand has taken an unconditional target to reduce its greenhouse gas emissions under the UNFCCC. It is applying the Kyoto Protocol framework of rules towards its target to ensure New Zealand's actions are transparent and have integrity. New Zealand remains a Party to the Kyoto Protocol and will continue to meet the reporting requirements of the Kyoto Protocol for the period 2013–20. Domestically New Zealand tracks progress towards its target in the 2020 net position report.[69]

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69 For the 2020 net position report, see the Ministry for the Environment's website: www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/latest-2020-net-position.

This chapter provides summary information on the latest trends of human-induced emissions of greenhouse gases in New Zealand. It also includes information on New Zealand's national inventory system. Annex A includes numerical data on inventory trends. Annex B contains additional details on New Zealand's inventory system and New Zealand's emissions units database (the registry). Further information on New Zealand's emissions and removals, and national inventory system can be found in New Zealand's annual National Inventory Report (NIR).[70]

The latest *Greenhouse Gas Inventory* (the inventory)[71] was submitted to the UNFCCC on 26 May 2017.[72] The submission was delayed by six weeks because activities of several government agencies were affected by the Kaikōura earthquake in November 2016. The delay in the inventory preparation, resulted in a delay to the national inventory compilation and the inventory submission to the UNFCCC.

The inventory includes information on emissions and removals of greenhouse gases for a complete time series from 1990–2015.[73] Inventory reporting under the UNFCCC covers five sectors:

1. energy (eg, transport, electricity generation and fuel used by industries such as agriculture or metal production)
2. agriculture (eg, agricultural soils, manure management, enteric fermentation)
3. industrial processes and product use (IPPU) – emissions from the chemical transformation of materials from one substance to another (eg, glass production)
4. waste (eg, municipal landfills and wastewater management)
5. land use, land-use change and forestry (LULUCF).

The greenhouse gas emissions and removals reported in this chapter were prepared in accordance with the UNFCCC reporting guidelines. Under the UNFCCC guidelines, the inventory reports emissions and removals from the entire LULUCF sector. For accounting purposes under the Kyoto Protocol, only the activities of afforestation, reforestation, deforestation and forest management are included (commonly referred to as Articles 3.3 and 3.4 activities). This means that the emissions totals and trends under UNFCCC and the Kyoto Protocol reporting and accounting are different.

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70 The abbreviation NIR is used in relation to the National Inventory Report

71 The inventory refers to the entire UNFCCC submission that includes the National Inventory Report, the common reporting format tables (CRF tables – the inventory database) and the simple electronic format tables (registry files).

72 Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Retrieved from www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/nzs-greenhouse-gas-inventory.

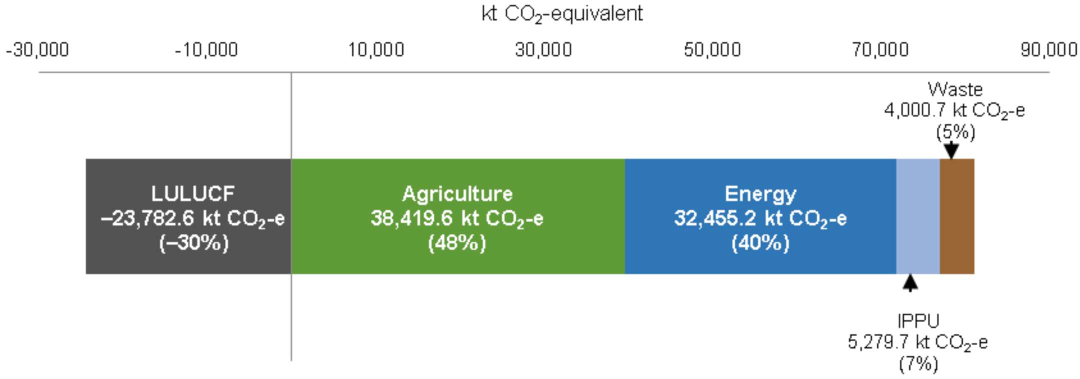
73 The inventory submission is always delayed by 15 months due to the time constraints for data collection and processing.

3.2 National trends in New Zealand's greenhouse gas emissions and removals

3.2.1 New Zealand's emissions in 2015

In 2015 New Zealand's gross greenhouse gas emissions (excluding the LULUCF sector) were 80,155.1 kilotonnes of carbon dioxide equivalent (kt CO_2-e). The two largest contributors to New Zealand's emissions profile were the agriculture and energy sectors (in total approximately 90 per cent of gross emissions). The emissions associated with the waste and IPPU sectors were relatively minor (figure 3.1). Changes in emissions between 1990 and 2015 by each inventory sector are summarised in table 3.1 and figure 3.2.

Figure 3.1: New Zealand's greenhouse gas emissions, by sector, 2015



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

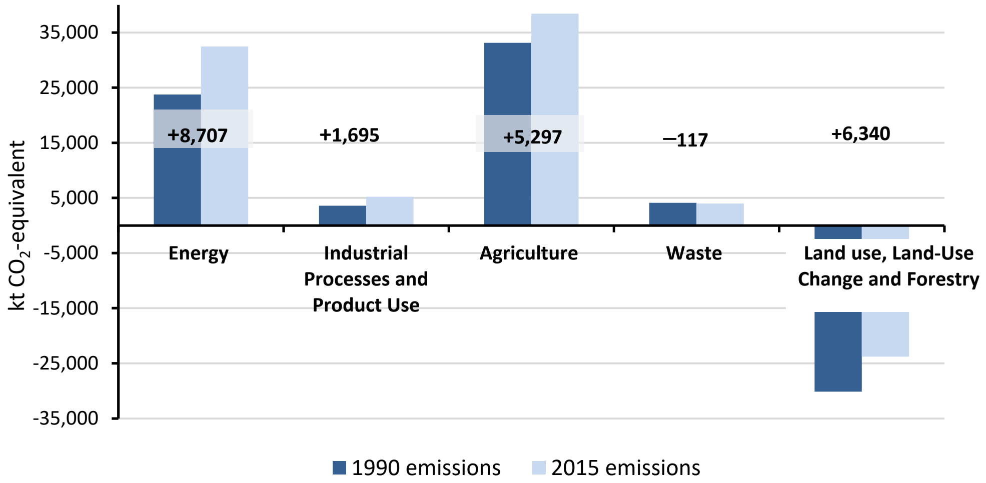
Table 3.1: New Zealand's emissions of greenhouse gases, by sector, 1990 and 2015

Sector	kt CO_2-equivalent 1990	2015	Change from 1990 (kt CO_2-equivalent)	Change from 1990 (%)
Energy	23,748.5	32,455.2	8,706.7	36.7
Industrial processes and product use	3,584.4	5,279.7	1,695.3	47.3
Agriculture	33,122.9	38,419.6	5,296.7	16.0
Waste	4,118.0	4,000.7	–117.4	–2.9
Gross (excluding LULUCF)	**64,573.8**	**80,155.1**	**15,581.3**	**24.1**
LULUCF	–30,122.4	–23,782.6	6,339.8	21.0
Net (including LULUCF)	**34,451.4**	**56,372.5**	**21,921.1**	**63.6**

Note: Net removals from the LULUCF sector are as reported under the UNFCCC (see chapter 6 of the NIR). Columns may not total due to rounding. Percentages presented are calculated from unrounded values. kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

Figure 3.2: Change in New Zealand's emissions by sector, between 1990 and 2015



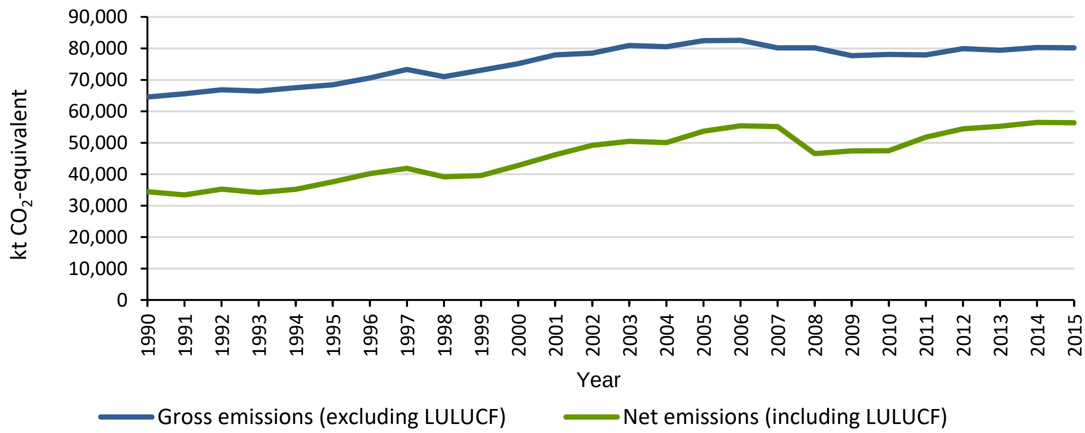
Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015*. Wellington: Ministry for the Environment.

3.2.2 Changes in New Zealand's gross emissions between 1990 and 2015

Between 1990 and 2015 New Zealand's gross emissions increased by 24.1 per cent (table 3.1 and figure 3.3). The average annual growth of emissions was approximately 0.9 per cent. The emissions sources that contributed the most to this increase were methane (CH_4) emissions from dairy cattle,[74] carbon dioxide (CO_2) from road transport and manufacturing industries and construction (especially the categories of: chemicals; and food processing, beverages and tobacco), nitrous oxide (N_2O) from agricultural soils, and consumption of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) from industrial and household refrigeration and air-conditioning systems. Figure 3.4 shows the yearly emissions changes by sector across the entire time series from 1990–2015, using 1990 emissions as a base level.

Figure 3.3: New Zealand's gross and net emissions (under the UNFCCC), 1990–2015



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015*. Wellington: Ministry for the Environment.

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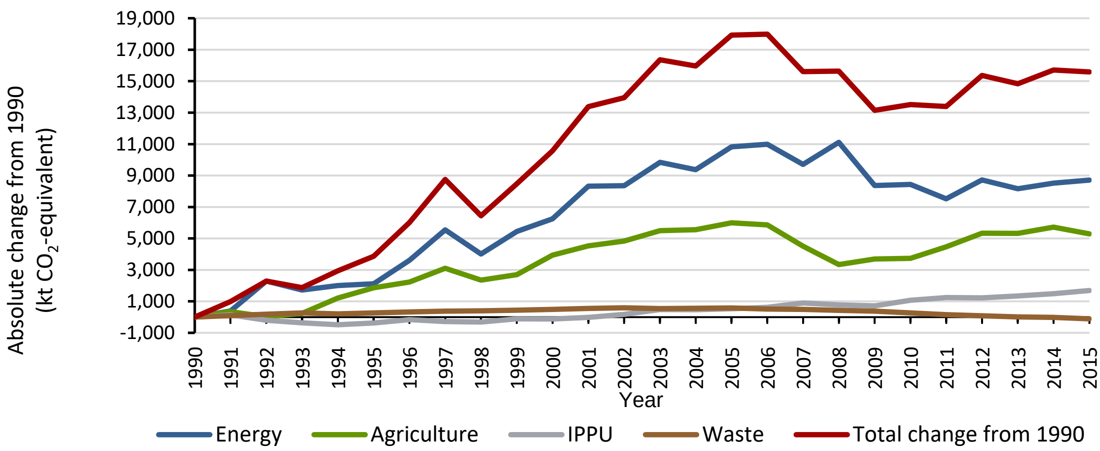
74 Methane emissions produced from ruminant livestock.

Figure 3.4: Trends in New Zealand's greenhouse gas emissions, by sector, 1990–2015



Note: Total emissions exclude net removals from the land use, land-use change and forestry sector. IPPU = industrial processes and product use; kt CO_2-e = kilotonnes of carbon dioxide equivalent.

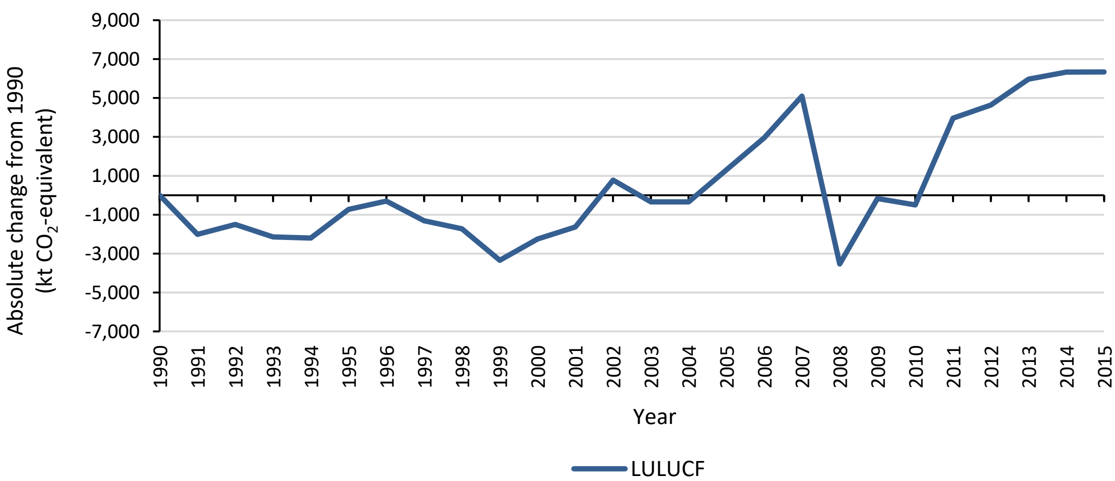
Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

3.2.3 Changes in New Zealand's net emissions between 1990 and 2015

With the inclusion of the LULUCF sector under UNFCCC reporting guidelines, New Zealand's net emissions in 2015 were lower than gross emissions, amounting to 56,372.5 kt CO_2-e (table 3.1 and figure 3.2). This is because in New Zealand a significant area of the land is covered by forests. Growing plants reduce the amount of CO_2 in the atmosphere, with the result that the LULUCF sector is a sink rather than a source of CO_2. Therefore New Zealand's net emissions are generally much lower than the gross emissions estimates.

New Zealand's net emissions are sensitive to yearly changes in the LULUCF sector (figure 3.5). Removals from the LULUCF sector are strongly influenced by cycles of harvesting plantation forests and changes in land use. While showing some fluctuations from year to year, New Zealand's net greenhouse gas emissions under the UNFCCC increased by 63.6 per cent between 1990 and 2015.

Figure 3.5: Absolute change in net emissions from the LULUCF sector, 1990–2015



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

3.2.4 Energy sector

The energy sector produces a large amount of CO_2 emissions (96.3 per cent of all emissions from the sector are CO_2) and smaller amounts of CH_4 and N_2O (2.9 per cent and 0.8 per cent of energy sector emissions respectively). The energy sector contributed 40.5 per cent to New Zealand's gross greenhouse gas emissions in 2015.

Emissions in the energy sector are influenced by not only demand but also climatic conditions. This is because a lot of New Zealand's stationary energy needs are met by renewable sources such as hydro-electric generation.

Two types of emissions are produced in the energy sector: combustion emissions and fugitive emissions. Combustion emissions result from burning fuel to produce useful energy. Examples of combustion emissions include:

- emissions from petrol and diesel used in transport
- production of heat from burning coal at industrial plants
- emissions from the use of natural gas for thermal electricity generation.

Fugitive emissions result from production, transmission and storage of fuels, and from non-productive combustion. Examples of fugitive emissions include:

- the venting of CO_2 at gas treatment plants
- gas flaring at oil production facilities
- emissions from geothermal fields released as a result of geothermal electricity production.

Combustion emissions from road transportation; public electricity and heat production; and manufacturing industries and construction (mostly food processing, beverages and tobacco; and chemicals) constituted the largest share of domestic emissions from the energy sector in New Zealand.

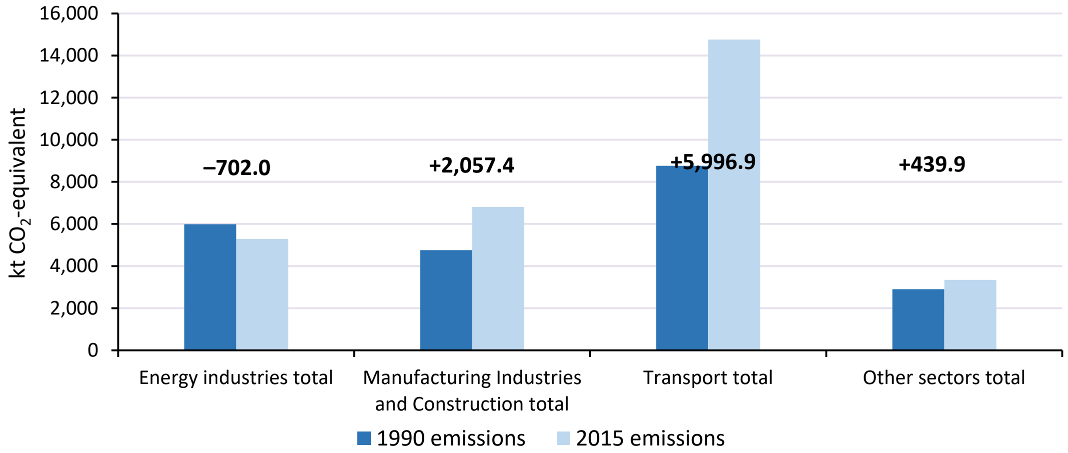
Electricity generation from the combustion of coal, oil and gas plays a crucial role in New Zealand's electricity system. In 2015 fossil fuel thermal plants provided 19.2 per cent of New Zealand's total electricity supply. However, the emissions from fossil fuel thermal plants in New Zealand is low by international standards due to the high proportion of demand met by hydro generation as well as other renewable sources such as wind. While renewables provide a strong base for New Zealand's electricity generation, electricity emissions remain sensitive to rainfall in catchments that feed the hydro-electric schemes.

Between 1990 and 2015, emissions from the energy sector increased by 36.7 per cent, reaching 32,455.2 kt CO_2-e. This growth in emissions is primarily from road transportation, manufacturing industries and construction (mostly food processing, beverages and tobacco; and chemicals), and public electricity and heat production (figure 3.6).

Emissions from the energy sector increased up until 2008, after which they have generally declined. The decline reflects a steady growth in energy production from renewable sources (mostly geothermal) as well as the energy sector's sensitivity to the effects of the recent global economic recession and 2011–13 earthquakes (see section 2.2, chapter 2 in the NIR[75] for further details).

[75] Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

Figure 3.6: Change in New Zealand's emissions from fuel combustion, by source, between 1990 and 2015



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

3.2.5 Agriculture sector

The agriculture sector contributed 47.9 per cent of the gross emissions in 2015 (38,419.6 kt CO_2-e). It accounted for 85.6 per cent of New Zealand's CH_4 emissions and 94.8 per cent of the country's N_2O emissions. In most other developed countries, agricultural emissions are typically around 12 per cent of national emissions, which means New Zealand has an unusual emissions profile in this regard. Dairy cattle, beef cattle, sheep and deer are grazed outside all year round, in contrast to many other developed countries, which practise intensive housing of major livestock. This means that New Zealand has a much lower proportion of agricultural emissions from manure management compared with other developed countries.

The largest sources of emissions from the agriculture sector in 2015 were CH_4 emissions from enteric fermentation[76] (73.1 per cent of the total emissions from the sector) and N_2O emissions from agricultural soils (20.6 per cent of the total emissions from the sector).

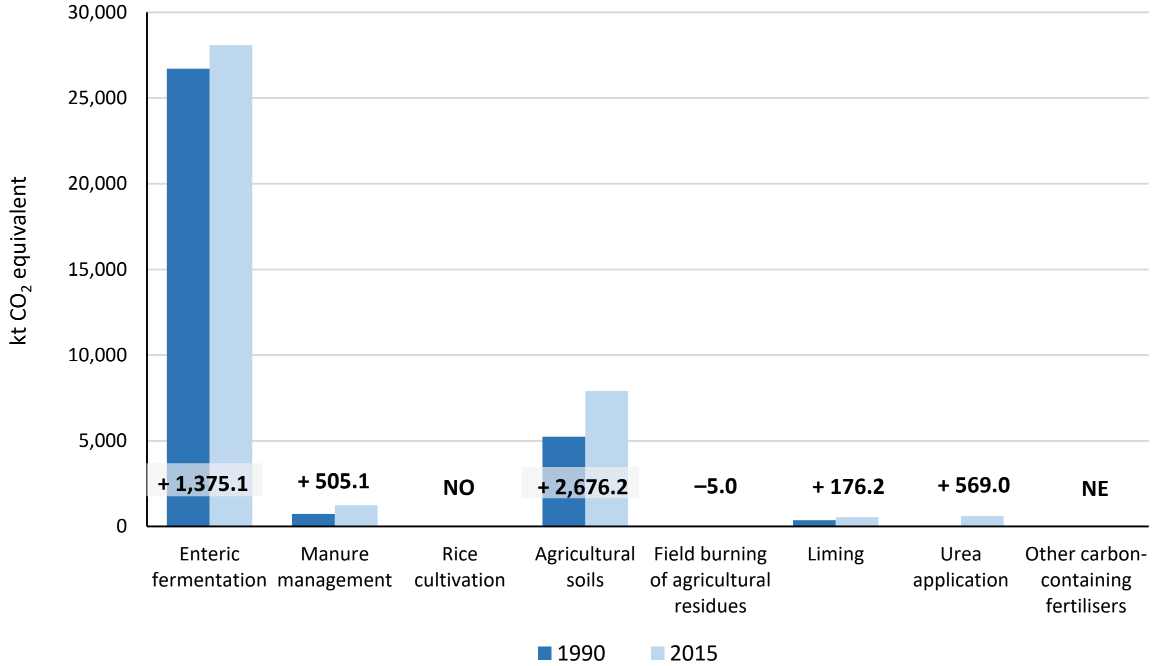
Between 1990 and 2005, the emissions from the agriculture sector increased by 18.1 per cent. From 2005–15, emissions from agriculture have remained relatively stable.

In total, 95.8 per cent of agricultural emissions in 1990 and 91.6 per cent in 2015 originated from the major livestock categories (dairy cattle, non-dairy cattle, sheep and deer), so trends in the agriculture sector emissions are largely driven by the populations of these ruminant livestock.

The key drivers for this change in emissions are an increase of 88.5 per cent in the size of the national dairy herd since 1990 and an approximately seven-fold (623 per cent) increase in N-containing synthetic fertiliser applied over this time. Decreases of 49.7 per cent in the sheep flock and 22.8 per cent in non-dairy cattle population partially offset these increases (figure 3.7).

76 Enteric fermentation is a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream of an animal. It is one of the factors contributing to increased CH_4 emissions.

Figure 3.7: Change in New Zealand's emissions from the agriculture sector between 1990 and 2015



Note: Rice cultivation does not occur (NO) in New Zealand. Emissions from other carbon-containing fertilisers are not estimated (NE). kt CO_2 –e = kilotonnes of carbon dioxide equivalent.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

Since 1990 the proportions of the main livestock types farmed in New Zealand have changed. The number of dairy cattle has increased, while the population of sheep and beef cattle has decreased. The relative profitability of dairy products has also risen, compared with that of sheep and beef products. Since 1990 there has also been an overall trend towards establishing new planted forests in grassland areas (see chapter 6 of the NIR[77] for further details).

Between 2014 and 2015, emissions from the agriculture sector decreased by 1.1 per cent as the national dairy herd decreased between 2014 and 2015 (by 3.2 per cent), resulting in a decrease in emissions from dairy cattle. The decrease in the dairy cattle population reflected the decline in production due to a large-scale drought and a fall in milk prices.

There was also a decrease in emissions from sheep and non-dairy cattle that reflected decreases in the size of the population for both animal types: emissions fell by 3.3 per cent for non-dairy cattle and 2.3 per cent for sheep between 2014 and 2015. Meanwhile, emissions from synthetic nitrogen fertilisers increased by 11.6 per cent and from agricultural liming by 9.4 per cent in 2015, compared with 2014.

3.2.6 Industrial processes and product use sector

The IPPU sector covers greenhouse gas emissions from industrial processes and product use (excluding direct combustion emissions). Industrial processes and product use emissions occur when materials are transformed from one substance to another in an industrial setting. Emissions are a result of the chemical reactions involved in these processes.

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77 Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

In New Zealand, activities or emissions covered by the sector include:

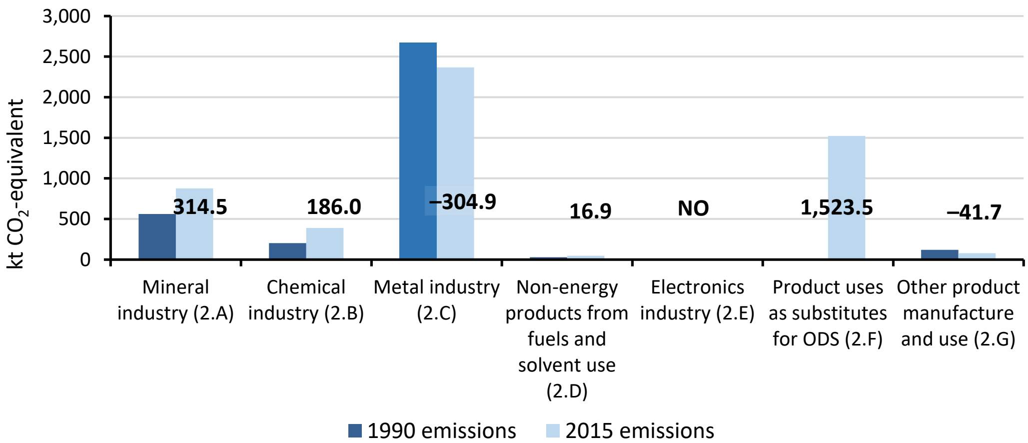
- iron or steel production
- aluminium production
- gold production
- cement clinker
- lime production
- glass production using soda ash
- emissions associated with HFCs and PFCs used mostly for refrigeration and air conditioning
- SF_6 associated with aluminium production and electric switchgear equipment
- use of solvents.

In 2015 direct greenhouse gas emissions from New Zealand's IPPU sector contributed 6.6 per cent (5279.7 kt CO_2-e) to the country's gross greenhouse gas emissions. The largest source category is the metal industry, where substantial CO_2 emissions come from iron and steel production and aluminium production. The mineral industry and chemical industry also contribute significant CO_2 emissions. Most of the non-CO_2 emissions come from product uses as substitutes for ozone-depleting substances, largely halocarbons used in refrigeration and air conditioning.

Between 1990 and 2015, emissions from IPPU increased by 47.3 per cent. This increase was mainly because of increasing emissions from HFCs used to replace ozone-depleting substances in refrigeration and air conditioning, and the increased use of household and commercial air conditioning. Carbon dioxide emissions have also increased, but at a slower rate, due to increased production of cement, metals and ammonia. There has been a substantial reduction in emissions of PFCs due to improved management of anode effects in aluminium production. Figure 3.8 summarises changes in emissions from the IPPU sector between 1990 and 2015.

Emissions from the IPPU sector increased 4.2 per cent between 2014 and 2015. The main increase (by 9.6 per cent) was in the consumption of HFCs. Emissions from metal and chemical industries also increased (by 0.9 and 2.4 per cent respectively) due to increasing production in these industries.

Figure 3.8: Change in New Zealand's emissions from the IPPU sector between 1990 and 2015



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent; ODS = ozone depleting substances.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

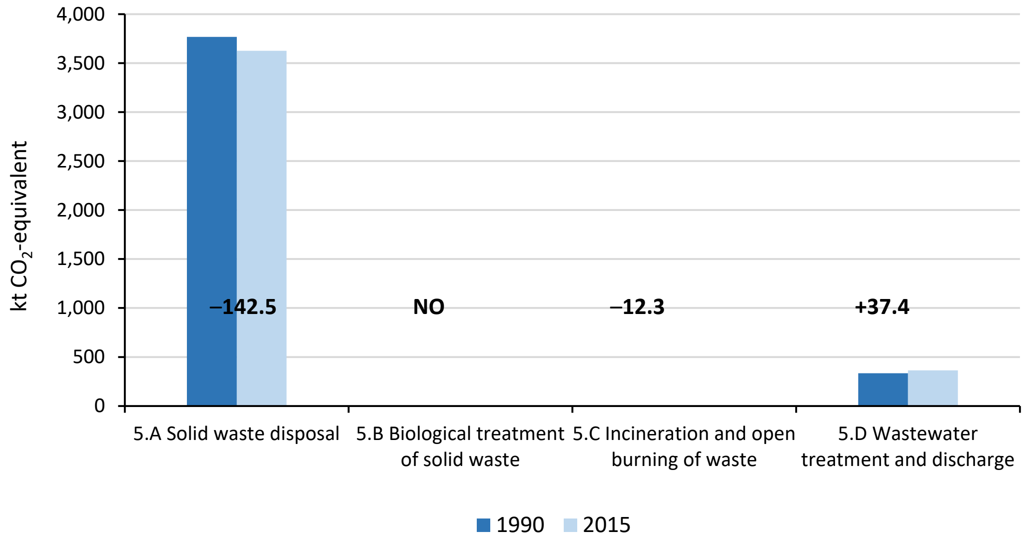
3.2.7 Waste sector

Greenhouse gas emissions from the waste sector result from the processing and disposal of solid waste, wastewater treatment and waste incineration. In New Zealand emissions from the waste sector are predominantly CH_4 emissions (96.7 per cent), followed by N_2O emissions (3.3 per cent) and CO_2 emissions (0.03 per cent).

In 2015 the waste sector accounted for 5.0 per cent of New Zealand's gross emissions. The largest source of waste sector emissions in 2011 was solid waste disposal on land (90.6 per cent), followed by wastewater treatment and handling (9.3 per cent of total waste sector emissions). Waste incineration is a minor contributor to the sectoral emissions (0.1 per cent).

Between 1990 and 2015, total emissions from the waste sector decreased by 2.9 per cent. Waste emissions have been below 1990 levels since 2013. This reduction resulted from initiatives to improve solid waste management practices and the recovery of landfill gas. Figure 3.9 shows the change in waste sector emissions between 1990 and 2015 by source.

Figure 3.9: Change in New Zealand's emissions from the waste sector, by source, between 1990 and 2015



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent; NO = not occurring.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

3.2.8 Land use, land-use change and forestry sector

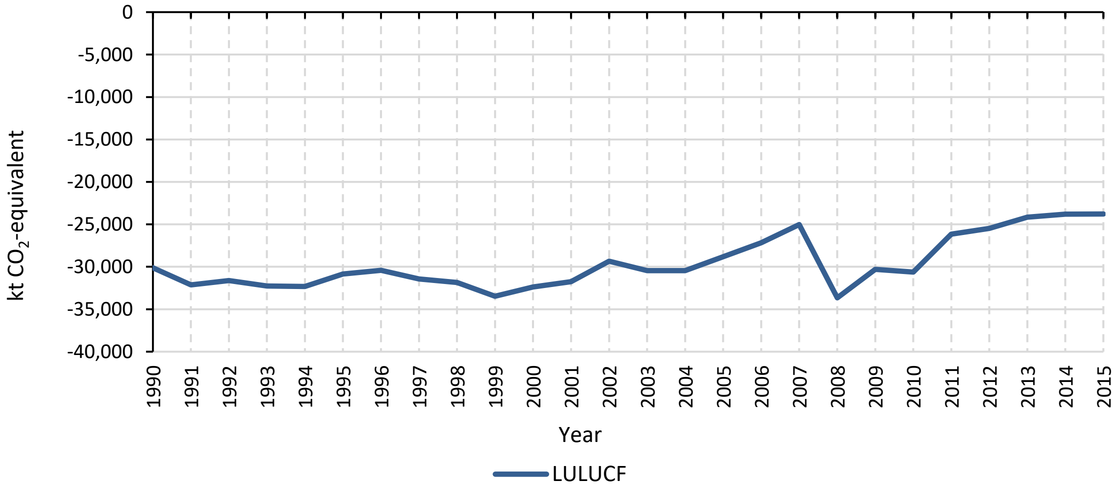
Together with agriculture, plantation forestry forms a core part of the New Zealand economy and has a significant influence on the LULUCF emissions profile. Because of its intensive forest management combined with a temperate climate, fertile soils and high rainfall, New Zealand has one of the highest rates of plantation forest growth among developed countries.

In New Zealand, the LULUCF sector is a net carbon sink. In 2015 net removals from the LULUCF sector (as reported under the UNFCCC[78]) were –23,782.6 kt CO_2-e.[79] This total comprises net removals of –23,964.0 kilotonnes of CO_2, and a small amount of CH_4 and N_2O (0.3 and 0.4 per cent of the net LULUCF emissions respectively). The greatest contribution to both emissions and removals was from the category of forest land remaining forest land. This is because a large amount of CO_2 is removed from the atmosphere by tree growth and there are also large emissions from sustainable harvesting of these forests.

Between 1990 and 2015, net removals from the LULUCF sector decreased by 21.0 per cent from the 1990 level of –30,122.4 kt CO_2-e. This is largely the result of increased harvesting of plantation forests as a larger proportion of the estate reaches harvest age. Yearly fluctuations in emissions from LULUCF are mainly driven by harvesting and deforestation in production forests, and historical rates of new forest planting (figure 3.10).

Between 2014 and 2015, net removals from the LULUCF sector remained relatively steady (0.1 per cent decrease). The largest change occurred within the grassland category as deforestation decreased by approximately 3300 hectares between 2014 and 2015, resulting in a decrease in emissions. This was largely offset by an increase in emissions in the harvested wood products and forest land categories.

Figure 3.10: New Zealand's LULUCF sector net removals, 1990–2015



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

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78 Under the UNFCCC guidelines, the Inventory reports emissions and removals from the entire LULUCF sector. For accounting purposes under the Kyoto Protocol, only the activities of afforestation, reforestation, deforestation and forest management are included (commonly referred to as Articles 3.3 and 3.4 activities). Therefore the emissions totals and trends under UNFCCC and the Kyoto Protocol reporting and accounting are different.

79 Removals are expressed as a negative value as per section 2.2.3 of: Intergovernmental Panel on Climate Change. 2006. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Hayama: Institute for Global Environmental Strategies.

3.2.9 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, reporting of afforestation, reforestation and deforestation activities since 1990, as well as of forest management, is mandatory during the second commitment period of the Kyoto Protocol. This is a change from the first commitment period, when reporting on forest management was voluntary. Reporting on cropland management, grazing land management, revegetation, and wetland drainage and rewetting is voluntary for 2013–20 (Kyoto Protocol, Article 3.4).

In 2015 net removals reported under Articles 3.3 and 3.4 of the Kyoto Protocol were –24,641.5 kt CO_2-e. The accounting quantity (calculated as the sum of emissions and removals for afforestation, reforestation and deforestation as under Article 3.3 of the Kyoto Protocol) was –12,535.3 kt CO_2-e.

Net removals from afforestation and reforestation activities (as accounted for under Article 3.3 of the Kyoto Protocol) in 2015 were -16,001.2 kt CO_2-e. The difference between the estimates reported under the UNFCCC and accounted for under the Kyoto Protocol is largely due to differences in accounting for pre-1990 forest within the LULUCF sector (under forest management in Kyoto Protocol reporting, and mainly as forest land remaining forest land in LULUCF reporting).

In 2015 net emissions due to deforestation were 3,465.8 kt CO_2-e. Net deforestation emissions include emissions and removals that occurred in 2015 on land that had been deforested since 1990. The deforestation was mainly for conversion into grassland, largely due to the relative profitability of pastoral farming, particularly dairy farming, compared with forestry.

Net removals for the area reported under the forest management category (Article 3.4 of the Kyoto Protocol) in 2015 are estimated as –12,106.2 kt CO_2-e. Reporting of emissions on forest management land is against a business-as-usual reference level, which means New Zealand only accounts for emissions or removals where these differ from the reference level.

For the second commitment period, Parties can elect to exclude emissions due to natural disturbance from their accounting. In accounting for its target under the UNFCCC, New Zealand has elected this provision but is not currently excluding any emissions due to natural disturbance in the second commitment period.

3.3 Emissions and removals by gas

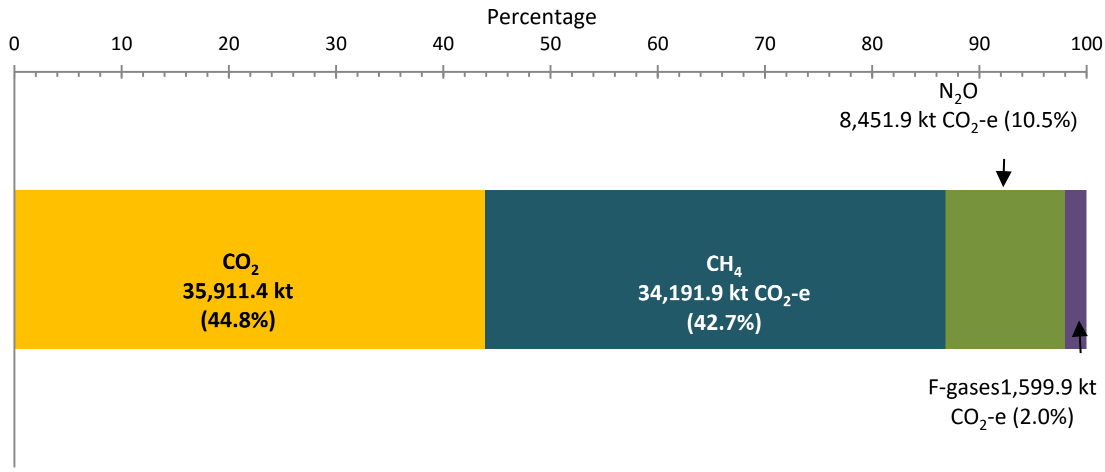
3.3.1 Overview

Inventory reporting under the UNFCCC covers the following direct greenhouse gases: CO_2, CH_4, N_2O, SF_6, PFCs, HFCs and nitrogen trifluoride (NF_3).[80] Figure 3.11 shows New Zealand’s emissions profile by gas in 2015. Table 3.2 shows the change in each direct greenhouse gas between 1990 and 2015. Trends in CO_2, CH_4, N_2O and fluorinated gases emissions over the period 1990–2015 are shown in figure 3.12, using 1990 emissions as a base level.

80 Because NF_3 emissions do not occur in New Zealand, no NF_3 data are included in the greenhouse gas inventory report.

In accordance with UNFCCC reporting guidelines, indirect greenhouse gases are included in inventory reporting but not in the national emissions total. These indirect gases include carbon monoxide (CO), sulphur dioxide (SO_2), oxides of nitrogen (NO_x) and non-methane volatile organic compounds (NMVOCs). Removals of CO_2 from the atmosphere are reported in the LULUCF sector.

Figure 3.11: New Zealand's gross greenhouse gas emissions, by gas, 2015



Note: HFCs = hydrofluorocarbons; kt CO_2-e = kilotonnes of carbon dioxide equivalent; PFCs = perfluorocarbons; SF_6 = sulphur hexafluoride.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

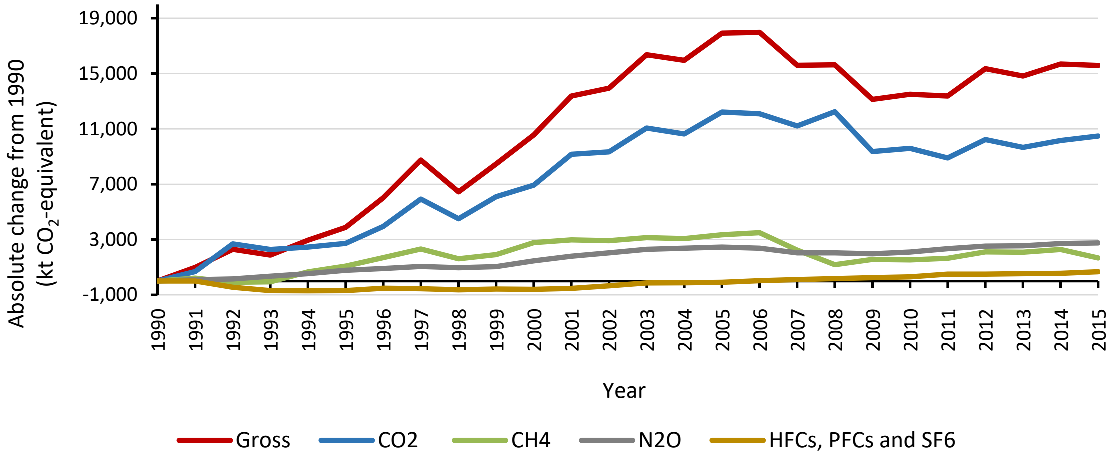
Table 3.2: New Zealand's emissions of greenhouse gases, by gas, 1990 and 2015

Direct greenhouse gas emissions	kt CO_2-equivalent 1990	2015	Change from 1990 (kt CO_2-equivalent)	Change from 1990 (%)
CO_2	25,428.6	35,911.4	10,482.8	41.2
CH_4	32,522.2	34,191.9	1,669.7	5.1
N_2O	5,693.1	8,451.9	2,758.8	48.5
HFCs	0.0	1,523.5	1,523.5	NA
PFCs	909.9	58.6	–851.4	–93.6
SF_6	20.0	17.9	–2.1	–10.6
Gross, all gases	**64,573.8**	**80,155.1**	**15,581.3**	**24.1**

Note: The percentage change for HFCs is not applicable (NA) because consumption of HFCs in New Zealand in 1990 was not occurring. CO_2 = carbon dioxide; CH_4 = methane; HFCs = hydrofluorocarbons; kt CO_2-e = kilotonnes of carbon dioxide equivalent; N_2O = nitrous oxide; PFCs = perfluorocarbons; SF_6 = sulphur hexafluoride.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

Figure 3.12: Change from 1990 in New Zealand's gross emissions by gas, 1990–2015



Note: CO_2 = carbon dioxide; CH_4 = methane; HFCs = hydrofluorocarbons; kt CO_2 equivalent = kilotonnes of carbon dioxide equivalent; N_2O = nitrous oxide; PFCs = perfluorocarbons; SF_6 = sulphur hexafluoride.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

3.3.2 Carbon dioxide

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. Human activities are altering the carbon cycle – both by adding more CO_2 to the atmosphere and by influencing the ability of natural sinks, like forests, to remove CO_2 from the atmosphere. The main human activity that emits CO_2 is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation. Some industrial processes, waste processing and land-use changes also emit CO_2.

Carbon dioxide emissions contributed the largest proportion of New Zealand's gross emissions in 2015 (44.8 per cent). The main contributors to total CO_2 emissions were road transport (37.0 per cent of gross CO_2 emissions) and public electricity and heat production (11.2 per cent). From 1990–2015, gross CO_2 emissions have increased by 41.2 per cent due to growing emissions in particular from road transport, and public electricity and heat production (table 3.3).

Table 3.3: New Zealand's emissions of carbon dioxide, 1990 and 2015

Carbon dioxide source	kt CO_2 1990	kt CO_2 2015	Change from 1990 (kt)	Change from 1990 (%)
Energy	22,491.8	31,252.8	8,761.0	39.0
Stationary energy	13,450.1	15,219.9	1,769.9	13.2
Transport	8,582.0	14,593.6	6,011.6	70.0
Fugitive emissions	459.7	1,439.3	979.6	213.1
IPPU	2,524.4	3,512.9	988.5	39.2
Waste	13.2	1.2	–12.0	–90.8
Agriculture	399.3	1,144.5	745.2	186.7
LULUCF	–30,392.7	–23,964.0	6,428.7	21.2
Gross CO_2 (excluding LULUCF)	**25,428.6**	**35,911.4**	**10,482.8**	**41.2**
Net CO_2 (including LULUCF)	**–4,964.1**	**11,947.4**	**16,911.5**	**340.7**

Note: IPPU = industrial processes and product use; kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

3.3.3 Methane

Methane (CH_4) is the second-most prevalent greenhouse gas emitted from human activities. It is emitted from agricultural systems (eg, the raising of livestock) as well as from human activities related to coal mining, natural oil and gas systems and waste processing. Natural processes in soil and chemical reactions in the atmosphere help remove CH_4 from the atmosphere. CH_4's lifetime in the atmosphere is much shorter than CO_2, but CH_4 is more efficient at trapping radiation than CO_2.

Methane contributed 42.7 per cent to the gross emissions in 2015. Of its total contribution, 82.2 per cent came from enteric fermentation in ruminant livestock (mainly dairy cattle) in the agriculture sector. Between 1990 and 2015, gross CH_4 emissions grew by 5.1 per cent (table 3.4). This is largely attributed to the increase in the population of the national dairy cattle herd over the same period.

Table 3.4: New Zealand's emissions of methane, 1990 and 2015

Methane source	kt CO_2-equivalent 1990	kt CO_2-equivalent 2015	Change from 1990 (kt CO_2-e)	Change from 1990 (%)
Energy	1,063.7	953.2	–110.5	–10.4
IPPU	27.6	106.7	79.1	286.6
Waste	4,006.6	3,869.2	–137.4	–3.4
Agriculture	27,424.2	29,262.8	1,838.6	6.7
LULUCF	93.2	79.3	–13.9	–14.9
Gross CH_4 (excluding LULUCF)	**32,522.2**	**34,191.9**	**1,669.7**	**5.1**
Net CH_4 (including LULUCF)	**32,615.4**	**34,271.3**	**1,655.9**	**5.1**

Note: CH_4 = methane; IPPU = industrial processes and product use; kt CO_2-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

3.3.4 Nitrous oxide

Nitrous oxide (N_2O) 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 nitrous oxide in the atmosphere. Nitrous oxide molecules stay in the atmosphere longer than CH_4, but for a shorter period than CO_2 molecules, before being removed by a sink or destroyed through chemical reactions. A significant portion of total N_2O emissions comes from human activities. In New Zealand the biggest sources of N_2O emissions are agriculture and transportation.

Nitrous oxide contributed 10.5 per cent to gross emissions in 2015. Of these emissions, 93.7 per cent came from agricultural soils. The growth in N_2O resulted from a nearly seven-fold (623 per cent) increase in elemental nitrogen applied through nitrogen-based fertiliser over 1990–2015. Another driver in increasing N_2O emissions is an increase in emissions from animal excreta, mostly due to the growing national dairy herd population. Gross N_2O emissions in 2015 exceeded the gross 1990 level by 48.5 per cent (table 3.5).

Table 3.5: New Zealand's emissions of nitrous oxide, 1990 and 2015

Nitrous oxide source	kt CO_2-equivalent 1990	kt CO_2-equivalent 2015	Change from 1990 (kt CO_2-e)	Change from 1990 (%)
Energy	192.9	249.1	56.2	29.1
IPPU	102.4	60.1	–42.3	–41.3
Waste	98.2	130.3	32.0	32.6
Agriculture	5,299.4	8,012.3	2,712.9	51.2
LULUCF	177.1	102.0	–75.1	–42.4
Gross N_2O (excluding LULUCF)	5,693.1	8,451.9	2,758.8	48.5
Net N_2O (including LULUCF)	5,870.2	8,553.9	2,683.7	45.7

Note: IPPU = industrial processes and product use; kt CO_2-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry; N_2O = nitrous oxide.

3.3.5 Hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride

Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) are sometimes referred to together as fluorinated gases (F-gases). They are human-made chemicals mostly used in refrigeration and air conditioning, and also in foams, aerosols, fire protection and solvents. F-gases can escape to the atmosphere during maintenance or through leaks from faulty or outdated equipment. These gases have long atmospheric lifetimes (decades for HFCs; millennia for PFCs and SF_6) and are potent greenhouse gases, hundreds or thousands of times more powerful than CO_2, over a 100-year timeframe.

In total, F-gases contributed 2.0 per cent of gross emissions in 2015. The largest contributor of these emissions was the consumption of HFCs and PFCs (98.9 per cent of all PFC, HFC and SF_6 emissions).

These gases have also undergone large relative changes between 1990 and 2015 (table 3.2). Emissions of PFCs have decreased by 93.6 per cent from the 1990 level. This decrease is the result of improvements in the aluminium smelting process at New Zealand's only aluminium smelter. HFC emissions have increased because of their use as substitutes for chlorofluorocarbons, which were phased out under the Montreal Protocol. No emissions of HFCs occurred in 1990, so no percentage has been shown in table 3.2. Meanwhile, emissions of SF_6 have decreased by 10.6 per cent. The majority of SF_6 emissions are from use in electrical equipment.

4 Policies and measures

Key developments since the *Sixth National Communication*

Targets

New Zealand met its target for the first commitment period under the Kyoto Protocol.

Signalling its commitment to addressing the global issue of climate change, New Zealand ratified the Paris Agreement on 4 October 2016. New Zealand's first emissions reduction target under this Agreement is to reduce greenhouse gas emissions by 30 per cent below 2005 levels by 2030.

Policies and measures

The New Zealand Emissions Trading Scheme (NZ ETS) is the primary tool underpinning New Zealand's domestic action to reduce emissions. Between 2015 and 2017 the New Zealand Government carried out a review of the NZ ETS. As a result, it decided to phase out over three years the transitional measure that required the surrender of only one emissions unit for each two tonnes of emissions. This is being phased out over three years. Following the conclusion of the review, In-principle policy decisions were made on proposals to improve the operation of the NZ ETS, including the introduction of auctioning and coordinating Government decisions on NZ ETS supply settings on a rolling five-year basis.

In 2015 the Government stopped accepting Kyoto Protocol emissions units in the NZ ETS, which now operates as a domestic-only emissions trading system. An international carbon markets project was established in 2016 to identify international carbon trading options, with a view to enabling New Zealand to source international emissions reductions in the 2020s.

On 5 May 2016 the Government announced an Electric Vehicles Programme, which aims to increase the uptake of electric vehicles.

In 2017 a low-emissions economy 'transition hub' was established within Government to bring together relevant government agencies to partner with the private sector on policy options for meeting New Zealand's emissions reduction targets under the Paris Agreement.

The New Zealand Government tasked the Productivity Commission (an independent Crown entity) with looking at how New Zealand can maximise the opportunities and minimise the risks of transitioning to a lower net-emissions economy.

In August 2017 the Commission published an issues paper that seeks feedback from individuals and organisations across New Zealand on what New Zealand should be doing to reduce emissions.

The New Zealand Government established three reference groups to provide specific advice:

- a Biological Emissions Reference Group to build a solid evidence base to ensure New Zealand has the best information on what the sector can do to reduce emissions
- a Forestry Reference Group looking at the important role the forestry sector can play in helping New Zealand meet our long-term climate change targets
- a Climate Change Adaptation Technical Working Group to look at options for how New Zealand can build resilience to the effects of climate change while growing its economy sustainably.

The New Zealand Energy Efficiency and Conservation Strategy 2017–2022 was released on 27 June 2017. The Strategy focuses on three priority areas that will provide the most cost-effective opportunities for energy savings and emissions reductions: process heat, transport and electricity.

The New Zealand Government has also reconfirmed a target of achieving 90 per cent renewable electricity generation by 2025.

4.1 Introduction

Recognising that climate change is a global issue requiring a global response, the New Zealand Government has sought to take leadership in areas where it considers it can most effectively make a contribution. Most notably, this has been in research into improved productivity and lowering emissions in the agriculture and energy sectors.

Domestically, New Zealand's policies reflect a commitment to achieve emissions reductions and transition to a low-emissions economy, while continuing to grow the domestic economy.

The primary tool underpinning New Zealand's domestic action is the New Zealand Emissions Trading Scheme (NZ ETS). Over 2015–2017, the NZ ETS was reviewed to assess how the scheme should evolve to support New Zealand in meeting future emissions reduction targets and its ongoing transition to a low emissions economy. Following the review, the Government made a series of in-principle policy decisions to improve the operation of the NZ ETS in the 2020s, including introducing auctioning, limiting participants' future use of international units, developing a different price ceiling, and coordinating decisions on unit supply settings on a five-year rolling basis. Further advice on options for implementing these decisions will be developed next year. As a result of the review, further advice is also being developed on phasing down free allocation, improving NZ ETS forestry settings, and operational improvement such as access to market information and compliance next year.

The NZ ETS is complemented by other domestic measures designed to support both a reduction in domestic emissions and economic growth. An example of another measure is the implementation of the Government's Electric Vehicles Programme.

4.1.1 Key targets

Over time the Government has made commitments to five distinct targets to reduce New Zealand's greenhouse gas emissions.

Kyoto Protocol's first commitment period target to reduce emissions to 1990 levels by 2012. This meant New Zealand had an emissions budget under the Kyoto Protocol for the first commitment period (2008–12) of 309.6 million initial assigned amount units. New Zealand met this target when its 'True-up Report' was reviewed by the United Nations Framework Convention on Climate Change (UNFCCC) in 2016.[81]

[81] http://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.

Unconditional target to reduce emissions to 5 per cent below 1990 levels by 2020. This unconditional target is equivalent to a 2013–2020 Quantified Emission Limitation and Responsibility Objective (QELRO)[82] of 96.8 per cent on 1990 emissions. This target is not inscribed in the Kyoto Protocol but will be met using the rules applicable to the Kyoto Protocol's second commitment period.

Conditional target range: in 2009 the Government announced a conditional target of between 10 and 20 per cent below 1990 greenhouse gas emissions levels by 2020, subject to conditions. These conditions include a comprehensive global agreement for the period and full recourse to a broad and efficient international carbon market. These conditions have not yet been met.

First Paris Agreement Nationally Determined Contribution (NDC) to reduce emissions to 30 per cent below 2005 levels by 2030. This target is equivalent to 11 per cent below 1990 levels by 2030. The target is expressed in the NDC as an absolute reduction target to be managed using an emissions budget for the period 2021–2030.[83]

This NDC (initially proposed as New Zealand's Intended Nationally Determined Contribution) was set after extensive analysis and stakeholder consultation in 2015. The analysis included estimating costs to the economy of reaching the target, and comparison with other developed country proposals to ensure New Zealand proposed at least comparable ambition.

Long-term target to reduce emissions to 50 per cent below 1990 levels by 2050. This target was notified in the *New Zealand Gazette* (New Zealand's official government newspaper and journal of constitutional record) in March 2011. The long-term target is in line with Intergovernmental Panel on Climate Change (IPCC) conclusions and the UNFCCC global goal of limiting warming to a maximum of 2°C above pre-industrial levels. This target provides long-term direction for New Zealand's domestic policies.

Because New Zealand's emissions profile is very different from that of other developed countries (as described in chapters 2 and 3), the cost of further mitigation by New Zealand is likely to be higher. All of New Zealand's targets are therefore ambitious, and will be met through a mixture of reducing domestic emissions, removing carbon by forests and participating in international carbon markets. Meeting the unconditional 2020 target will also involve recognising the surplus achieved during the first commitment period of the Kyoto Protocol.

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 as part of future stocktakes under the Agreement. New Zealand will continue to regularly review its contributions to international mitigation action, taking into account the latest science, development of new technologies, progress by other countries and the commitments we have made.

82 A QELRO specifies the *average* emissions permitted by a target over time, in line with a multi-year carbon budget approach.

83 www4.unfccc.int/ndcregistry/Pages/Home.aspx.

Summary of key targets and target setting

The Government has three active national targets for reducing New Zealand's greenhouse gas emissions that cover both the medium and long term:

1. an unconditional target of 5 per cent below our 1990 greenhouse gas emissions levels by 2020, which will be met under Kyoto Protocol rules
2. as part of New Zealand's first Nationally Determined Contribution under the Paris Agreement, a target of 30 per cent below our 2005 greenhouse gas emissions levels by 2030 (equivalent to 11 per cent below 1990 levels by 2030)
3. a long-term target of 50 per cent below our 1990 greenhouse gas emissions levels by 2050.

4.2 Policy context for climate change actions

4.2.1 Roles and responsibilities

The **Ministry for the Environment (MfE)** is established under statute and is the New Zealand Government's primary advisor on the environment, international matters affecting the environment and climate change. Key activities related to climate change that MfE undertakes include: advising the Government on the NZ ETS legislation and the development of regulations under the scheme, and international negotiations and reporting under the UNFCCC and the Kyoto Protocol.

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 implementation of specific climate change policies, once agreed to by Government, is frequently led by other relevant departments. The following agencies execute functions relevant to climate change policy.

The **Ministry of Business, Innovation and Employment's (MBIE)** overarching purpose is to "grow New Zealand for all", and it therefore has a strong focus on sustainable economic growth "that doesn't compromise our environment". A deliberate transition to a lower-emissions economy is one of the priorities in MBIE's 2017/18 business strategy. MBIE's responsibilities include energy policy, science and innovation policy, research funding and economic development. Current activities of interest in relation to climate change include providing the appropriate regulatory and policy framework for the exploration and use of oil, natural gas, renewable energy resources and alternative fuels; policy related to energy efficiency and energy conservation; and energy information and modelling.

MBIE also provides advice to the Government on research, innovation and science policy. This includes advising on the national science priorities, administering Government investment in science, overseeing the Crown's research agencies, and investing in research and innovation that relates directly to understanding the climate system, including mitigation of emissions (eg, carbon capture and storage, and renewable energy), climate change impacts, and adaptation.

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 programmes in various sectors.

The **Environmental Protection Authority (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 (the Register) and the administration of all the non-forestry sectors in the NZ ETS.[84] This includes emissions reporting by NZ ETS participants and applications for industrial allocation under the NZ ETS.

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 assistance managed through the New Zealand Aid programme.

The **Ministry for Primary Industries (MPI)** contributes to Government policy development for 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 collects data on national annual greenhouse gas emissions for the agricultural and forestry sectors to support reporting under the UNFCCC and annual accounting under the Kyoto Protocol. MPI also provides direct funding for some elements of climate change research (including for the national inventory) and sustainable farming. 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.

New Zealand Trade and Enterprise (NZTE) is New Zealand's international business development agency. One of its goals is to introduce offshore investors and strategic partners to New Zealand companies that are developing clean technologies or projects.

The **Ministry of Transport (MoT)** is the Government's principal advisor on transport policy in New Zealand. It advises Government on enhancing domestic transport efficiency. MoT is responsible for developing climate change policies specific to transport and it is the lead agency for implementing the Electric Vehicles Programme. MoT 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 **New Zealand Transport Agency (NZTA)** is the operational agency for delivering land transport objectives. NZTA's main functions are to plan land transport networks, invest in land transport infrastructure and public transport services (in conjunction with local government), plan and deliver the national state highway network, and manage access to the land transport system through setting standards and licensing drivers and vehicles.

The **Department of Conservation (DOC)** manages national parks and reserves (the Conservation estate)[85] and provides policy advice 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 Resource Management Act 1991, which includes preparing a New Zealand Coastal Policy Statement to set national priorities for the coastal environment.

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

85 A third of New Zealand's land area is managed as part of the conservation estate.

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.

The Treasury provides fiscal, regulatory and economic perspectives on climate change policy.

Local government has functions and responsibilities relating to managing 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 and decision-making; building control; emergency management; and the provision of infrastructure and community services.

The **Natural Resources Sector (NRS)** is a network of central government agencies whose core membership is the Department of Conservation, Land Information New Zealand, the Ministry for Primary Industries, the Ministry of Business, Innovation and Employment, the Ministry for the Environment and Te Puni Kōkiri. The main purpose of the NRS is to enhance collaboration between government agencies and ensure a strategic, integrated and aligned approach is taken to natural resources development and management across government agencies. The network is chaired by the Chief Executive of the Ministry for the Environment.

4.2.2 Key strategies

The New Zealand Government is committed to doing its fair share to reduce global emissions. As a result, New Zealand's strategic approach seeks to maintain a balance between emissions reductions, trade and economic growth. The key strategies, updated to include developments in New Zealand's policy context since the finalisation of the *Sixth National Communication* in 2013, are outlined below.

New Zealand Energy Strategy 2011–2021

The New Zealand Energy Strategy 2011–2021, the Government's high-level energy policy statement, was released in August 2011. This sets the strategic direction for the energy sector and the role energy will play in the New Zealand economy in the context of two key challenges: energy security and responding to climate change. The Government's overarching goal is for "New Zealand to make the most of its abundant energy potential – through environmentally-responsible development and efficient use of the country's diverse energy resources".[86]

The strategy identifies four priority areas:

- diverse resource development, including investment in, and use of, both renewable energy resources and non-renewable energy resources (this includes a goal that 90 per cent of electricity generated will come from renewable resources by 2025)

86 Ministry of Economic Development (now the Ministry of Business, Innovation and Employment). *New Zealand Energy Strategy 2011–2021.* Wellington: Ministry of Economic Development. Retrieved from www.mbie.govt.nz/info-services/sectors-industries/energy/energy-strategies.

- environmental responsibility – reducing energy-related greenhouse gas emissions and applying best practice in environmental management for energy projects
- efficient use of energy
- secure and affordable energy.

New Zealand Energy Efficiency and Conservation Strategy 2017–2022

Unlocking Our Energy Productivity and Renewable Potential, the New Zealand Energy Efficiency and Conservation Strategy 2017–2022 (NZEECS), is a companion to the Energy Strategy.

Its goal is that New Zealand has an energy-productive and low-emissions economy. The three priority areas are:

- renewable and efficient use of process heat
- efficient and low-emissions transport
- innovative and efficient use of electricity.

The NZEECS is prepared in accordance with the Energy Efficiency and Conservation Act 2000, is in effect for a period of five years and will guide EECA's work programme and policy across government during that time.

The NZEECS sets out the following objectives.

- Businesses make energy-efficient and renewable energy investments and adopt best practice management.
- Individuals, households and community institutions choose energy-efficient technologies, adopt energy-efficient behaviours and make greater use of renewable energy.
- The public sector demonstrates leadership by adopting greater energy efficiency and renewable energy.

The NZEECS contains a target for each of the priority areas.

- Industrial emissions decrease in intensity by at least 1 per cent per annum on average between 2017 and 2022.
- Electric vehicles make up 2 per cent of the vehicle fleet by the end of 2021.
- Ninety per cent of electricity will be generated from renewable sources by 2025 (in an average hydrological year), provided security of supply is maintained.

Business Growth Agenda

The Government's Business Growth Agenda (agreed by Government in late 2012 and since implemented) is a programme of work intended to support New Zealand businesses to grow to create jobs and improve New Zealanders' standard of living. The Business Growth Agenda focuses on six key ingredients businesses need in order to grow: export markets, innovation, infrastructure, Natural Resources Sector work programme (covering primary industries, energy and resources, land use, water, environment (including climate change)), local government, and conservation. The NRS work programme is intended to drive cross-government work in priority areas, including on climate change. This represents a desire to shift from working in *sectors* to working across the whole *system* in New Zealand's climate change policy.

4.3 Policies and measures, and their effects

In preparing this chapter, New Zealand has been mindful of the *Reporting Guidelines on National Communications*. As a result, 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 are innovative or easily replicated by other parties.[87] Website links are provided to allow the interested reader to access more detail on specific initiatives.

4.3.1 Cross-cutting measures

The New Zealand Emissions Trading Scheme

The NZ ETS creates an obligation on greenhouse gas emitters who are participants in the scheme to report on their greenhouse gas emissions and surrender emissions units that correspond to their obligations. NZ ETS participants are required to surrender New Zealand Units (NZUs), the primary units of trade in the scheme, to meet their NZ ETS obligations. Some types of international emissions units, issued under the Kyoto Protocol, were previously accepted for surrender from 2008 until early 2015.

NZ ETS reporting and surrender obligations

All sectors of the New Zealand economy have reporting and surrender obligations under the NZ ETS, with the exception of the agriculture sector, which currently has reporting requirements only. Entry to the NZ ETS was phased in by sector. Forestry was the first sector to have reporting and surrender obligations, entering the scheme retrospectively on 1 January 2008. Specific obligations, however, differ based on whether a forest was established before 1 January 1990 (pre-1990 forests) or after 31 December 1989 (post-1989 forests).

The stationary energy, industrial processes and liquid fossil fuels sectors entered the scheme, and assumed reporting and surrender obligations, in 2010. The waste sector followed in 2012, with its reporting obligations commencing from 2012 and surrender obligations coming into effect from 2013.[88] Bulk importers and users[89] of fluorinated gases (F-gases) joined the NZ ETS from 2013 and assumed reporting and surrender obligations at this time.

The agriculture sector has been required to report on its major emissions (methane from ruminants, and nitrous oxide from soils and the use of nitrogenous fertilisers) since 1 January 2012, but there is no legislated date for agricultural emissions to assume surrender obligations under the NZ ETS. The last Government has said that this will not happen until economically viable and practical technologies are available to reduce these emissions, and New Zealand's trading partners have made more progress on tackling their emissions in general.

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87 The estimated total mitigation impacts of policies and measures as at 2020 do not align with the change in emissions between the "without measures" scenario and the "with measures" scenario from chapter 5. This is due to the inherent uncertainty associated with isolating the individual effects of policies and measures. The approach used for modelling the overall impact of policies and measures is conservative to avoid the potential to overestimate the impact of multiple individual policy measures.

88 This refers to methane emissions from waste disposal sites.

89 The 2012 NZ ETS amendments also introduced a levy system for small importers and users of synthetic greenhouse gases.

Earlier legislated amendments to the NZ ETS

The policy settings for the NZ ETS are contained in the Climate Change Response Act 2002. The Act was amended in 2008 to establish the NZ ETS. This amendment legislation specified a transition phase in which the various sectors of the economy (including agriculture) would be brought into the NZ ETS over the period 2008–13, and provided for free allocation to trade-exposed sectors – namely industries that produce internationally traded products.

The Act was amended again in 2009 to extend the transition measures. The 2009 amendments also put in place detailed provisions for free allocation of NZUs for industrial activities that are emission-intensive and trade-exposed (ie, they produce internationally traded products).

In 2012 further amendments were made that maintained the transition phase settings and gave the Government the power to auction NZUs. The 2012 amendments also introduced technical updates to improve the operation and administration of the NZ ETS. These changes included the introduction of 'offset forest planting' as an option for pre-1990 forests – that is, allowing owners to plant a carbon-equivalent area of forest elsewhere as an alternative to surrendering units for deforestation.

In 2014, the Act was amended to close the NZ ETS 're-registration loophole'. This loophole allowed post-1989 foresters to register and de-register from the NZ ETS and make financial gains each time. As voluntary participants, post-1989 foresters were able to profit by surrendering lower value international units when de-registering from the NZ ETS, and then re-register into the NZ ETS and be allocated higher value New Zealand Units (NZUs). This activity offered no environmental benefit. The legislative change passed requires post-1989 foresters to surrender only NZUs when voluntarily exiting the NZ ETS.

Review of the NZ ETS from 2015–2017

The Government undertook a review of the NZ ETS in two stages from 2015 to mid-2017.[90]

The review assessed how the NZ ETS should evolve to support New Zealand in meeting future emissions reduction targets and its ongoing transition to a low emissions economy. The first stage of the review focused on:

1. removing the transitional measure that reduced surrender obligations to one NZU for each 2 tonnes of actual emissions for the liquid fossil fuels, industrial processes, stationary energy and waste sectors[91]
2. managing the costs of these sectors moving to full surrender obligations.

The Government announced in May 2016 that the one-for-two transitional measure would be phased out over three years. This phase-out is now being implemented, with surrender obligations increasing in three equal steps from 2017–19. Full obligations will apply from the 2019 calendar year.

The second stage of the review focused on the overall design and operation of the NZ ETS, to assess how the NZ ETS can best support New Zealand to meet its first NDC under the Paris Agreement and subsequent NDCs. Submissions on this stage highlighted that stakeholders want clear and stable policy direction and continued engagement with the Government on the NZ ETS.

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[90] Agriculture was excluded from the review terms.

[91] The one-for-two transitional measure never applied to forestry.

The review concluded in mid-2017 with in-principle decisions on the following four proposals to improve the operation of the NZ ETS in the 2020s.

- Introduce an auctioning mechanism. This will allow the supply of units into the NZ ETS to align with the carbon budget for New Zealand's first NDC for 2021–30 and with subsequent NDCs.
- Limit participants' use of international units when the NZ ETS re-opens to international carbon markets.
- Develop a different approach to setting and operating a price ceiling for NZUs. Currently the NZ ETS has a price ceiling that works by offering NZUs for surrender at NZ$25. Possible future options include a volume-limited price ceiling as part of an auctioning mechanism.
- Coordinate decision-making. Decisions and announcements about key supply volumes and related settings in the NZ ETS will be made on the basis of a rolling five-year period.

These decisions are intended to allow for a more predictable and transparent process for future decision-making on supply and price measures, and to make the NZ ETS more compatible with other emissions trading schemes for future access to international carbon markets.

Next steps on NZ ETS in-principle decisions

The Government intends to engage further with stakeholders on the next steps in implementing these in-principle decisions. The next steps include designing the implementation of auctioning, developing a different approach to setting and operating a price ceiling, and more detailed proposals for the unit supply decision-making process.

Work will continue on improvements to the NZ ETS approaches to forestry and free allocation, as well as operational and technical improvements such as providing market information and improvements to the compliance regime. This work is integrated with a wider work programme, including the Productivity Commission Inquiry and transition hub, on the various aspects of how New Zealand will meet its 2030 target and eventually transition to a low-emissions and climate-resilient economy.

NZ ETS implementation costs

The approximate cost of implementing and administering the NZ ETS since 2008 is NZ$45.59 million. The budgeted NZ ETS implementation and administration costs borne by Government, as budgeted for the 2015/16 financial year (year to June 2016), were approximately NZ$6.69 million.[92] Data on administration costs borne by participants are incomplete.

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92 Vote Environment 2015/16. Retrieved from www.treasury.govt.nz/budget/2016/suppestimates/index.htm/suppest16envir.pdf

Other information

Greenhouse gases affected: All greenhouse gases covered by the Kyoto Protocol: carbon dioxide (CO_2), methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons and sulphur hexafluoride. New Zealand has no emissions of nitrogen trifluoride.

Quantitative effect of the policy or measure: An estimated 2930 kilotonnes of carbon dioxide equivalent (kt CO_2-e) emissions will be avoided by the NZ ETS.

Type of policy or measure: Economic, regulatory.

Implementing entities: The Environmental Protection Authority administers the register and enforces the scheme. The Ministry for the Environment develops regulations for the NZ ETS. The Ministry for Primary Industries administers compliance with forestry regulations and the forestry allocation plan.

Status of implementation: Implemented.

More information: For details of the NZ ETS, see www.mfe.govt.nz/climate-change/reducing-greenhouse-gas-emissions/new-zealand-emissions-trading-scheme.

Productivity Commission

The Government has tasked an independent body, the Productivity Commission, to identify how New Zealand can maximise the opportunities and minimise the costs and risks of transitioning to a lower net-emissions economy.

The inquiry will identify options for how New Zealand could reduce its domestic greenhouse gas emissions and transition towards a low-emissions future, while continuing to grow incomes and well-being. The inquiry seeks to answer the question of how New Zealand can maximise the opportunities and minimise the costs and risks of a transition to a low-emissions economy. It will examine how New Zealand's regulatory, technological, financial and institutional systems can help to achieve this transition.

In August 2017 the Commission published an issues paper that aimed to assist individuals and organisations to participate in the inquiry. A final report to the Government is due by 30 June 2018.

Low-emissions economy transition hub

A low-emissions economy transition hub was established within Natural Resources Sector government agencies in 2017. This hub brings relevant government agencies together to work and partner with the private sector where appropriate.

The hub is designed to provide costed, tested and modelled policy options for meeting New Zealand's NDCs under the Paris Agreement. The hub's work will be informed by the recommendations made by the Productivity Commission and the various climate change reference groups established in 2017. This includes developing options on the balance of domestic emissions reductions, forestry, and international emissions reductions to contribute towards meeting New Zealand's first NDC.

Government procurement and property

The New Zealand Government Principles and Rules of Sourcing[93] set the basis for good procurement practice. The principles require government agencies to make procurement decisions based on best value for money, take account of costs and benefits over the life of the goods or services being procured, and have regard to environmental, economic and social impacts.

The Ministry of Business, Innovation and Employment has responsibility for leading initiatives to strengthen government agencies' procurement capability and practices. The New Zealand Government Procurement and Property (NZGPP) branch of MBIE has issued guidance on the practical application of total cost of ownership and sustainable procurement.[94]

NZGPP has negotiated a series of contracts under which all government agencies can source commonly used goods and services. Where relevant, these contracts have sustainability criteria built into them. The high number of agencies purchasing under the contracts has encouraged suppliers to improve their sustainability performance.

In a recent development, NZGPP is supporting the wider government initiative to encourage the introduction of electric vehicles. It has now included electric vehicles on the All of Government Vehicles panel and has been assisting with aggregating public and private sector demand for electric vehicles to encourage greater supply of electric vehicles in the New Zealand market.[95] Energy efficiency standards and installation of re-charging points for electric vehicles are also included in government property lease contracts.

Improvements in procurement practices are now supported by the development and implementation of a procurement capability review tool.[96] Government agencies can assess and benchmark their procurement practices, including delivering the Government's wider policy agenda. To drive improvement in agencies' procurement practices, the procurement benchmarks contribute to the chief executive performance assessment and the Government's confidence ratings for investing in agencies.

4.3.2 Energy

Renewable energy

The Government's approach to developing New Zealand's renewable energy resources is to ensure market incentives and the regulatory framework support further investment in appropriate renewable energy projects by removing any unnecessary regulatory barriers. There is no government subsidy for new electricity generation in New Zealand because renewable energy is already cost-competitive. However, the NZ ETS is intended to send a clear price signal and create a competitive advantage for renewable generation.

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93 www.procurement.govt.nz/procurement/for-agencies/key-guidance-for-agencies/the-new-government-rules-of-sourcing

94 www.procurement.govt.nz/procurement/for-agencies/guides-and-tools/A-to-Z-guides-tools-templates

95 All-of-government contracts represent single supply agreements for selected common goods and services for most government departments.

96 www.procurement.govt.nz/procurement/for-agencies/procurement-capability-index

Process heat offers one of New Zealand's largest opportunities to improve energy efficiency and reduce emissions as, unlike electricity, process heat is supplied using primarily fossil fuels. The New Zealand Energy Efficiency and Conservation Strategy 2017–2022 identified the use of renewable energy for process heat as one of the three priority areas for this reason. Under this priority MBIE and EECA are developing a process heat plan – called Process Heat in New Zealand – to improve energy efficiency and the use of renewable energy in the process heat sector and to build the evidence base to help achieve this.

MBIE is currently funding renewable energy research to support sustainable and efficient use of natural resources and in energy demand and use. Research in renewable energy is supported under the Endeavour Fund (an annual contestable investment) and Crown research institutes such as the Institute of Geological and Nuclear Sciences Limited (GNS Science) (geothermal) and Scion (biofuels). As of 2016/17, the Government had invested approximately NZ$10.6 million per year in science programmes supporting renewable energy research. These organisations include renewable energy in their Statements of Core Purpose[97] and invest core funding to support capability in this area (see section 8.2.2). This figure excludes other government agencies and private sector funding.

Energy efficiency programmes

Efficient products programmes

As noted in previous *National Communications*, New Zealand and Australia have a joint Equipment Energy Efficiency (E3) programme to align energy efficiency regulation across both markets.[98] This supports the Trans-Tasman Mutual Recognition Arrangement between the countries, which allows that any product produced in, or imported into, one country may be legally sold in the other. Since 2002 there has been ongoing development of mandatory labels and performance standards for a range of commonly used residential, commercial and industrial electrical products, allowing both countries to set consistent standards and measures for energy efficiency. Twenty-five product classes are regulated and further regulation is being considered for five product areas under the current E3 Prioritisation Plan, as described below.

The programme aims to reduce emissions from electricity[99] consumption. It achieves this aim by regulating minimum energy performance levels for certain product classes, and through mandatory energy performance labelling.

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97 For the Statement of Core Purpose for each agency, see:
GNS: www.gns.cri.nz/Home/About-Us/Corporate-Documents/Statement-of-Core-Purpose
Scion: www.scionresearch.com/__data/assets/pdf_file/0017/51650/SCION-Statement-of-Core-Purpose-SCP-Nov-2010.pdf.

98 See www.energyrating.gov.au/programs/e3-program.

99 The regulations cover all forms of energy but, aside from gas water heaters, only electrical products are currently regulated.

Minimum energy performance standards

Under the minimum energy performance standards, products must be tested and shown to meet a minimum standard for energy efficiency before they can be sold. The standards apply to 22 product classes in New Zealand.[100]

Compulsory product labelling

Product labelling regulations require energy efficiency information to be displayed to consumers at the point of sale for seven product classes: fridges and freezers, clothes washers, clothes dryers, dishwashers, heat pumps, air conditioners, monitors and televisions. The labels assess how much electricity the appliance is likely to use in a year (on average) and provide a star rating that compares the appliance's efficiency to other appliances of its type.

E3 Prioritisation Plan

The E3 Prioritisation Plan focuses on updating and expanding energy efficiency regulations to include new measures for industrial fans, new and revised measures for lighting products (including light emitting diodes), and revised measures for domestic fridges and freezers, heat pumps/air conditioners, and commercial refrigeration.

Other information

Greenhouse gas affected: Carbon dioxide.

Quantitative effect of the policy or measure: By 2020 the measures implemented in the E3 programme are projected to avoid 312 kt of CO_2 emissions.

Type of policy or measure: Regulatory, information.

Implementing entity: Energy Efficiency and Conservation Authority.

Status of implementation: Implemented.

More information is available on:

- minimum performance energy standards and labelling at: www.eeca.govt.nz/standards-ratings-and-labels
- a database of product models registered under minimum energy performance standards in New Zealand and Australia at: http://reg.energyrating.gov.au/comparator/product_types.

ENERGYWISE consumer information programme

ENERGYWISE™ is EECA's consumer information programme that helps consumers use energy better by providing well-evidenced, accessible advice on energy efficiency, energy conservation and renewable energy. ENERGYWISE™ provides authoritative advice via its website, digital media and television advertising.

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[100] The product classes are: televisions; external power supplies; set top boxes; domestic fridges and freezers; gas water heaters; computer room air conditioners; four classes of air conditioners an heat pumps – multiple split systems, single phase (ducted), single phase (non-ducted), and three phase; commercial building chillers; commercial refrigeration; distribution transformers; distribution transformers – dry type; electric hot-water cylinders; electric hot-water cylinders – low pressure copper thermal; compact fluorescent lamps; ballasts for fluorescent lamps; linear fluorescent lamps; three-phase electric motors; computers; and monitors.

Warm Up New Zealand: Healthy Homes insulation programme

Since it began in 2009, EECA's Warm Up New Zealand Programme has insulated and improved the thermal performance of more than 300,000 homes to improve health, productivity and energy efficiency.

The Warm Up New Zealand (WUNZ) programme has run in two phases: WUNZ: Heat Smart (2009–13) was available to all households, and WUNZ: Healthy Homes (2013–18) is targeted to households with low incomes and high health needs. The WUNZ programme has contributed to more than 300,000 insulation retrofits to date.

As the programme is in its final year, EECA is working with the insulation industry to maintain its capability once the programme ends, and support the Government's new compulsory insulation regulations for rental properties, introduced under an amendment to the Residential Tenancies Act 1986. Under this amendment, all residential rental homes will be required to have insulation; social housing by 1 July 2016 and all other rental homes by July 2019. For any new tenancy from 1 July 2016, landlords have been required to provide a statement on the tenancy agreement about the location, type and condition of insulation in the rental home.

Other information

***Greenhouse gas affected*:** Carbon dioxide

Quantitative effect of the policy or measure: ENERGYWISE is expected to achieve 28 kt CO_2-e annually by 2020. Since WUNZ was introduced in 2009, the programme has been achieving on average 7 kt CO_2-e annually. The major benefits of the programme are improved health outcomes from increased thermal performance of insulated homes for a given level of energy service.[101]

***Type of policy or measure*:** Financial and industry support, information.

Implementing entity: Energy Efficiency and Conservation Authority.

***Status of implementation*:** Implemented

More information is available on:

- the ENERGYWISE programme at: www.energywise.govt.nz
- the Warm Up New Zealand: Heat Smart programme at: www.energywise.govt.nz/funding-and-support/funding-for-insulation.

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101 Evaluation reports confirm and quantify the success of the programme. Net benefits to New Zealand were calculated to be worth NZ$1.3 billion over the expected lifetime of measures delivered under the programme, with a benefit:cost ratio of more than 4:1. The majority (99 per cent) of the measured net benefit is from improved health resulting from warmer, drier conditions after insulation is installed. For evaluation reports, see www.healthyhousing.org.nz/research/current-research/evaluation-of-warm-up-new-zealand-heat-smart.

Large Energy User programme for businesses

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 our energy-related emissions.[102] It is estimated that large energy-using businesses could improve their energy efficiency by up to 20 per cent through smarter energy use and investment in efficient technology.

Through its Large Energy User programme, EECA encourages large energy users across New Zealand to commit to finding long-term energy solutions to their particular energy management challenges, by providing tailored services appropriate to the current position of the business on its energy management journey. EECA partners directly with large energy users because their large-scale operations offer the most cost-effective gains, providing the greatest benefits to our economy. Their prominence also provides energy efficiency leadership to other businesses, large and small.

Public sector leadership

The New Zealand public sector leads by directly reducing energy use and emissions, incentivising wider action and using opportunities as a group of infrastructure providers and large energy users in its own right. EECA specifically targets large energy users in the public sector and helps it to demonstrate leadership by committing to energy-efficient and renewable energy investments and adopting best-practice energy management. The target sectors are central and local government, health providers and the education sector, which are often large users of fossil fuel.

Process heat

In previous years, EECA has focused strongly on electricity efficiency gains. In line with the process heat priority in the NZEECS, and with changes to EECA's levy funding,[103] EECA can now more effectively target areas to those of greatest public benefit such as the carbon-intensive process heat sector. This shift will result in lower electricity efficiency savings than in previous years but will lead to a greater reduction in carbon emissions from gas and coal efficiency improvements as well. EECA will also continue to encourage replication and diffusion through its work in targeted industries and sectors and associated case studies.

Large Energy User programme

The Large Energy User programme is designed to overcome market barriers and improve energy management capability, enabling large energy users in New Zealand to make continuous improvements in energy performance. The programme's services include:

- directly engaging with large energy users, including account management support and the use of energy management tools such as energy audits, energy systems optimisation and energy management plans
- providing training and industry development

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[102] Ministry of Business, Innovation and Employment. 2016. *Energy in New Zealand 2016*. Wellington: MBIE.

[103] Levy funding – changes to the way EECA is funded from July 2017 has enabled it to focus on the more carbon-intensive sectors of the economy – process heat and transport. In 2017/18 the Crown intends to recover funding through the petroleum or engine fuels monitoring levy and the gas levy, as well as the electricity efficiency levy. EECA will use levy funding to run programmes directly linked to the source of funding, and demonstrate the links by reporting back to levy payers every year.

- providing online information resources such as the Energy Management Journey tool, the Heat Recovery Guide and technology webinars
- promoting new innovative technology through provision of funding and information
- facilitating renewable heat (switching from more carbon-intensive fossil fuels)
- undertaking technology demonstration projects to increase the uptake of proven, yet underused energy-efficient technologies and processes
- providing interest-free Crown loans for public sector organisations.

EECA partially funds some non-capital projects; for example, it uses energy management tools to identify energy-saving opportunities and implement no-cost/low-cost projects. It also provides capital co-funding through Crown loans and technology demonstrations.

Other information

***Greenhouse gas affected*:** Carbon dioxide.

Quantitative effect of the policy or measure: The emissions reductions directly associated with this programme have not been quantified.

Type of policy or measure: Fiscal, information.

Implementing entity: Energy Efficiency and Conservation Authority.

***Status of implementation*:** Implemented.

More information is available at: www.eecabusiness.govt.nz/services-and-funding/crown-loans.

Commercial buildings programmes

There is significant potential for commercial buildings in New Zealand to be designed, built and managed to maximise energy efficiency opportunities, primarily through electricity efficiency. An inefficient building locks in inefficient patterns of energy use throughout its life, which can be over 50 years.

EECA supports ongoing improvements in the energy performance of commercial buildings through two main initiatives: commercial building performance advice and NABERSNZ™ (see below).

Commercial buildings performance advice

EECA provides design and performance advice to building owners and developers to ensure that energy-efficient building and plant options are embedded in the design and fit-out of new commercial buildings and major refurbishments of existing buildings. Since July 2017 performance advice has been available only for publicly owned or occupied buildings.

NABERSNZ™

NABERSNZ™ is a scheme for rating the energy efficiency of existing office buildings and identifies opportunities for implementing energy performance in buildings. In 2013 EECA, in collaboration with the New Zealand Green Building Council, launched the NABERSNZ™ scheme to measure and rate the energy performance of commercial buildings in New Zealand. The scheme is based on the successful National Australian Built Environment Rating System (NABERS) and has been adapted for New Zealand conditions. EECA targets publicly owned or occupied buildings.

NABERSNZ™ is a voluntary scheme that aims to help owners and tenants to reduce energy use and costs, and also reduce greenhouse gas emissions. Under NABERSNZ™, qualified assessors measure and score the energy performance of office buildings, giving tenants and owners a star rating out of six.

Other information

Greenhouse gas affected: Carbon dioxide.

Quantitative effect of the policy or measure: The business programme is estimated to reduce CO_2-e emissions on average by 115 kt annually by 2020 using MfE's average electricity emission factor.[104]

Type of policy or measure: Information, voluntary programme, labelling.

Implementing entity: Energy Efficiency and Conservation Authority.

Status of implementation: Implemented.

More information is available on:

- the business programme at: www.eecabusiness.govt.nz
- commercial buildings performance advice at www.eecabusiness.govt.nz/funding-and-support/commercial-building-performance-advice
- NABERSNZ™ at www.nabersnz.govt.nz.

4.3.3 Transport

The transport sector is responsible for over 18 per cent of New Zealand's total greenhouse gas emissions, with road vehicles responsible for the majority of CO_2 emissions within this. This area offers the potential for significant emissions reductions for New Zealand.

The Government's primary mechanism to mitigate greenhouse gas emissions from the transport sector is to include transport fuels in the NZ ETS. Other transitional incentives and research are under way to complement the scheme in the areas of new fuels and technology, improved efficiency of commercial fleets, and encouraging forms of transport that are less carbon-intensive. These policies and measures are discussed below.

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104 Ministry for the Environment. 2016. *Guidance for Voluntary Greenhouse Gas Reporting – 2016: Using Data and Methods from the 2014 Calendar Year.* Wellington: Ministry for the Environment.

Strategic context

The Government's overarching goal for the New Zealand transport system is to have "an effective, efficient, safe, secure, accessible and resilient transport system that supports the growth of our country's economy, in order to deliver greater prosperity, security and opportunities for all New Zealanders".[105]

The New Zealand Energy Strategy 2011–2021 adds a focus on energy efficiency to the strategic direction and infrastructure planning for the transport sector. It highlights the potential to reduce energy use in urban areas through walking, cycling and greater use of public transport, and places an expectation on local authorities to ensure integrated travel options through their transport and planning roles. Local authorities are also expected to improve the efficiency of local transport networks and layouts so that people and freight can move about with greater ease and energy efficiency.

The NZEECS 2017–2022 has efficient and low-emissions transport as one of its three priorities. It also outlines actions that businesses, individuals, households and community institutions, and the public sector can take to work towards the strategic objectives.

Reflecting this context, the 2015/16–2024/25 Government Policy Statement on Land Transport includes, as key objectives and associated means of support, having a land transport system that:

- provides appropriate transport choices – to be supported by continued investment in public transport to give appropriate travel choices to users, and increased investment in cycle networks in both urban and suburban areas
- mitigates the effects of land transport on the environment – to be supported by a continued significant investment in mitigating the adverse effects of improvements, and clear reporting on the investment in environmental mitigation.

Vehicle efficiency

Vehicle Fuel Economy Labelling scheme

The Vehicle Fuel Economy Labelling scheme, 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. The scheme is to be updated in the future to incorporate external changes such as the adoption of the world light-fleet test standards, electric vehicles and an increasing emphasis on greenhouses gases and climate change.

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105 Ministry of Transport. 2011. *Connecting New Zealand: A Summary of the Government's Policy Direction for Transport*. Wellington. Ministry of Transport, p 3.

Other information

Greenhouse gas affected: Carbon dioxide.

Quantitative effect of the policy or measure: The Energy Efficiency and Conservation Authority estimates that the Vehicle Fuel Economy Labelling scheme will encourage CO_2 savings of 41 kt CO_2-e per year by 2020.

Type of policy or measure: Regulation.

Implementing entities: New Zealand Transport Agency and the Energy Efficiency and Conservation Authority.

Status of implementation: implemented.

More information is available at: www.eeca.govt.nz/content/vehicle-fuel-economy-labels.

Technology

Electric vehicles

In 2016 the Government announced the Electric Vehicles Programme, which is a suite of initiatives to increase the uptake of electric vehicles in New Zealand. In recognition of the opportunity that electric vehicles represent given New Zealand's competitive advantage in renewable electricity generation, the Programme aims to tackle and remove barriers that may prevent households and businesses from choosing electric vehicles. The initiatives under the Programme include:

- setting a target of doubling the number of electric vehicles in New Zealand every year to reach approximately 64,000 by the end of 2021
- extending the Road User Charges exemption on light electric vehicles until they make up 2 per cent of the light vehicle fleet, and introducing a new Road User Charges exemption for heavy electric vehicles until they make up 2 per cent of the heavy vehicle fleet[106]
- government agencies coordinating activities to support the development and roll-out of public charging infrastructure, including providing information and guidance
- providing NZ$1 million annually for a nationwide information and promotion campaign on electric vehicles that contributes to the accelerated uptake of electric and/or other low-emissions vehicles over five years
- providing the Low Emission Vehicles Contestable Fund of up to NZ$6 million per year to encourage and support innovative low-emissions vehicle projects.

[106] 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.

Other information

***Greenhouse gas affected*:** Carbon dioxide.

***Quantitative effect of the policy or measure*:** The emissions reductions directly associated with this programme have not been quantified.

***Type of policy or measure*:** Fiscal.

Implementing entity: Ministry of Transport.

Status of implementation: Implemented – legislation to implement the exemption was passed by Parliament in August 2009 and extended in 2012 to 2020.

More information is available at: www.transport.govt.nz/ourwork/climatechange/electric-vehicles.

Urban Cycleways Programme

The New Zealand Government has committed to significantly accelerating investment in and uptake of cycling through the Urban Cycleways Programme. 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. It spans 54 cycling projects in 22 local authority areas and supports a target to achieve an additional 10 million cycle trips by 2019 (relative to a 2014 baseline), which represents a 30 per cent increase in cycling. The Programme is due for completion by 2019 and is being complemented by significant local and national activities to encourage cycling as a mode of transport.

Infrastructure

Public transport

The Government is committed to ongoing investment in public transport. As part of the 2015–2018 National Land Transport Programme, it has committed nearly NZ$2 billion from the National Land Transport Fund for public transport. This is divided into NZ$1.8 billion for public transport services and NZ$200 million for public transport infrastructure – the highest-ever investment in any three-year period.

New Zealand has implemented a new policy framework for planning and contracting public transport, known as the Public Transport Operating Model. The Model provides the framework for delivering the Government’s goal of growing patronage and increasing the value for money of investment in public transport. Central to the model is an ongoing partnership between regional councils and public transport operators, which recognises that both parties have a stake in, and rely on each other for, delivering high-quality, efficient and affordable urban bus, ferry and rail services that people want to use.

Other information

***Greenhouse gas affected*:** Carbon dioxide.

Quantitative effect of the policy or measure: The emissions reductions directly associated with this programme cannot be quantified.

***Type of policy or measure*:** Educational and fiscal.

Implementing entity: Ministry of Transport.

***Status of implementation**:* The legislative components of the Public Transport Operating Model were established under the Land Transport Management Amendment Act 2013 and came into force on 13 June 2013.

More information is available at: www.transport.govt.nz/ourwork/Land/PTOM.

Roads of national significance

Current work on the Government's seven roads of national significance includes redesigning the road network to move high-volume freight routes away from residential areas, schools and vulnerable road users. Where these roads move through urban areas, the New Zealand Transport Agency is investing in ways to reduce the impact of this traffic on neighbouring communities. This provides benefits to communities, saves time and money in moving freight, and reduces congestion and heavy-vehicle emissions.

State highway design, construction and operation

The New Zealand Transport Agency aims to reduce greenhouse gas emissions via the design, construction and operation of state highways. It is developing a tool that automates calculation of both harmful air pollutant and greenhouse gas emissions from motor vehicles. This tool has been applied across the state highway network and local authority roads throughout New Zealand. A geographical information system framework is used to house the tool so that it can readily present data as maps and the tool has been used to create a national vehicle emissions data set for 2016. The New Zealand Transport Agency has also completed carbon footprints for a number of its large capital projects and has established targets and programmes to reduce and monitor emissions during project construction. When evaluating the costs and benefits of a new capital project, the Agency estimates the CO_2 emissions resulting from users of the network.

4.3.4 Industry

Emissions produced as a result of industrial processes are captured by the NZ ETS. Bulk importers of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) and users of sulphur hexafluoride 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.[107]

[107] Exporters of HFCs and PFCs are eligible to receive NZUs, as long as they meet prescribed eligibility criteria.

A levy is also 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.

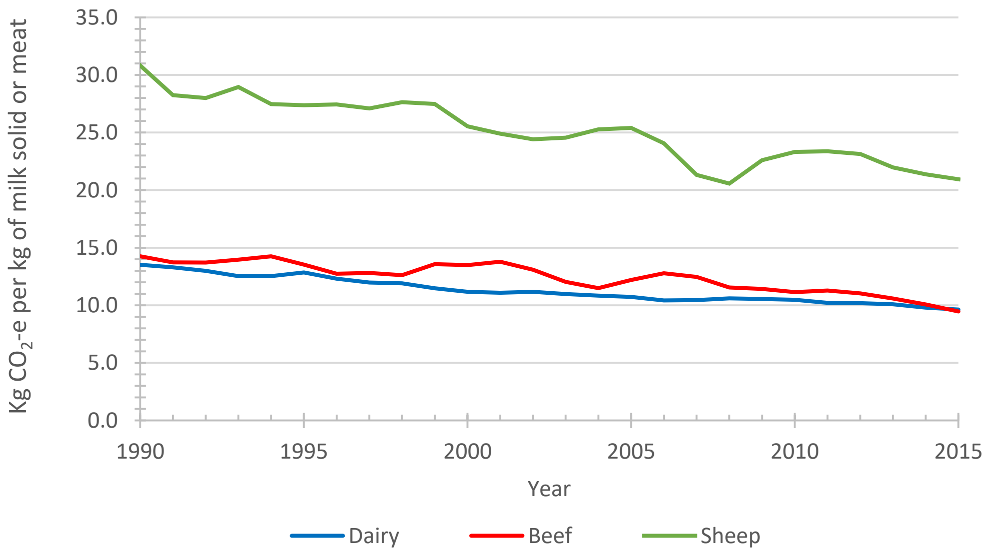
The Kigali Amendment to the Montreal Protocol puts in place a worldwide phase-down of the use of HFCs. The Government has consulted stakeholders (May and June 2017) on a proposal to regulate the imports of HFCs using a permitting system.

4.3.5 Agriculture

Reflecting the significance of agricultural emissions in New Zealand's overall emissions profile, New Zealand remains committed to exploring collaborative and innovative solutions to reducing agricultural emissions, supporting regional economic development and maintaining a global trade in efficiently produced, high-quality food. The New Zealand Government is also committed to working with the agriculture sector to build an evidence base for what mitigation is possible.

Since 1990 New Zealand pastoral farmers have made improvements in efficiency and productivity across the pastoral agriculture sector. This has led to significant decreases in emissions per unit of product for sheep, beef and dairy (figure 4.1). Without these improvements, agricultural emissions would have increased more than 40 per cent to produce the same amount of food.[108] Farmers have improved productivity through innovations in feed and nutrition, animal genetics, pasture management and animal health.

Figure 4.1: Emissions intensity for major livestock categories, 1990–2015



[108] See New Zealand Agricultural Research Consortium *Highlights 2015*. Retrieved from www.nzagrc.org.nz/user/file/1046/NZAGRC%20Highlights%202015.pdf.

Currently there are few economically viable options for reducing absolute greenhouse gas emissions from agriculture. New Zealand's main policy approaches therefore primarily focus on:

- continued research and development investment in innovative technologies and practices
- building a robust and agreed evidence base with agriculture sector groups to explore what mitigation is possible on-farm now, and the costs and opportunities of doing so.

The New Zealand Government has invested consistently in research and development to improve the measurement and mitigation of agricultural emissions. It also provides leadership internationally through the Global Research Alliance on Agricultural Greenhouse Gases on research and capacity building to reduce agricultural emissions globally. Research and development are carried out under the:

- Biological Emissions Reference Group
- Global Research Alliance on Agricultural Greenhouse Gases
- New Zealand Agricultural Greenhouse Gas Research Centre
- Greenhouse Gas Inventory Research Fund (see section 8.4.6 for further details)
- Pastoral Greenhouse Gas Research Consortium
- Primary Growth Partnership
- Sustainable Land Management and Climate Change Plan of Action
- Sustainable Farming Fund.

Biological Emissions Reference Group

The Biological Emissions Reference Group, a joint government and industry reference group, was set up in September 2016 to agree an evidence base for what the agriculture sector can do to reduce emissions at the farm level, now and into the future, and the costs and opportunities of doing so.

The Group intends to publish a final report by mid-2018. With the evidence in this report, it aims to inform any future actions or policies to reduce methane (CH_4) and nitrous oxide (N_2O) emissions from agriculture.

Other information

Greenhouse gases affected: Methane, nitrous oxide, carbon dioxide.

Quantitative effect of the policy/measure: The emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure: Research, information sharing, training, education.

Status of implementation: Implemented.

More information is available at: www.mpi.govt.nz/protection-and-response/environment-and-natural-resources/emissions-trading-scheme.

Dairy Action on Climate Change

In June 2017 the New Zealand dairy industry (DairyNZ, in partnership with Fonterra) announced the Dairy Action for Climate Change. The purpose of this work, led by the dairy industry, is to develop a framework for the dairy sector to address CH_4 and N_2O emissions and contribute to meeting New Zealand's first NDC.

The Ministries for the Environment and Primary Industries are supporting the ongoing development of the programme. In particular, they are supporting extension activities designed to raise awareness of climate change among dairy farmers, and demonstrating the potential for emissions reductions via farm systems changes. Initiatives will be implemented by November 2018.

Other information

Greenhouse gases affected: Methane, nitrous oxide, carbon dioxide.

Quantitative effect of the policy or measure: The emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure: Research, information sharing, training, education.

Status of implementation: Implemented.

More information is available at: www.dairynz.co.nz/news/latest-news/climate-change-dairy-gears-up-to-lower-greenhouse-gas-emissions.

National Policy Statement for Freshwater Management

Freshwater management in New Zealand is largely devolved to regional councils 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 2011 the National Policy Statement for Freshwater Management (NPS-FM) came into effect and had subsequent amendments in 2014 and 2017. The 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.

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.

Other information

Greenhouse gases affected: Methane, nitrous oxide.

Quantitative effect of the policy or measure: For the agriculture projections we quantified the expected effect of the NPS-FM. For further details, see section 5.5

Type of policy or measure: National Policy Statement, regional council implementation.

Status of implementation: Implemented. Location-specific water objectives are being developed.

More information is available at: www.mfe.govt.nz/publications/fresh-water/national-policy-statement-freshwater-management-2014.

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. The GRA encompasses the voluntary, collaborative efforts of its 48 member countries[109] and 14 partner organisations, spread across the globe. The work of the GRA is conducted through its four research groups, focused on key agricultural sub-sectors (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 section 9.6), in addition to co-chairing the GRA's Livestock Research Group and hosting the GRA Secretariat and Special Representative. The New Zealand Government has committed total funding of NZ$65 million until June 2020 to support the GRA.

Other information

Greenhouse gases affected: Methane, nitrous oxide, carbon dioxide.

Quantitative effect of the policy or measure: The emissions reductions directly associated with the GRA cannot be quantified.

Type of policy or measure: Research, information sharing, training, education.

Status of implementation: Implemented.

More information is available at: www.globalresearchalliance.org.

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109 Argentina, Australia, Belgium, Bolivia, Brazil, Canada, Chile, China, Colombia, Costa Rica, Denmark, Dominican Republic, Ecuador, Egypt, Finland, France, Germany, Ghana, Honduras, Indonesia, Ireland, Italy, Japan, Lithuania, Malaysia, Mexico, Netherlands, New Zealand, Nicaragua, Norway, Panama, Paraguay, Peru, Philippines, Poland, Republic of Korea, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Tunisia, United Kingdom, United States, Uruguay, Viet Nam and Zimbabwe.

New Zealand Agricultural Greenhouse Gas Research Centre

The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) is funded by the Ministry for Primary Industries and brings together nine organisations that conduct research to reduce New Zealand's agricultural greenhouse gas emissions.[110] Research at the NZAGRC is focused on finding practical ways of reducing on-farm CH_4 and N_2O emissions while improving productivity and sequestering soil carbon.

The NZAGRC's five areas of research focus are:

- mitigating CH_4 emissions, including by breeding low-emissions animals, identifying low-methane feeds, developing vaccines to inhibit enteric methane, and discovering inhibitory compounds that reduce enteric CH_4 emissions. This is a joint programme with the Pastoral Greenhouse Gas Research Centre, funded by industry and government
- mitigating N_2O emissions, including by identifying and testing plant species effects on N_2O emissions, manipulating denitrification processes, feed management options, management effects on emission factors, developing urine patch detectors, and identifying and testing inhibitory compounds that reduce N_2O emissions
- increasing soil carbon content, including by identifying the potential of different soils to store more carbon, manipulating carbon inputs to stabilise and enhance stocks; developing tools to quantify soil carbon content and the stability of stored carbon, and modelling management manipulations
- integrated farm systems, including by demonstrating profitable, practical and low-emissions systems for sheep, beef and dairy farming
- Māori-focused research aligned with integrated farm systems, which seeks to assist the Māori[111] pastoral sector to increase resource efficiency and farm productivity while lowering greenhouse gas emissions. For details on progress towards solutions, see section 9.4.2.

Other information

Greenhouse gases affected: Methane, nitrous oxide, carbon dioxide.

Quantitative effect of the policy or measure: The emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure: Research, information, capability building, education.

Implementing entity: Ministry for Primary Industries.

Status of implementation: Implemented.

More information is available at: www.nzagrc.org.nz.

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[110] The seven member Crown research institutes and universities are: AgResearch, Landcare Research, Lincoln University, Massey University, National Institute of Water and Atmospheric Research, Plant and Food Research and Scion. The two other organisations are DairyNZ and the Pastoral Greenhouse Gas Research Consortium.

[111] Māori are the indigenous people of New Zealand.

Pastoral Greenhouse Gas Research Consortium

The Pastoral Greenhouse Gas Research Consortium (PGgRc) is a partnership, funded 50:50 by Government and industry, that aims to provide livestock farmers with the information and means to mitigate their greenhouse gas emissions. The PGgRc and the NZAGRC jointly developed a research, development and extension strategy. The PGgRc mainly focuses on research to reduce CH4 emissions in ruminant animals.

The PGgRc has been in operation since 2002. It has eight partners from the dairy, sheep, beef, deer, agricultural research and fertiliser industries, including DairyNZ, Beef+Lamb New Zealand, DEEResearch and Fertiliser Research, all of which conduct 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.

Key outcomes the PGgRc has achieved include:

- identifying and developing the ability to breed low-CH_4-emitting sheep
- sequencing the first methanogen genome and identifying targets that are being used to develop a CH_4-reducing vaccine
- identifying five classes of compounds that show promise as inhibitors of CH_4 emissions.

The PGgRc also actively pursues collaborations with international agricultural animal health and chemical companies to provide avenues to commercialise any products.

Other information

Greenhouse gases affected: Methane, nitrous oxide.

Quantitative effect of the policy or measure: The emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure: Research, information, education.

Implementing entity: Ministry of Business, Innovation and Employment.

Status of implementation: Implemented.

More information is available at: www.pggrc.co.nz.

Primary Growth Partnership

In 2009 the Government established the Primary Growth Partnership (PGP). The scheme focuses on boosting innovation, profitability and productivity through ongoing investment in primary sector innovation and delivering long-term economic growth and sustainability across the following primary industry sectors:

- pastoral (including wool) and arable production
- horticulture
- seafood (including aquaculture)

- forestry and wood products
- food processing (including nutraceuticals and bioactives).[112]

Investments cover the whole of the value chain (from producer to consumer): research and development, product development, commercialisation, commercial development, technology transfer, and education and skills development. Programmes are focused on delivering ambitious long-term outcomes and generally run for five to seven years.

Programmes undertaken by the PGP require joint investment between the Government and industry. The PGP can invest up to 40 per cent of a programme's total funding (up to 50 per cent for programmes approved before December 2015). As at 30 June 2017, the PGP has invested in 22 programmes. Over the life of these programmes, the PGP and industry have committed a total of NZ$759 million. Many programmes provide sustainability and climate change benefits of either reducing absolute emissions from the primary sector or reducing emissions per unit of product.

Examples include the Transforming the Dairy Value Chain PGP course, which has established a course for rural professionals on greenhouse gas emissions and management. The course's aim is to enable rural professionals to better understand how greenhouse gases – and the policies aimed at curbing them – will affect farming. The course is delivered by Massey University and was put together with expertise from DairyNZ, Massey University, AgResearch, the Ministry for Primary Industries and NZAGRC.

The PGP also provides core funding for NZAGRC.

Other information

Greenhouse gases affected: Methane, nitrous oxide, carbon dioxide.

Quantitative effect of the policy or measure: The emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure: Research, information, training, capacity building.

Implementing entity: Ministry for Primary Industries.

Status of implementation: Implemented.

More information is available at: www.mpi.govt.nz/funding-and-programmes/primary-growth-partnership.

Sustainable Land Management and Climate Change Plan of Action

In September 2007 the Government outlined an integrated package for the land-based sectors: the Sustainable Land Management and Climate Change Plan of Action (SLMACC). By 2014 many of the SLMACC strands of action had been completed. Those remaining include the research programme, greenhouse gas inventory research and the technology transfer programme. The research programme covers all aspects of climate change in the land-based

112 Bioactives and nutraceuticals are specific compounds present in food that have health-promoting benefits.

sectors, including impacts and adaptation, reducing greenhouse gas emissions and increasing forest carbon sinks. Over 150 projects have been commissioned by 2017.

Work undertaken in the SLMACC includes:

- research on how to reduce methane emissions from agriculture – key outcomes from this work include identifying feeds that can decrease methane emissions in sheep, and developing bio-filters to capture methane emissions from housed animals, effluent ponds and landfills
- the use of the nitrification inhibitor dicyandiamide (DCD), which reduces N_2O emissions from livestock-grazed pasture by up to 30 per cent. Further work in this area is on hold, pending the development of an international food safety standard for DCD through the Codex Alimentarius
- the technology transfer 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 Climate Cloud website, which holds over 1800 peer-reviewed resources on the risks, impacts and adaptation solutions from climate change and adverse events. For further information, see www.climatecloud.co.nz
- contributing to the funding of the development of Overseer®, an on-farm nutrient budgeting tool to identify greenhouse gas emissions levels at the farm level. This tool can provide farmers with information about nitrogen-use efficiency and nitrate leaching and includes a module for estimating greenhouse gas emissions on-farm. It is being rolled out to over 10,500 dairy farmers in New Zealand by Fonterra (a dairy cooperative) as a tool to more effectively manage nitrogen and reduce nitrate leaching on-farm. Regional councils are also using the tool to set limits on the amount of nitrogen that can flow into waterways from farms in certain catchments.

Other information

Greenhouse gases affected: Methane, nitrous oxide, soil carbon and forest carbon.

Quantitative effect of the policy or measure: The emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure: Research, information, education, capability.

Implementing entity: Ministry for Primary Industries.

Status of implementation: Implemented.

More information is available on:

- climate change measures at: www.mfe.govt.nz/climate-change/state-of-our-atmosphere-and-climate/new-zealands-greenhouse-gas-inventory
- the agricultural section of the National Inventory Report at: www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/greenhouse-gas-reporting
- Overseer at: www.overseer.org.nz.

Sustainable Farming Fund

The Sustainable Farming Fund (SFF) invests in applied research and projects led by farmers, growers or foresters. The SFF has supported over 1000 projects between 2000 and 2017. The majority of projects are related to production efficiency and sustainability. Some deal with greenhouse gas emissions directly and others with the impacts of and adaptation to climate change. For example, projects have dealt with irrigation and efficient water use, as well as nitrogen use and efficiency.

Other information

Greenhouse gases affected: Methane, nitrous oxide, carbon dioxide.

Quantitative effect of the policy or measure: The emissions reductions, impacts and adaptation directly associated with this programme cannot be quantified.

Type of policy or measure: Research, information, education, technology transfer, capability building.

Implementing entity: Ministry for Primary Industries.

Status of implementation: Implemented.

More information is available at: www.mpi.govt.nz/funding-and-programmes/fisheries-and-aquaculture/sustainable-farming-fund.

4.3.6 Forestry

Forests can act as significant carbon sinks, by absorbing CO_2, as well as helping to achieve other positive environmental outcomes (such as reducing erosion). In 2015 the land use, land-use change and forestry (LULUCF) sector offset 29.7 per cent of New Zealand's gross emissions. In 2015 the Land Use and Carbon Analysis System (LUCAS) measured 2.1 million hectares of plantation forest and 7.83 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 than 0.1 per cent of New Zealand's annual timber production is harvested from natural forests. Commercial timber harvested from privately owned natural forest is restricted to that sourced under sustainable forest management plans and permits, and in most cases harvesting is not permitted in natural forest on public land. These changes have been in place since 1993 and 2002, respectively, following amendments to the Forests Act 1949.

New Zealand's sustainable forest management regime occurs over a cyclical process of planting, harvesting and replanting. Extensive forest planting on pastoral land occurred on a commercial basis, between 1992 and 2003, due to a relatively high expected rate of return for forests (due to high export log prices). These forests have contributed, and will continue to contribute, to offsetting New Zealand's projected emissions growth until 2020.

New Zealand has five principal measures that promote afforestation (for several reasons including carbon sequestration, erosion and water quality) and provide incentives to maintain forests:

1. NZ ETS
2. Permanent Forest Sink Initiative (PFSI)
3. Sustainable Land Management Hill Country Erosion Programme (HCEP)
4. Erosion Control Funding Programme (ECFP – formerly the East Coast Forestry Project)
5. Afforestation Grant Scheme (AGS).

Between 2008 and 2015 the majority of total afforestation in New Zealand can be attributed to the Government initiatives listed above. Between 1990 and 2015 these initiatives have also led to the sequestering of an estimated additional 24,812 kt CO_2-e from the atmosphere. This figure includes afforestation resulting from the NZ ETS, PFSI, ECFP, HCEP and AGS, as well as the estimated impact the NZ ETS has had on reducing pre-1990 planted forest deforestation since 2008.

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. The forestry sector entered the NZ ETS in 2008, and as at 30 June 2017 around 47 per cent of forests planted after 1989 had been voluntarily registered in the NZ ETS. The forests planted 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 current mandatory emissions return period,[113] but are also liable to repay units if there is a reduction in carbon stock. The majority of land owners with forests planted before 1990 face deforestation liabilities under the NZ ETS if they deforest.

As noted in section 4.3.1, the NZ ETS was recently reviewed to assess its overall operation and effectiveness, and to ensure its settings are able to support New Zealand to meet its future emissions reduction targets. From this review, additional work is planned to improve the incentives for afforestation. This includes reducing the operational complexity for forests in the NZ ETS, as well as considering two accounting approaches: accounting for forests up until the long-term carbon stock is reached; and accounting for carbon stored in harvested wood products.[114]

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 $2.2 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 – treating over 3500 hectares each year. The fund also supports catchment facilitation work and capability-building initiatives.

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113 The mandatory emissions return periods have been 2008–12 and 2013–17.

114 Ministry for the Environment. Outcomes from stage two of the NZ ETS Review 2015/16: www.mfe.govt.nz/nzets/2015-16-review-outcomes.

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.

Permanent Forest Sink Initiative

The Permanent Forest Sink Initiative (PFSI) promotes the establishment of permanent forests on land that was unforested before 1 January 1990. It offers land owners with land registered with the PFSI the opportunity to earn emissions units for the carbon sequestered by their forests since the start of the last mandatory emissions return period.

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. In 2016, 15,464 hectares of forest were registered in the PFSI, of which over 70 per cent was natural forest.

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 41,000 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.

Afforestation Grant Scheme

Through the Afforestation Grant Scheme (AGS) NZ$19.5 million will be invested between 2015 and 2020 to encourage and support the planting of new forests. This builds on the success of a previous scheme from 2008-13 that resulted in the planting of close to 12,000 hectares of new forest. The objective of the AGS is to encourage and support new forest planting, with applications prioritised, if necessary, according to their contribution to environmental outcomes. This Scheme is expected to result in 15,000 hectares of new forest planting by 2020.

Under the AGS, land owners can receive a government grant of NZ$1300 per hectare for establishing new forests on eligible land. Recipients of the grant own the new forests while the Government retains the Kyoto Protocol removal units (and liabilities) generated during the 10-year period of the grant agreement.

The Government committed funding to establish new forests on 12,450 hectares by 2018. The NZ$19.5m budget for AGS will be 82 per cent committed following three successful rounds. The AGS is on track to meet its 15,000-hectare target in five years.

Other information

Greenhouse gas affected: Carbon dioxide.

Quantitative effect of the measures: The cumulative effect of policies and measures on the LULUCF sector between 1990 and 2030 is 96,215 kt CO_2-e (see table 5.19).

Type of policy or measure: Voluntary agreements, fiscal.

Implementing entities: Ministry for the Environment (NZ ETS), Ministry for Primary Industries (forestry and agricultural funding and programmes).

Status of implementation: Implemented.

More information is available at: www.mpi.govt.nz/forestry/forestry-in-the-ets www.mpi.govt.nz/funding-and-programmes/forestry.

Other measures

National Environmental Standards

From 1 May 2018 the National Environmental Standards for Plantation Forestry, a new set of regulations under the Resource Management Act 1991, will apply to all plantation forests in New Zealand. The Standards will reduce unwarranted variation in the way the forestry sector is regulated, and provide greater consistency in the treatment of eight main forestry activities across New Zealand.[115] This will maintain or improve environmental outcomes related to forestry activities in New Zealand and will also improve operational and investment certainty for the forestry industry.

Forestry Reference Group

New Zealand has also established the Climate Change Forestry Reference Group. The purpose of this Group is to explore and test evidence, analysis and policy options with officials to inform and support climate change policy that enables forestry to contribute meaningfully to New Zealand's climate change targets. The Group is made up of individuals who have strong experience and expertise in the forestry sector, carbon forestry, post-1989 forestry participation in the NZ ETS, permanent carbon forestry, farm forestry and Māori forestry.

4.3.7 Waste

The major legislation governing waste management in New Zealand is the Waste Minimisation Act 2008. The Act sets out the Government's long-term priorities and:

- places a levy on all waste going to disposal facilities (those landfills that receive household waste and operate at least in part as a business) to fund waste minimisation initiatives
- creates a process for accrediting voluntary product stewardship schemes and for making the development of product stewardship schemes mandatory (for 'priority' products)

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115 Afforestation, mechanical land preparation, earthworks, forest quarrying, river crossings, pruning and thinning to waste, harvesting and replanting.

- clarifies the roles and responsibilities of territorial authorities with respect to waste minimisation
- established the Waste Advisory Board to provide advice to the Minister for the Environment.

The legislation is supported by the New Zealand Waste Strategy. This Strategy was revised in 2010 (replacing the 2002 strategy) and replaces the previous targets with two high-level goals:

- reduce the harmful effects of waste
- improve the efficiency of resource use.

The waste management sector is also required to report on its emissions and has obligations to surrender emissions units under the NZ ETS.

National Environmental Standard for Landfill Methane

In 2004 the Government introduced specific standards for landfills in the Resource Management (National Environmental Standards for Air Quality) Regulations. The standards are designed to ensure effective management of discharges of greenhouse gases generated from large landfills. Since the implementation of the regulation, to the end of 2012 it is estimated that 1640 kt CO_2-e have been recovered from landfills that would have otherwise contributed to greenhouse gas emissions.

Waste Minimisation Fund

Fifty per cent of the levy on waste disposed of to landfills (minus administration) is allocated to waste minimisation projects through the Waste Minimisation Fund. The purpose of the Fund is to support projects that increase resource efficiency, reuse, recovery and recycling, and decrease waste to landfill. Several projects targeting organic waste have been awarded funding through the Waste Minimisation Fund. For examples of projects awarded funding, see section 9.5.1.

Other information

Greenhouse gas affected: Methane.

Quantitative effect of the policy or measure: The emissions reductions directly associated with this programme cannot be quantified.

Type of policy or measure: Regulatory.

Implementing entity: Ministry for the Environment.

Status of implementation: Implemented.

More information is available on:

- the Waste Minimisation Act 2008 at: www.mfe.govt.nz/laws/waste-minimisation.html
- waste policies at: www.mfe.govt.nz/issues/waste.

4.4 Monitoring, evaluation and review

4.4.1 The New Zealand Emissions Trading Scheme

As previously mentioned, the NZ ETS is New Zealand's principal policy response to climate change. Section 4.3.1 has described how the Government has carried out a review of the NZ ETS from 2015–17, with a focus on making it fit for purpose in meeting New Zealand's first Nationally Determined Contribution under the Paris Agreement.

The Climate Change Response Act includes a clause enabling the Minister for Climate Change Issues to initiate a review of the operation and effectiveness of the NZ ETS at any time.

4.4.2 Waste Minimisation Act 2008

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 by 1 July 2020. 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.

4.4.3 Sustainable Land Management and Climate Change research programme

A governance review of the Sustainable Land Management and Climate Change research programme was carried out in 2011 and the recommendations implemented. In 2016 a series of research theme evaluations of the programme were commissioned, which are due for completion in June 2018. The research themes cover the outputs and outcomes from the individual projects under Primary Sector Climate Change Impacts and Adaptation, Forestry Carbon Sinks, Agricultural Greenhouse Gas Mitigation, and Climate Change Technology Transfer.

4.4.4 New Zealand Agricultural Greenhouse Gas Research Centre

The New Zealand Agricultural Greenhouse Gas Research Centre underwent a review of its governance, administrative processes, leadership and performance against key performance indicators in 2013 (a similar review will take place in 2018). The Pastoral Greenhouse Gas Research Consortium (which works in partnership to assist NZAGRC commercialise its research) underwent a review of its progress towards commercialisation of mitigation technologies in 2015. These organisational reviews have been supplemented by reviews of the joint science programme by specially convened international science review panels. All elements of the science programme have been reviewed on a two year rotating cycle.

4.4.5 EECA's programmes

EECA has an ongoing programme to monitor the performance of its programmes and to evaluate their effectiveness.

In 2016, EECA reviewed its programmes to assess how they fitted with a number of strategic initiatives underway including the refreshed New Zealand Energy Efficiency and Conservation Strategy (NZEECS 2017–2022). As part of tightening its strategic focus, EECA decided to retire the ENERGY STAR label and to exit from the Fuel Efficient Tyres programme and the Heavy Vehicle Fuel Efficiency programme.

4.5 Policies and measures no longer in place

The following policies and measures that were reported on in the *Sixth National Communication* are no longer in place.

4.5.1 Voluntary product labelling – ENERGY STAR®

ENERGY STAR® is an independent international programme that awards labels to only the most energy-efficient products on the market.[116] ENERGY STAR® was launched in New Zealand in 2005, and ran through to June 2017.

In 2016, EECA reviewed the programme and determined that it was no longer effective and had become less relevant as the E3 programme had gained momentum.

4.5.2 Warm Up New Zealand: Heat Smart

The Warm Up New Zealand: Heat Smart programme ended in September 2013. Until then, it had been the Government's principal energy efficiency programme in the residential sector since 2009. The programme provided consumers with information on home insulation, grants for the installation of energy efficiency measures (through subsidies for ceiling and underfloor insulation installed through approved service providers) and clean heating devices[117] in homes built prior to 2000.[118]

The scheme paid – without income restriction – one-third of the cost of installing ceiling and under-floor insulation up to a maximum of NZ$1300. People on lower incomes were eligible for up to 60 per cent of the total cost of insulation and NZ$1200 towards a clean heating appliance, provided the home was first insulated. Landlords whose tenants were low-income earners could also receive the 60 per cent subsidy.

The programme was co-funded with four partners: local government, iwi, service providers and energy retailers. Generally this third-party funding was applied to low-income households to cover the remaining 40 per cent of the costs of insulation not provided by the programme.

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[116] ENERGY STAR® was typically available to only the top 25 per cent of products in a class, based on energy efficiency.

[117] Clean heating devices approved by the EECA include specified wood burners, pellet burners, heat pumps and flued gas heaters. The clean heating component of the programme stopped in October 2012, when the Government decided to re-focus the remaining funding on insulation retrofits.

[118] After January 2000 insulating ceiling and under-floors became a requirement when building a new home.

In Budget 2009 the Government allocated the programme NZ$323 million over four years. The initial aim was to retrofit over 180,000 homes. In November 2009 the Government announced that the programme would be enhanced by an additional NZ$24 million of funding targeted at low-income families, allowing an additional 8000 households to benefit.

In Budget 2012, the programme was extended further, to deliver a total of at least 230,000 insulation retrofits. Up to the end of September 2013, the programme delivered 235,000 insulation retrofits. This level of activity was above the original target.

4.5.3 RightLight

EECA ran RightLight from 2009 to November 2015. RightLight was a web-based programme for information on energy-efficient lighting and design. RightLight came to an end in November 2015 because EECA was satisfied efficient light bulb sales had grown to a point where a targeted campaign was no longer required. Lighting-related messaging has been folded into the wider ENERGYWISE™ messaging.

4.5.4 Heavy Vehicle Fuel Efficiency programme

EECA introduced the Heavy Vehicle Fuel Efficiency programme in September 2012. The programme aimed to improve the fuel efficiency of heavy vehicle fleets by providing grants for fleet audits, information for fleet managers about how to save fuel, and training for truck drivers on fuel-efficient and safe driving. A review of the programme in 2016 found evidence that the programme led to improvement in fuel efficiency, lower maintenance costs, and safer driving in some fleets. However, the programme did not deliver on its anticipated benefits for a range of reasons, including the lack of timely and accurate data on fuel use from fleet managers, low fuel prices, and staff shortages in the sector, which affected drivers' availability for training. As a result of these findings, the programme was discontinued in 2017.

4.5.5 Fuel Efficient Tyres programme

In 2014 EECA embarked on a two-year programme to work in partnership with the tyre industry to promote the sale of fuel-efficient tyres. Its key components were the voluntary labelling of ENERGYWISE™-approved tyres at point of sale, a marketing campaign and promotion of fuel-efficient tyres by tyre retailers.

EECA reviewed this programme at the end of its planned two-year trial in 2016 and decided to exit it in 2017 because there was no evidence of an increase in the sale of fuel-efficient tyres.

4.5.6 Green Growth Advisory Group

In January 2011 the Government established a Green Growth Advisory Group. The Group was tasked with exploring how New Zealand can build a more productive and competitive economy while achieving high-quality environmental outcomes.

The Group reported to the Government in December 2011. Its central conclusion was that rather than focusing on a select group of 'green' industries, New Zealand needs a broad growth strategy whereby all sectors take into account their environmental performance. In making this recommendation, the Group noted that "New Zealand faces two major challenges in de-coupling economic growth from GHG emissions growth. Many of the industries of particular importance to the economy have high emissions intensity". New Zealand therefore needs to:

- focus on innovation and productivity gain to reduce emissions intensity in growth industries that currently have high intensity
- accelerate growth in industries of already lower emissions intensity.

The Group favoured a combination of both scenarios, consistent with New Zealand's long-term targets for emissions reduction.

4.5.7 Carbon capture and storage

The Government has previously supported international research efforts on the global uptake of carbon capture and storage (CCS), especially by large CO_2 emitters, because it was considered to be a significant technology for mitigating climate change.

The opportunities for adopting CCS in New Zealand are more limited than in some other countries because New Zealand has relatively few large point sources of CO_2 emissions, particularly given the high renewable contribution to electricity generation. This means that CCS has limited potential to help New Zealand mitigate current carbon emissions. However, the possibility of using CCS may help maintain flexibility in the future use of New Zealand's energy resources for economic development.

5 Projections and total effect of policies and measures

Key points:

- New Zealand's gross emissions (excluding net emissions and removals from the LULUCF sector) are projected to rise to 79,958 kt CO_2-e in 2020 (23.8 per cent above 1990 levels or 0.3 per cent below 2015 levels) and to 77,239 kt CO_2-e in 2030 (19.6 per cent above 1990 levels or 3.7 per cent below 2015 levels).
- Gross emissions are projected to be 3.6 per cent lower in 2020 and 10.2 per cent lower in 2030 than they were projected to be in the *Second Biennial Report* published in 2015.
- New Zealand's net emissions (including emissions and removals from the LULUCF sector) are projected to rise to 64,264 kt CO_2-e in 2020 (86.5 per cent above 1990 levels or 13.9 per cent above 2015 levels) and to 73,196 kt CO_2-e in 2030 (112.5 per cent above 1990 levels or 29.7 per cent above 2015 levels).
- Net emissions are projected to be 9.4 per cent higher in 2020 and 1.9 per cent lower in 2030 than they were projected to be in the *Second Biennial Report*.
- 'With measures' and 'without measures' scenarios of greenhouse gas emissions have been modelled to project the effect of New Zealand's key quantifiable policies and measures out to 2030.
- Three different forestry scenarios have uncertainties due to future rates of afforestation, deforestation, harvesting rates, rotation ages and carbon prices.
- Projections show the impact of New Zealand's policies and measures are estimated to reduce gas emissions by 113.2 million tonnes of carbon dioxide equivalent between 2016 and 2030.

5.1 Introduction

This chapter reports on projections of New Zealand's greenhouse gas emissions and removals to 2030, updating projections provided in *New Zealand's Sixth National Communication* and in the *New Zealand Second Biennial Report.*[119] The projections of greenhouse gas emissions and removals cover the following sectors:

- energy
- transportation
- industrial processes and product use (IPPU)
- agriculture
- forestry, or land use, land-use changes and forestry (LULUCF)
- waste.

[119] www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/nzs-national-communication-and-biennial-report

All of the projected greenhouse gas emissions and removals are 'with measures' unless otherwise stated; that is, they include the effect of New Zealand's key quantifiable climate change policies and measures currently implemented. Not all policies New Zealand has put in place can currently be quantifiably measured. Details of the policies and measures included in both the 'with measures' and the 'without measures' scenarios are discussed for each sector in section 5.5. The projections methodology for New Zealand is closely linked to the methodology used to estimate emissions and removals in New Zealand's annual National Inventory Report (NIR), as part of *New Zealand's Greenhouse Gas Inventory*.[120]

This chapter also provides 'without measures' projections, which estimate what New Zealand's emissions could be in the absence of climate change policies. All projections are measured in kilotonnes (kt) of gas unless specifically noted otherwise. Where applicable, emissions have been converted to a carbon dioxide equivalent (CO_2-e) using global warming potentials (GWPs) from the Intergovernmental Panel on Climate Change (IPCC) *Fourth Assessment Report*,[121] which is consistent with reporting in the NIR. Projected removals are net removals resulting from LULUCF, as defined under the United Nations Framework Convention on Climate Change (UNFCCC).

A cross-governmental technical group, led by the Ministry for the Environment, produces New Zealand's projections of emissions and removals on a sector-by-sector basis. The Ministry for Primary Industries projects the net emissions and removals from LULUCF, and emissions from agriculture. The Ministry of Business, Innovation and Employment projects the emissions from stationary energy and transport, and carbon dioxide (CO_2) emissions from IPPU. The Ministry for the Environment projects emissions of fluorinated gases from IPPU, and emissions from waste.

Projections of emissions and removals are inherently uncertain. Variables such as economic growth and population growth, commodity prices, currency exchange rates, the assumed carbon price, the assumed rate of afforestation and deforestation, and the harvest level/age of forests all have significant effects on projected emissions and removals. Seasonal changes, especially variation in rainfall, can affect both energy and agricultural emissions. There is also uncertainty in the methodology to estimate emissions from biological sources within agriculture and LULUCF.

5.2 Projected greenhouse gas emissions and removals, 'with measures'

Table 5.1 summarises New Zealand's actual (historical) and projected greenhouse gas emissions and removals by both sector and gas. Emissions and removals from 1990–2015 are based on data reported in *New Zealand's Greenhouse Gas Inventory 1990–2015* published in 2017 (containing the 2017 NIR), while values for 2016 and later are projections based on a 'business as usual' or 'with measures' scenario. New Zealand's projected 'with measures' scenario is also illustrated for gross and net emissions in figure 5.1.

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[120] www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/nzs-greenhouse-gas-inventory

[121] IPCC. 2009. *Fourth Assessment Report*. Retrieved from www.ipcc.ch/report/ar4.

New Zealand’s gross emissions (excluding net emissions and removals from the LULUCF sector) are projected to rise to:

- 79,958 kt CO_2-e in 2020 (23.8 per cent above 1990 levels or 0.3 per cent below 2015 levels)
- 77,239 kt CO_2-e in 2030 (19.6 per cent above 1990 levels or 3.7 per cent below 2015 levels).

New Zealand’s net emissions (including emissions and removals from the LULUCF sector) are projected to rise to:

- 64,264 kt CO_2-e in 2020 (86.5 per cent above 1990 levels or 13.9 per cent above 2015 levels)
- 73,196 kt CO2-e in 2030 (112.5 per cent above 1990 levels or 29.7 per cent above 2015 levels).

The difference between gross and net emissions projections highlights the role the LULUCF sector has in offsetting current and projected emissions. Section 5.3.5 gives more information on and analysis of this topic. Information on projection assumptions is also included in appendix C.1 (annex C).

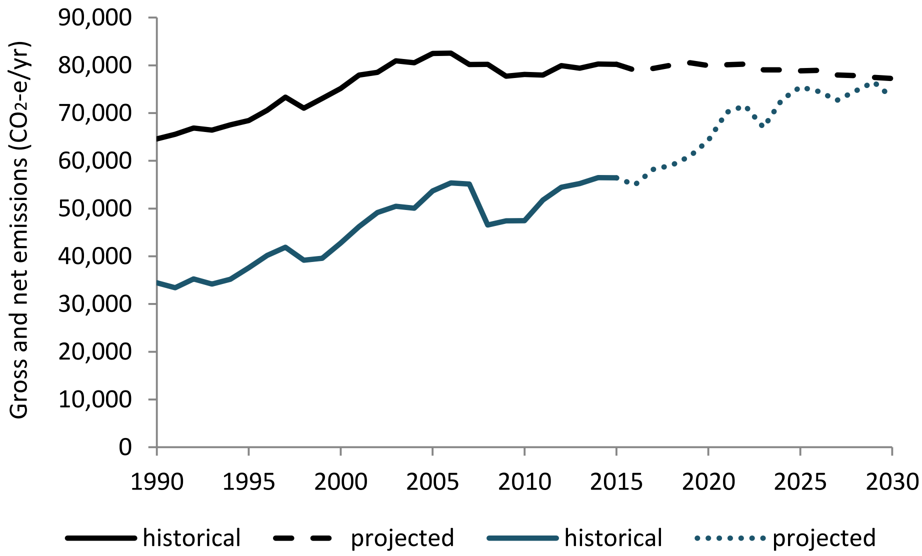
Table 5.1: New Zealand’s historical and projected ‘with measures’ scenario for greenhouse gas emissions and removals by sector and gas, 1990–2030

	Greenhouse gas emissions and removals (kt CO_2-e)									
	1990	1995	2000	2005	2010	2015	2016	2020	2025	2030
Category	Historical							Projected		
Sector										
Energy	14,984	14,911	17,579	20,672	18,034	17,693	16,274	16,418	14,889	14,324
Transportation	8,765	10,959	12,423	13,902	14,150	14,762	15,537	16,188	16,108	15,014
IPPU	3,584	3,209	3,462	4,113	4,655	5,280	5,187	5,487	5,843	6,185
Agriculture	33,123	34,984	37,067	39,115	36,862	38,420	37,950	37,888	38,056	37,737
LULUCF	−30,122	−30,852	−32,368	−28,817	−30,614	−23,783	−24,014	−15,694	−3,400	−4,043
Waste	4,118	4,385	4,611	4,693	4,375	4,052	4,025	3,976	3,963	3,978
Gas										
CO_2 emissions including net CO_2 from LULUCF	−4,964	−3,009	−297	8,512	4,142	11,947	10,526	19,585	30,277	28,020
CO_2 emissions excluding net CO_2 from LULUCF	25,429	28,152	32,359	37,642	35,018	35,911	34,732	35,467	33,864	32,250
CH_4 emissions including CH_4 from LULUCF	32,615	33,709	35,384	36,007	34,157	34,322	34,236	34,238	34,309	33,978
CH_4 emissions excluding CH_4 from LULUCF	32,522	33,597	35,297	35,869	34,047	34,243	34,157	34,159	34,230	33,899

Category	1990	1995	2000	2005	2010	2015	2016	2020	2025	2030
	Greenhouse gas emissions and removals (kt CO_2-e)									
	Historical							Projected		
N_2O emissions including N_2O from LULUCF	5,870	6,664	7,354	8,324	7,934	8,554	8,540	8,480	8,527	8,466
N_2O emissions excluding N_2O from LULUCF	5,693	6,467	7,153	8,149	7,783	8,452	8,427	8,372	8,419	8,357
HFCs	0	58	246	738	1,159	1,524	1,601	1,915	2,306	2,697
PFCs	910	150	68	69	47	59	33	24	17	12
SF_6	20	24	20	26	24	18	23	23	23	23
Total with LULUCF	34,451	37,596	42,774	53,677	47,463	56,424	54,960	64,264	75,459	73,196
Total without LULUCF	64,574	68,448	75,143	82,494	78,077	80,206	78,974	79,958	78,859	77,239

Note: CH_4 = methane; CO_2 = carbon dioxide; HFCs = hydrofluorocarbons; kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry; N_2O = nitrous oxide; PFCs = perfluorocarbons; SF_6 = sulphur hexafluoride.

Figure 5.1: New Zealand's historical and projected 'with measures' gross emissions and net emissions[122] (kt CO_2-e)



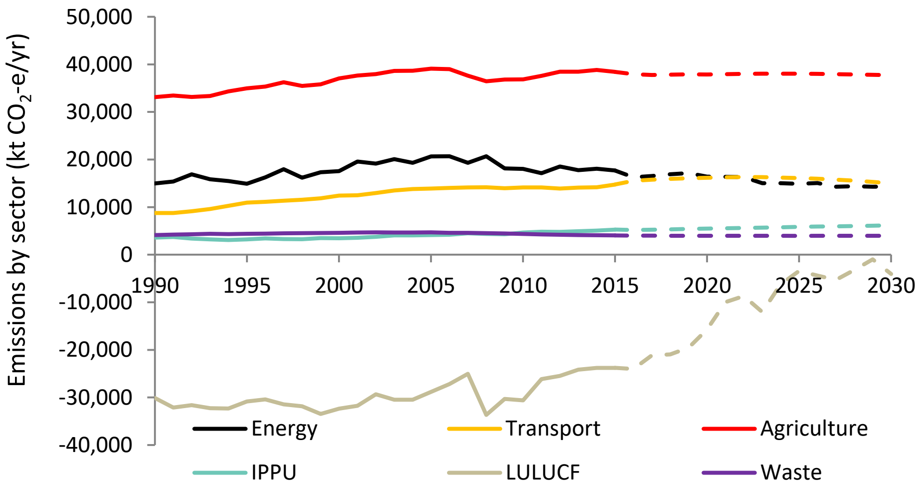
Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

122 These net removals do not represent how New Zealand will account for forestry removals against its 2030 target, as accounting rules will be applied to calculate our target emissions.

5.3 Overview of sectors

This section summarises information from each sector, including the projections of greenhouse gas emissions, sector analysis of emissions projections and the methodology followed to produce projections of emissions.

Figure 5.2: New Zealand's historical and projected 'with measures' greenhouse gas emissions from each sector, 1990–2030



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

5.3.1 Energy

Projections

For the purposes of projections, the energy sector includes:

- electricity generation
- stationary energy
- industrial and commercial use of fossil fuels and/or production of energy
- fugitive emissions.

Projections of emissions from transport are presented separately.

Emissions from the energy sector are projected to be:

- 16,418 kt CO_2-e in 2020 (10 per cent above 1990 levels, or 7 per cent below 2015 levels)
- 14,324 kt CO_2-e in 2030 (4 per cent below 1990 levels, or 19 per cent below 2015 levels).

Carbon dioxide emissions are projected to decrease slightly out to 2030, whereas methane (CH_4) and nitrous oxide (N_2O) emissions from energy are projected to remain at relatively steady levels from 2016–30.

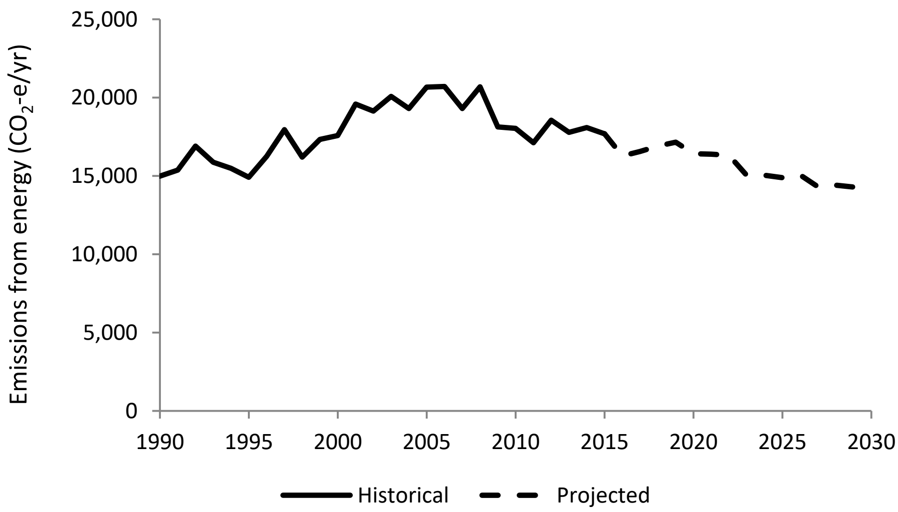
Table 5.2 and figure 5.3 present historical emissions from 1990–2015 and projected emissions from 2016–30 for the energy sector.

Table 5.2: Historical and projected emissions from the energy sector by gas, under a 'with measures' scenario, 1990–2030

	Energy greenhouse gas emissions (kt)									
	Historical							Projected		
Gas type	1990	1995	2000	2005	2010	2015	2016	2020	2025	2030
CO_2	13,910	13,896	16,320	19,572	16,676	16,659	14,917	15,012	13,489	12,952
CH_4	40	37	46	39	50	37	50	52	52	51
N_2O^*	0.3	0.3	0.3	0.5	0.4	0.4	0.4	0.4	0.3	0.4
Total (kt CO_2-e)	14,984	14,911	17,579	20,672	18,034	17,693	16,274	16,418	14,889	14,324

Note: * Due to the small amount of emissions determined in the time series, values are presented to one decimal place. All gases are reported in kilotonnes (kt) and the totals are reported in kilotonnes of carbon dioxide equivalent (kt CO_2-e). CH_4 = methane; CO_2 = carbon dioxide; N_2O = nitrous oxide.

Figure 5.3: Historical and projected greenhouse gas emissions from the energy sector, 1990–2030



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

Analysis

Total energy demand is expected to continue to grow throughout the modelled period, but at the same time the emissions intensity of energy (emissions per unit of energy delivered) is expected to decline.

Energy emissions are expected to increase slightly between 2015 and 2019, but then fall between 2019 and 2030.

The remaining coal-fired power plant in New Zealand is expected to be decommissioned by 2022, reducing emissions from coal. Coal-fired electricity generation is expected to be replaced mainly by a combination of geothermal, wind and gas-fired peaking plants in the modelled scenario.

Projections out to 2030 show further reductions in emissions for the primary and manufacturing sectors compared to *Energy Demand and Supply Scenarios* (EDGS, 2016).[123]

[123] For further information see: www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/modelling/electricity-demand-and-generation-scenarios/documents-image-library/edgs-2016.

This is partly due to reduced energy use combined with fuel switching to less carbon-intensive fuels. Fuel switching occurs due to the dynamic interplay between supply and demand and their impact on the relative prices of fuels. A key driver is the price of natural gas, which also strongly influences the price of electricity. Due to a relative increase in the price of natural gas, the model results for the later years show a reduction in demand from industry and the primary sectors for natural gas and electricity, which are offset by increases in demand for solid fuels, geothermal and wood.

Methodology

The scenarios used in this report are updated versions of those used in the *Sixth National Communication* (6NC) and *Second Biennial Report* (BR2). Energy projections have been based on the EDGS (2016) which includes historic fuel demand data to 2015. As a result the latest industrial fuel demand forecasting builds from a lower starting point than the *Second Biennial Report* resulting in lower fuel demand and as a result emissions, particularly in the short term.

For detailed information on projected energy and transport emissions and CO_2 emissions from IPPU, see the *Energy Modelling Technical Guide*.[124]

The projections in this report are based on the 'Mixed Renewables' scenario from the 2016 Electricity Demand and Generation Scenarios (EDGS), published by the Ministry of Business, Innovation and Employment. However, the carbon price assumed for this report is a different trajectory to the EDGS 'Mixed Renewables' scenario. In addition, the current New Zealand Emissions Trading Scheme (NZ ETS) measures for stationary energy participants are assumed to continue. Gross domestic product (GDP) growth, crude oil price, coal price, exchange rates, gas discoveries and population growth assumptions are, however, the same as those in the 'Mixed Renewables' scenario.

5.3.2 Transport

Projections

Emissions from the transport sector are projected to be:

- 16,188 kt CO_2-e in 2020 (85 per cent above 1990 levels, or 10 per cent above 2015 levels)
- 15,014 kt CO_2-e in 2030 (71 per cent above 1990 levels, or 2 per cent above 2015 levels).

Carbon dioxide gas emissions are expected to peak at 16,083 kt CO_2 in 2022 and then decrease out to 2030. From 2016–30, CH_4 and N_2O gas emissions from transport remain at relatively steady levels.

Table 5.3 and figure 5.4 present historical emissions from 1990–2015 and projected emissions from 2016–30.

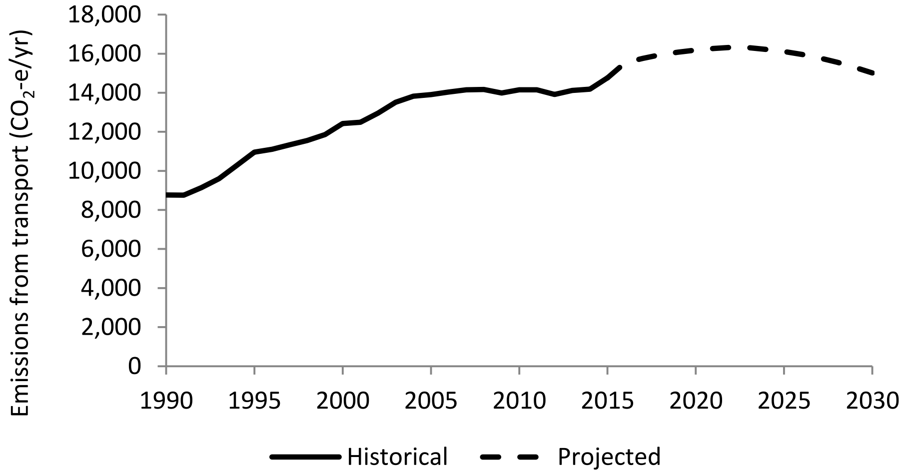
[124] Ministry of Business, Innovation and Employment. 2016. *Energy Modelling Technical Guide.* Wellington: MBIE. Retrieved from: www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/modelling/electricity-demand-and-generation-scenarios/documents-image-library/edgs-2016/energy-sector-modelling-technical-guide.pdf.

Table 5.3: Historical and projected emissions from the transport sector by gas, under a 'with measures' scenario, 1990–2030

	Transport greenhouse gas emissions (kt)									
	Historical							Projected		
Gas type	1990	1995	2000	2005	2010	2015	2016	2020	2025	2030
CO_2	8,582	10,746	12,187	13,656	13,946	14,594	15,308	15,948	15,869	14,790
CH_4	3	3	2	2	1	1	2	3	2	2
N_2O^*	0.4	0.5	0.6	0.7	0.6	0.5	0.6	0.6	0.6	0.6
Total (kt CO_2-e)	8,765	10,959	12,423	13,902	14,150	14,762	15,537	16,188	16,108	15,014

Note: * Due to the small amount of emissions determined in the time series, values are presented to one decimal place. All gases are reported in kilotonnes (kt) and the totals are reported in kilotonnes of carbon dioxide equivalent (kt CO_2-e). CH_4 = methane; CO_2 = carbon dioxide; N_2O = nitrous oxide.

Figure 5.4: Historical and projected greenhouse gas emissions from the transport sector, 1990–2030



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

Analysis

Greenhouse gas emissions from transport are expected to slightly increase out to 2022 and then decline to 2030. This is due to the demand for petrol and diesel fuel for road transport. Demand for petrol and diesel fuel is expected to decrease as fleet fuel efficiency (including as a result of electric vehicle uptake) continues to improve.

Electricity generation in New Zealand is from predominantly renewable sources and the shift to electric vehicles contributes to the decline in emissions from 2022.

The New Zealand vehicle fleet is near saturation on a per capita basis. Population growth is the main driver of the increase in emissions from transport out to 2020 and 2030. This is offset by fuel efficiency improvements for new vehicles. The vehicle fleet is older in New Zealand than in many other countries, and the consequently slow rate of replacement means fuel efficiency improvements take longer to have an effect in New Zealand relative to other developed countries.

Emissions from international air and sea transport

Emissions from fuel used in international air and sea transport are reported separately and are not included in the actual or projected national totals of transport emissions.

5.3.3 Industrial processes and product use

In line with 2006 IPCC guidelines, the solvents sector has been merged into the IPPU sector since New Zealand's *Second Biennial Report*. The CO_2 emissions from IPPU incorporate the same methodological changes as the energy sector. The non-CO_2 based components of IPPU include emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and CH_4 from the production of methanol, as well as N_2O emissions from the application and use of medical products.

Projections

From 2015, emissions from the IPPU sector are projected to rise to 5,487 kt CO_2-e by 2020 (53 per cent above 1990 levels, 4 per cent above 2015 levels).

Emissions from IPPU sector are projected to increase to 6,185 kt CO_2-e by 2030 (75 per cent above 1990 levels, or 16 per cent above 2015) (see table 5.4 and figure 5.5).

Carbon dioxide emissions from industrial processes are assumed to remain at steady levels from 2016–2030, whereas the emissions of non-CO_2 based components such as PFCs, HFCs and SF_6 are expected to increase over the same period. Methane emissions are assumed to decrease out to 2030 whereas N_2O emissions from the application and use of medical products were assumed to remain steady out to 2030.

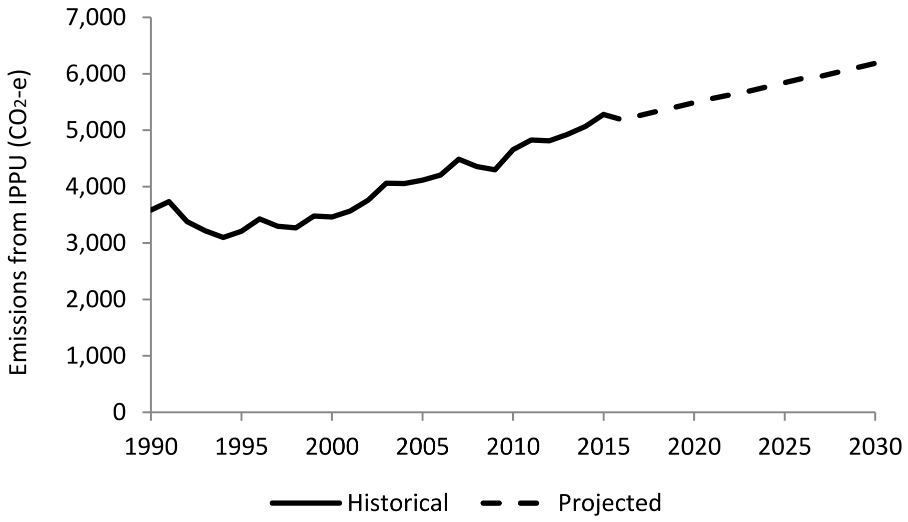
Table 5.4: Historical and projected emissions from the IPPU sector by gas, under a 'with measures' scenario, 1990–2030

	IPPU greenhouse gas emissions (kt)									
	Historical							Projected		
Gas type	1990	1995	2000	2005	2010	2015	2016	2020	2025	2030
CO_2	2,524	2,819	2,928	3,215	3,324	3,313	3,377	3,377	3,377	3,377
CH_4	1	3	6	1	2	4	4	4	3	2
N_2O*	0.3	0.3	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1
HFCs										
HFC-23	0	0	0	0	0	0	0	0	0	0
HFC-32	0	0	3	3	14	28	30	36	43	50
HFC-125	0	5	31	199	334	466	490	590	715	840
HFC-134a	0	46	175	277	421	587	613	717	848	978
HFC-143a	0	6.5	36	257	386	428	452	551	674	798
HFC-152a	0	0	0	0	0	0	0	0	0	0
HFC-227ea	0	0	1	1	2	11	12	14	17	19
HFC-245fa	0	0	0	0	1	2	2	2	3	4
HFC-365mfc	0	0	0	0	1	2	2	3	3	4
Total HFCs (CO_2-e)	0	58	246	738	1,159	1,524	1,601	1,915	2,306	2,697
PFCs										
CF_4	781	122	56	58	39	49	23	16	10	6
C_2F_6	129	24	11	12	8	10	5	3	2	1
C_3F_8	0	4	0	0	0	0	5	5	5	5

Gas type	1990	1995	2000	2005	2010	2015	2016	2020	2025	2030
	IPPU greenhouse gas emissions (kt)									
	Historical							Projected		
Total PFCs (CO_2-e)	910	150	68	69	47	59	33	24	17	12
SF_6 (CO_2-e)	20	24	20	26	24	18	23	23	23	23
Total (CO_2-e)	3,584	3,209	3,462	4,113	4,655	5,280	5,187	5,487	5,843	6,185

Note: * Due to the small amount of emissions determined in the time series, values are presented to one decimal place. Fluorinated gases are reported in kilotonnes of carbon dioxide equivalent (kt CO_2-e) and the totals are reported in kt CO_2-e. CH_4 = methane; CO_2 = carbon dioxide; HFCs = hydrofluorocarbons; N_2O = nitrous oxide; PFCs = perfluorocarbons; SF_6 = sulphur hexafluoride.

Figure 5.5: Historical and projected greenhouse gas emissions from the IPPU sector, 1990–2030



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

Analysis

In New Zealand, CO_2 and CH_4 emissions from IPPU result from the manufacture of iron and 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 projection. For the purpose of projecting greenhouse gas emissions from this sector, the level of output from these industries is assumed to remain steady from 2016–30.

Projected emissions of the fluorinated gases (PFCs, HFCs and SF_6) were not directly modelled, but were assumed to follow historical trends. Emissions of PFCs have declined since the 1990s as a result of the New Zealand Aluminium Smelter making changes to its processing methods, and the low level of PFC emissions from aluminium processing is projected to continue.

The use of HFCs has grown rapidly since the early 1990s when they replaced chlorofluorocarbons, which are being phased out under the Montreal Protocol. Emissions of HFCs are expected to continue to be the main source of industrial process emissions up to 2030.

In 2016 New Zealand ratified the Kigali Amendment to phase down HFC consumption. For the purposes of the current projections, how the Kigali Agreement will affect projections for HFC greenhouse gas emissions is not considered. Future research has been commissioned as to how this phase-down may be achieved domestically. It is expected that once suitable policy options to meet this phase-down become known, we will then understand the impact on emissions projections. The 2011 peak in emissions of fluorinated gases shown in 6NC does not appear to be indicative of a longer-term trend.

Methodology

The projections of both CO_2 and CH_4 emissions are held at a constant value from 2016–30. Carbon dioxide emissions are based on an assumed level of 95 per cent production efficiencies of activity data reported in the 2017 NIR (ie, for the 2015 year).

Because CH_4 emissions are from methanol production, which occurs at a single entity in New Zealand, projections of CH_4 and CO_2 emissions are assumed to follow similar trends. The values of CH_4 emissions are based on the maximum value across the historical time series from the 2017 NIR and then these emissions are phased down out to 2030. This is based on the assumption that natural gas supply shrinks and prices for energy rise. Emissions from fluorinated gases and N_2O are based on historical emissions trends.

5.3.4 Agriculture

Projections

From 2015, emissions from agriculture are projected to slightly decrease to 37,888 kt CO_2-e by 2020 (14 per cent above 1990 levels or 1 per cent below 2015 levels) and to 37,737 kt CO_2-e by 2030 (14 per cent above 1990 levels, or 2 per cent below 2015 levels).

From 2016–30, CO_2 and N_2O emissions from agriculture remain at steady levels, whereas the emissions of CH_4 are expected to slightly decrease out to 2030.

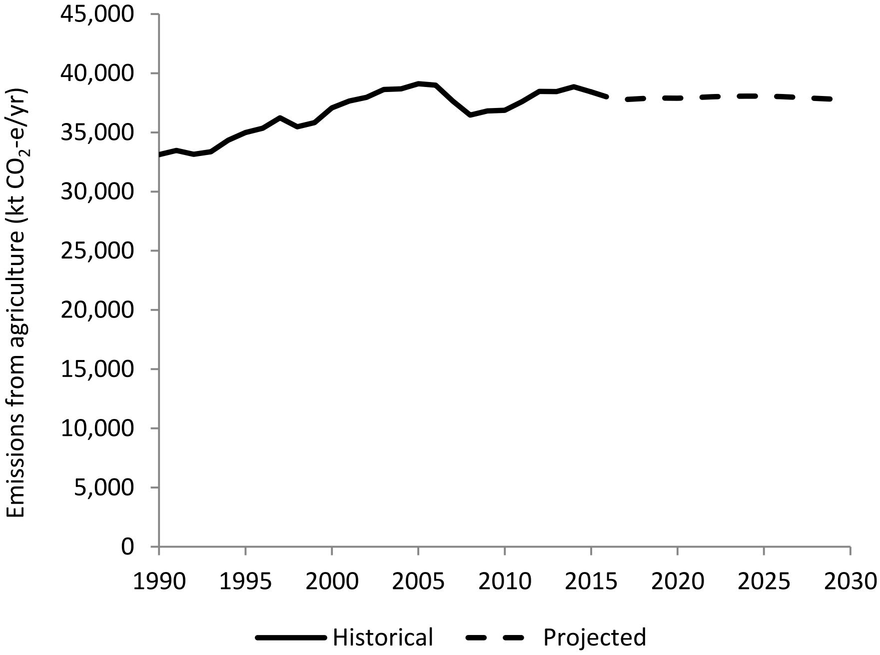
Table 5.5 and figure 5.6 present actual emissions from 1990–2015 and projected emissions from 2016–30.

Table 5.5: Historical and projected emissions from the agriculture sector by gas, under a 'with measures' scenario, 1990–2030

	Agriculture greenhouse gas emissions (kt)									
	Historical						Projected			
Gas type	1990	1995	2000	2005	2010	2015	2016	2020	2025	2030
CO_2	399	678	911	1,194	1,070	1,144	1,129	1,129	1,129	1,129
CH_4	1,097	1,131	1,178	1,211	1,138	1,171	1,154	1,154	1,159	1,148
N_2O	18	20	22	26	25	27	27	27	27	27
Total (kt CO_2-e)	33,123	34,984	37,067	39,115	36,862	38,420	37,950	37,888	38,056	37,737

Note: All gases are reported in kilotonnes (kt) and the totals are reported in kilotonnes of carbon dioxide equivalent (kt CO_2-e). CH_4 = methane; CO_2 = carbon dioxide; N_2O = nitrous oxide.

Figure 5.6: **Historical and projected greenhouse gas emissions from the agriculture sector, 1990–2030**



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

Analysis

The projected stabilisation or slight decline of agricultural emissions in New Zealand between 2015 and 2030 is due to:

- a continued decline in the amount of land used for agriculture, reflecting greater incentives to establish new forests and reduced incentives to deforest as a result of government schemes and policies encouraging the use of land for forestry (such as the Afforestation Grant Scheme and the NZ ETS)
- changes in farm management practices due to the implementation of the National Policy Statement for Freshwater Management (NPS-FM)
- continued reductions in emissions intensity (emissions per unit of product) as a result of continued improvements in animal productivity and on-farm efficiency.[125]

Changes in emissions between 2015 and 2030

From 2015–30, dairy expansion is expected to slow, with reduced rates of land-use conversion to dairy, and lower annual increases in the dairy cow population (see appendix C.2 in annex C). This trend, combined with a continued decline in the sheep population, results in a slight decline in projected agricultural emissions from 2015–30.

Expected improvements in farm management practices and technology will lead to increases in per-animal productivity, based on past performance trends. By 2030 both dairy cow milk production (per animal) and lamb carcass weights (per animal) are projected to increase by 8 per cent, as explained below.

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125 For further information, see: www.mpi.govt.nz/protection-and-response/environment-and-natural-resources/emissions-trading-scheme/agriculture-and-greenhouse-gases.

Table 5.6 summarises how emissions, animal numbers, and production are projected to change from 2015–30. In the dairy sector, emissions are projected to increase by 12.5 per cent from 2015–30, while total milk production is projected to increase by 16.8 per cent by 2030. Beef emissions are projected to decrease by 4.0 per cent by 2030, while a slight increase of 0.7 per cent by 2030 is projected for beef meat production. Sheep emissions are projected to fall by 24.1 per cent by 2030, while total sheep meat production is expected to fall by 16.0 per cent over the same period.

Table 5.6: Projected changes in emissions, production and animal numbers under a 'with measures' scenario – for dairy, sheep and beef, 2015–30

	Projected change in emissions by activity		
Animal type	Dairy	Beef	Sheep
Percentage change 2015–30	12.5%	–4.0%	–24.1%
	Projected change in total production		
Total milk/meat production type	Dairy milk	Beef meat*	Sheep meat**
Percentage change 2015–30	16.8%	0.7%	–16.0%
	Projected change in animal numbers		
Animal type	Dairy	Beef	Sheep
Percentage change 2015–30	6.6%	–0.5%	–27.1%

Note: * Includes meat from heifers, steers and bulls. ** Includes mutton and lamb.

The projections need to be considered in the context of the economic uncertainties of the agricultural industry, which are largely driven by overseas market demand and highly variable climatic conditions.

Methodology

Projections of agricultural greenhouse gas emissions have been produced by completing the following steps.

Forecasts of activity data, such as animal production and animal population numbers, were produced using the Ministry for Primary Industries' Pastoral Supply Response Model (PSRM). From these outputs, the assumed effects of the NPS-FM were used to modify the forecasted activity data. These modified activity data were then put into MPI's agricultural greenhouse gas inventory model to project future greenhouse gas emissions from agriculture. These procedures are explained in greater detail below.

Emissions from 1990–2015 are identical to those reported in New Zealand's NIR (submitted to the UNFCCC on 24 May 2017). The projections use the same methodology and emission factors as those used for the NIR.

The potential effect of new mitigation technologies such as vaccines, inhibitors and low-emissions feeds is not included in these projections as this research has not yet been proven or quantified to a level that would enable significant implementation.

Emissions from minor categories make up 1.3 per cent of total annual agricultural emissions. These categories include:

- crop burning
- decay of crop residues

- cropland cultivation (histosols and nitrogen mineralisation)
- ‘minor’ livestock species (swine, goats, horses, llama and alpacas, mules and asses, and poultry).

There is not enough evidence to suggest that activities in these categories will increase or decrease significantly so these are projected to remain identical to the 2015 emissions level between 2016 and 2030.

Pastoral Supply Response Model

The Ministry for Primary Industries projects New Zealand’s future agricultural activity by using economic analysis and bottom-up modelling. The PSRM forecasts agricultural production and animal productivity using data on:

- historical agriculture production, animal numbers and prices
- land-use forecasts
- historical and forecast commodity prices.

Agriculture land-use forecasts are based on historical, national-level interactions between competing land classes, farm prices, commodity export prices and farm profitability. The PSRM is also used by MPI to inform the Situation and Outlook for Primary Industries, which is published quarterly. The ‘midpoint’[126] scenario assumptions for forest harvesting, replanting and deforestation rates are used as an input to ensure that the agriculture projections are consistent with LULUCF projections.

The ‘with measures’ scenario was estimated for each year by modifying the PSRM output to account for the assumed effects of freshwater management reform (see below).

Effects of the National Policy Statement for Freshwater Management

The NPS-FM aims to improve the quality of fresh water in New Zealand, and requires regional councils to establish water quality objectives for catchments in their region.

The NPS-FM was first introduced in 2011. It was updated in 2014 to provide more detailed instruction on how regional councils should manage water resources to maintain and improve freshwater quality. The 2014 NPS-FM also established two measurements for water quality (relating to ecosystem health and human health for recreation) that must be managed at or above minimum ‘bottom line’ values. For further information on this policy, see section 4.3.5.

Research undertaken by Motu Economic and Public Policy Research modelled the effects of implementing the NPS-FM on future agricultural activity.[127] The results showed that its implementation is likely to slow the growth of livestock populations, production and agricultural emissions, because it:

- introduces nutrient discharge caps, which could require reductions in the application of fertiliser and restrictions in the stocking of animals near water bodies and restrict land-use intensification

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[126] For more information on the midpoint emissions scenario used in LULUCF, see section 5.3.5.

[127] A Daigneault, S Elliot, S Greenhalgh, S Kerr, E Lou, L Murphy, L Timar, S Wadhwa. 2016. *Modelling the Potential Impact of New Zealand’s Freshwater Reforms on Land-based Greenhouse Gas Emissions*. Wellington: Ministry for Primary Industries.

- requires farmers to demonstrate good farm management practices (such as the establishment of riparian buffers near streams, and manure and fertiliser management – application area, timing and amount)
- uses nutrient management tools to improve decision-making to optimise productivity and reduce environmental impacts.

It is expected that these requirements and restrictions will start to affect agricultural emissions from 2016. The NPS-FM is expected to be fully implemented by all regional councils between 2025 and 2030.

The NPS-FM effects on emissions and removals will be automatically reflected in the inventory. That is, if NPS-FM causes lower animal numbers, the activity data will have already accounted for this.

Agricultural greenhouse gas inventory model

Forecasts of future agricultural activity (which were taken from the PSRM and modified to account for the effects of the NPS-FM) were used by the agricultural greenhouse gas inventory model to obtain emissions projections out to 2030. For projections, the greenhouse gas inventory model uses the identical methodology and emission factors as used in the compilation of the NIR.

Estimating greenhouse gas emissions

New Zealand uses a range of methods to calculate agricultural emissions that are appropriate to the size of the different emissions categories. Figure 5.7 outlines how the inventory calculates different emissions categories.

In 2015, 91.6 per cent of New Zealand's agriculture emissions were due to four grazed livestock categories: dairy cattle, non-dairy cattle, sheep and deer. New Zealand uses detailed livestock population and production data and a complex ruminant animal nutritional and energy model to calculate emissions from these livestock categories. This includes CH_4 and N_2O emissions from enteric fermentation and manure management.

Other livestock species (swine, goats, horses, llama and alpacas, mules and asses, and poultry – referred to as 'minor' livestock categories) account for only 0.5 per cent of New Zealand's agriculture emissions and are estimated using Tier 1 methods.[128] Where possible, New Zealand has used country-specific emissions methods and factors to estimate emissions for these minor livestock species.

Direct and indirect N_2O emissions from synthetic fertiliser account for 4.1 per cent of New Zealand's agricultural emissions and are calculated using country-specific emission factors. Carbon dioxide emissions from liming and urea contributed 3.0 per cent of New Zealand's total agricultural emissions in 2015.

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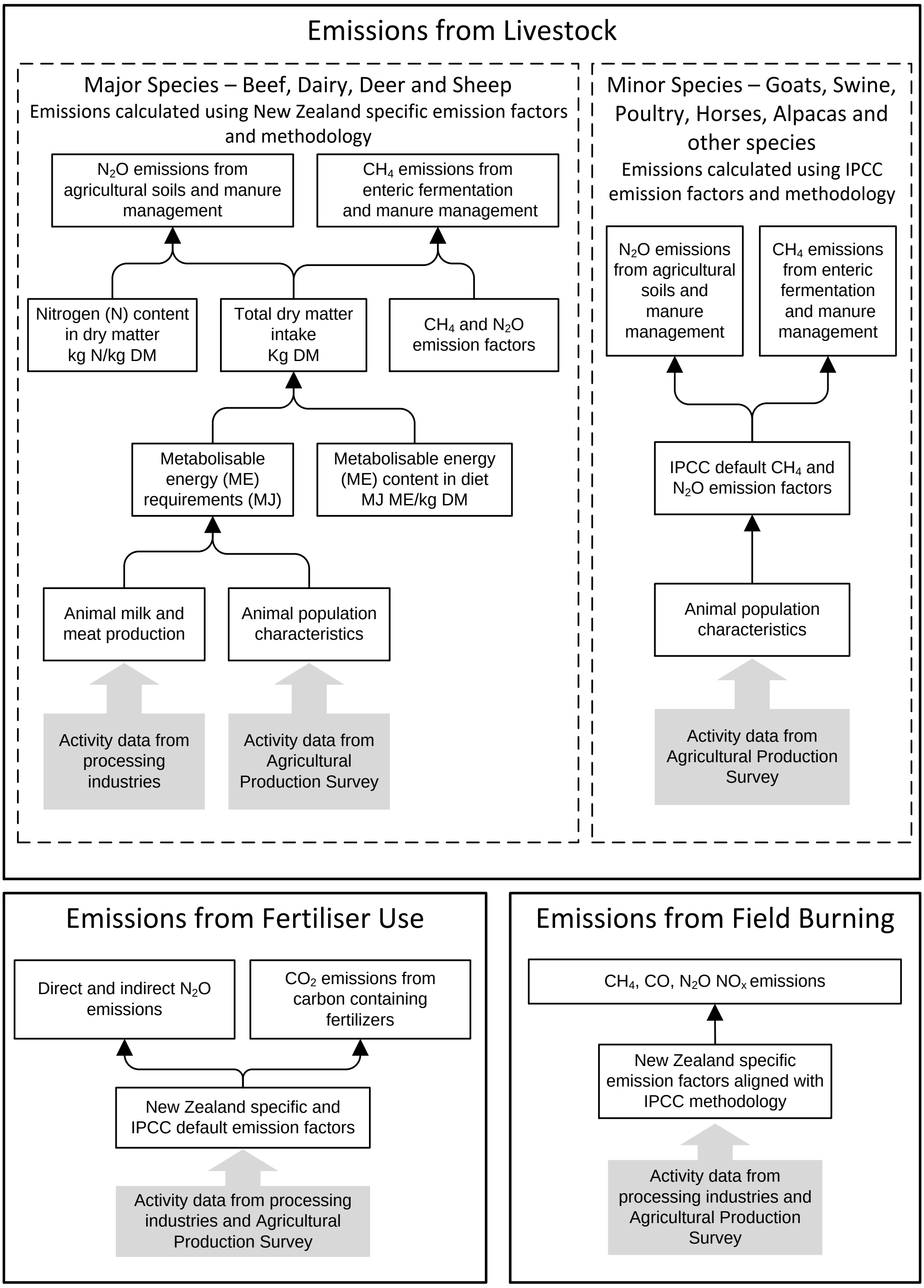
128 Intergovernmental Panel on Climate Change. 2006. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Hayama: Institute for Global Environmental Strategies.

The remaining 0.8 per cent of New Zealand's agriculture emissions is due to organic fertiliser, crop residue returned to the soil, cropland cultivation (histosols and nitrogen mineralisation) and cropland burning. Emissions from crop residues and the burning of agriculture residues are calculated using a Tier 2 method.[129]

Figure 5.7: How New Zealand's agriculture emissions are calculated



[129] Ibid.

New Zealand's methodology for estimating greenhouse gas emissions from the agriculture sector is based on the revised 2006 IPCC guidelines.[130] For a further explanation of the methodology, see New Zealand's 2017 NIR; for full details, see *Detailed Methodologies for Agricultural Greenhouse Gas Emission Calculation*.[131]

5.3.5 Land use, land-use change and forestry

Background

New Zealand's land use, land-use change and forestry (LULUCF)[132] sector is currently a net sink of CO_2. In 2015 LULUCF contributed around -23,783 kt CO_2-e net removals, compared with –30,122 kt CO_2-e in 1990. The main reason for the decline in removals over 1990–2015 is that harvesting of New Zealand's sustainable plantation forests increased, as did deforestation compared with 1990 levels. For a more detailed explanation of the change, see the 2015 NIR (section ES.4).

New Zealand's LULUCF sector is likely to see a continued trend in declining annual removals as extensive plantation forests established in the late 1980s and early 1990s reach maturity and are harvested for timber production. However, given the cyclical emissions and removals profile of plantation forests (absorbing CO_2 during growth and releasing it after harvest), the LULUCF sector is expected to revert to an increasing net carbon sink during the 2030s once the forests harvested in the 2020s are replanted.

Methodology

Projected emissions and removals from the LULUCF sector are calculated using methodologies consistent with those used for the NIR,[133] with activity data and emission factors used in the NIR comprising the historical time series (1990–2015) used in this report. As with projections of emissions for any sector, the LULUCF sector is sensitive to the underlying assumptions used. Uncertainty has been included in the projections through the use of scenarios that represent low, midpoint and upper levels of removals, reflecting estimates of future rates of afforestation, deforestation, harvesting, pre-1990 natural forest sequestration, harvested wood products and carbon prices from 2016–30.

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130 Ibid.

131 Ministry for Primary Industries. 2016. *Detailed Methodologies for Agricultural Greenhouse Gas Emission Calculation*. Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/greenhouse-gas-reporting/agricultural-greenhouse-gas-inventory-reports.

132 The term LULUCF is used to refer to the forestry and other land-use categories of the agriculture, forestry and other land use (AFOLU) chapter of the 2006 IPCC guidelines. 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.

133 Projections of carbon stock changes have been developed for forest land and grassland categories only. In New Zealand's 2017 NIR, the forest land and grassland categories accounted for the vast majority (98 per cent) of net emissions in the sector (table 6.1.1, 2017 NIR).

Projections

The basis for the LULUCF removal scenarios is summarised in the box below.

Assumptions for upper-, midpoint- and lower-removal scenarios for the LULUCF sector

Upper-removal projections assume carbon prices of over NZ$25 per tonne of CO_2-e, and average annual rates of deforestation and afforestation of around 2300 and 14,200 hectares respectively from 2016–30. This scenario assumes extended post-1989 forest rotation ages of around 32 years.

Midpoint-removal projections assume carbon prices of between NZ$12.5 and NZ$25 per tonne of CO_2-e, and average annual rates of deforestation and afforestation of around 4300 and 10,200 hectares respectively from 2016–30. This scenario assumes post-1989 forest rotation ages of around 30 years.

Lower-removal projections assume carbon prices of between NZ$0 and NZ$12.5 per tonne of CO_2-e and average annual rates of deforestation and afforestation of around 7300 and 5400 hectares respectively from 2016–30. This scenario assumes post-1989 forest rotation ages of around 28 years and lower removals from exported harvested wood products.

The main drivers for the change in net LULUCF removals in the forest land and grassland categories are described below.

Pre-1990 natural forests

Activity data and sequestration rates for New Zealand's pre-1990 natural forest from the NIR are used for the historical time series 1990–2015 (see section 6.4.2 of the NIR). Pre-1990 natural forest projections from 2016–30 are based on research completed by Landcare Research.[134] The report findings estimated that the regenerating component of the pre-1990 natural forest estate would continue to sequester an average of 1.39 tonnes of carbon per hectare per year. When applied to the area of New Zealand's regenerating pre-1990 natural forest (around 1.21 million hectares in 2015), this then equates to sequestration rates of around 6100 kt CO_2 per year over the 2016–30 projection period. 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.

Planted forests (pre-1990 planted forest and post-1989 forests)

Historical planted forest activity data and emission factors are sourced from the NIR (see section 11.3.2 of the 2017 NIR). To estimate emissions and removals over 2016–30, planted forest age-class data (sourced from the NIR) are combined with afforestation scenarios from a forest growth simulation model.[135]

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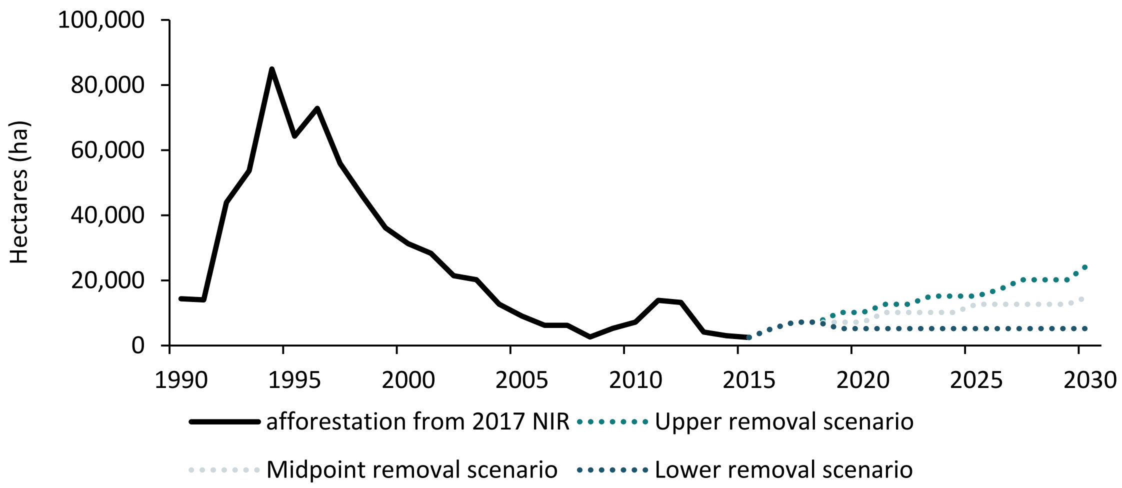
134 R Holdaway, F Carswell, M Kimberley. 2015. *Projections of New Zealand's Natural Forest Estate*, unpublished.

135 The forest growth simulation model tracks the area planted, harvested and deforested through time and generates annual estimates of carbon stock and change by multiplying the area at a given age by the carbon yields per hectare.

Projected afforestation scenarios combine estimated afforestation from New Zealand Government forestry initiatives (see section 4.3.6) with MPI modelling and incorporating recent research.[136] The projected afforestation scenarios factor in a range of drivers, including government forestry initiatives (such as the Afforestation Grant Scheme, Permanent Forest Sink Initiative, Hill Country Erosion Programme and the East Coast Funding Programme), wood product returns, carbon prices, relative land-use economics, land costs and availability.

Figure 5.8 provides historical planted forest and projected afforestation scenarios from 2016. The projected upper- and midpoint-removal afforestation scenarios allow for a gradual increase in afforestation, while the lower-removal scenario assumes that recent levels of afforestation continue.

Figure 5.8: New Zealand's estimated historical afforestation amounts, 1990–2015, and projected afforestation scenarios, 2016–30



Harvesting

Almost all harvesting in New Zealand (99.3 per cent) occurs in planted production forests.[137] Planted forest harvesting area, age and emissions from 1990–2015 are sourced from the NIR. Projections are modelled from historical forest plantings, assume a target rotation length of between 28 and 32 years depending on the scenario, and are tempered by yield constraints. Updated harvesting projections are one of the main improvements implemented since the *Second Biennial Report*. These projections, undertaken by Scion Research,[138] include improved activity data, yields and assumptions.[139]

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136 B Manley. 2016. Afforestation responses to carbon price changes and market certainties. NZ School of Forestry, University of Canterbury. Retrieved from www.mfe.govt.nz/publications/climate-change/afforestation-responses-carbon-price-changes-and-market-certainties.

137 Consistent with the NIR (section 6.4) any harvesting that occurs in natural forests is captured within the natural forest carbon stock and stock change estimates.

138 S Wakelin. 2017. Pre-1990 forest harvest and carbon uptake projections, unpublished.

139 Improvements included: revised pre-1990 planted forest age class; actual and projected levels of afforestation and deforestation; revised yields; and new assumptions on the area of planted forest that is likely to be uneconomical to harvest.

New Zealand's wood supply is expected to increase throughout the 2020s. Because New Zealand had fast-growing production forests and high levels of afforestation in the late 1980s and early 1990s, LULUCF projections become particularly sensitive to production forest harvest age, levels and timing. As such, the three removal scenarios incorporate this sensitivity and attempt to capture variations in production forest harvest levels and timing.

Rotation length (ie, the time from planting, through harvesting to replanting) is also variable and could change due to log market conditions, forest owner objectives and (potentially) in response to the NZ ETS. Land owners with forests planted after 1990 that are registered in the NZ ETS will consider not only log prices and harvesting costs, but also the carbon balance in the forest (eg, whether it is better to continue to accrue units, or to harvest and meet liabilities), and the price of carbon, which could be a significant new factor that comes into harvesting decisions.

Harvested wood products

New Zealand's planted forests are dominated by *Pinus radiata*. This is used in a wide range of applications including timber-frame construction, packaging, plywood, medium-density fibreboard (MDF), posts and poles, and mechanical and chemical pulping. Estimates of net emissions from harvested wood products (HWP) from 1990–2015 are sourced from the NIR. For the methodology used to estimate net removals from HWP over this period, see section 6.10 of the 2017 NIR.

The upper- and midpoint-removal scenarios use the same methodology for domestic and export products as the NIR. This results in export raw materials being converted into the same product mix as domestic production. These export products are then decayed using the same product half-lives as domestically produced HWP, as per the production approach set out in the 2006 IPCC guidelines.[140]

The lower-removal scenario has exported raw materials converted to products and decayed using conversion factors and product half-lives based on recent research.[141] This research has not yet been included in New Zealand's NIR, but is included in the improvement plan for future inventories. The findings would likely result in lower removals from HWP than currently estimated in the NIR.

Deforestation

Historical planted and natural forest deforestation activity data and emission factors are sourced from the NIR.

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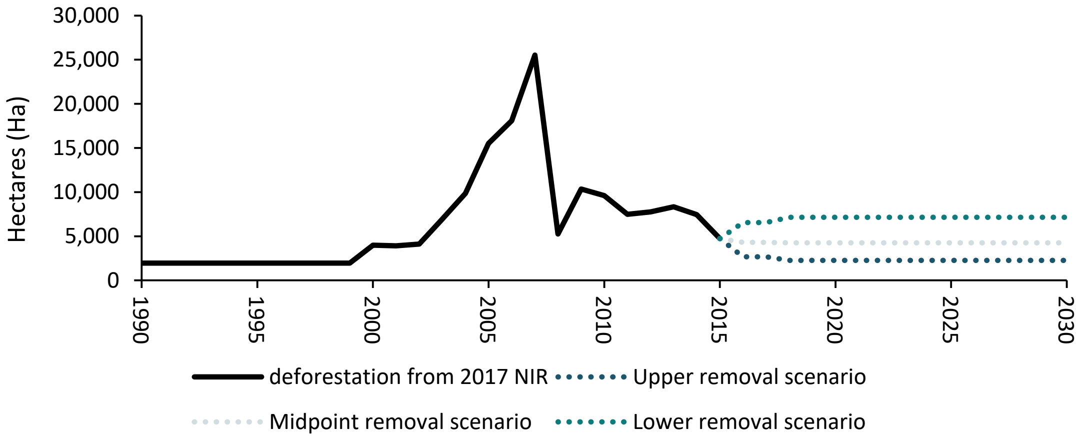
[140] Intergovernmental Panel on Climate Change. 2006. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Hayama: Institute for Global Environmental Strategies.

[141] B Manley, D Evison. 2016. *Material Flow and End-use of Harvested Wood Products Produced from New Zealand Log Exports*. Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/document-vault/13912. This research investigated the end-use and life in service of export logs in New Zealand's three major export markets (China, South Korea and India). They developed an aggregate decay curve based on a range of HWP produced in export markets. This aggregate decay curve has rapid initial decay as short-lived products are discarded from use, combined with a long tail as long-lived products are eventually discarded. Alternatively the research can be described as a weighted average half-life of around 6.6 years for HWP produced from New Zealand export logs, although this does not accurately reflect the decay of these HWP. This compares with the weighted average half-life for domestically produced HWP of just over 20 years.

Projections of planted production forest deforestation are based on annual surveys of planted forest owners' deforestation intentions.[142] With the majority 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 (see table 6.1.6 of the 2017 NIR). The average over the last five years is assumed to be a valid estimate for the projected midpoint-removal scenario, while the lower- and upper-removal scenarios assume a 50 per cent variance to the midpoint, which captures variation in recent years. Figure 5.9 presents total historical and projected deforestation scenarios used in the LULUCF projections.

Figure 5.9: New Zealand's estimated historical deforestation amounts, 1990–2015, and projected deforestation scenarios, 2016–30



Biomass burning emissions

Non-CO_2 emissions from biomass burning from 1990–2015 (based on the NIR) and projections from 2016 are provided in table 5.7. Biomass burning projections are based on historical trends in wildfire and controlled burning, and include non-CO_2 emissions from both forest and grassland. Biomass burning is not a significant source of emissions for New Zealand, because the practice of controlled burning is limited, and wildfires are not common due to New Zealand's temperate climate and vegetation.

Table 5.7: 2015 National Inventory Report (1990–2015) and projected (2016–2030) non-CO_2 LULUCF emissions from biomass burning activities

	Inventory (historical)						Projected			
Gas type	1990	1995	2000	2005	2010	2015	2016	2020	2025	2030
CH_4	3.7	4.5	3.5	5.5	4.4	3.2	3.2	3.2	3.2	3.2
N_2O	0.6	0.7	0.7	0.6	0.5	0.3	0.4	0.4	0.4	0.4
Total (kt CO_2-e)	270.3	308.2	286.6	312.3	259.2	178.5	191.8	187.2	187.4	187.3

Note: Both gases are reported in kilotonnes per year (kt/yr) and the totals are reported in kilotonnes of carbon dioxide equivalent (kt CO_2-e). CH_4 = methane; N_2O = nitrous oxide.

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142 B Manley. 2005–2016. Deforestation Intentions Surveys. Retrieved from www.mpi.govt.nz/news-and-resources/publications.

Analysis

The net LULUCF removals in table 5.8 and figure 5.10 combine activity data and emission factors from the NIR with projections of natural forest, planted forest, afforestation, deforestation, harvesting and harvested wood products from 2016–30. LULUCF projections are very sensitive to future harvest levels of planted production forest. The three projection scenarios of upper, midpoint and lower removals use post-1989 forest target rotation ages of 32, 30 and 28 years respectively to reflect this uncertainty. If forest owners delayed harvest and moved to a longer rotation, the effect would be to increase removals in the short term as the trees grow and sequester more carbon, but thereafter to increase emissions as eventually these trees are harvested for timber in later years.

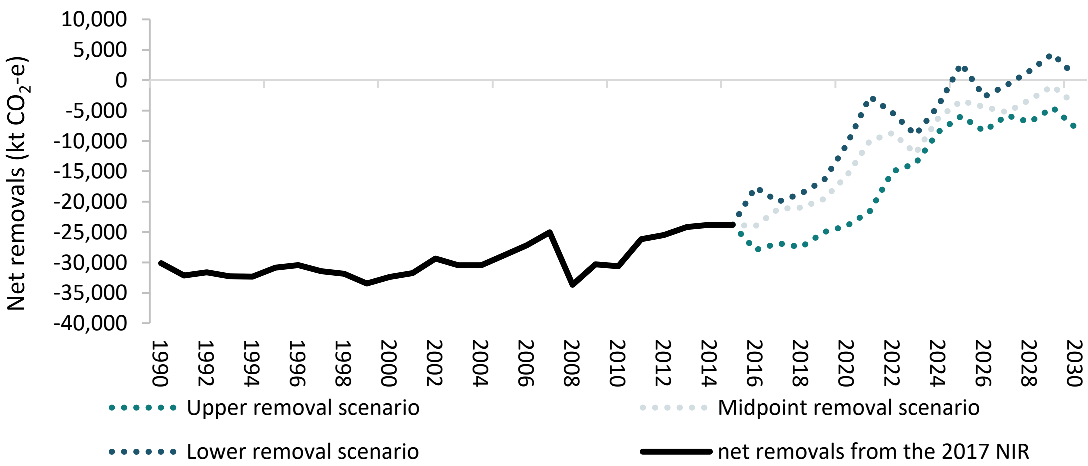
Table 5.8 summarises net removals from 1990–2015 from the NIR and figure 5.10 illustrates these net removals across the same time series. The same table and figure also present projected upper-, midpoint- and lower-removal scenarios from 2016 to 2030.

Table 5.8: Net LULUCF removals from the 2017 NIR, 1990–2015, and projected scenarios, 2016–30

LULUCF: NIR and projected removal scenarios	Net removals (kt CO_2-e)									
	1990	1995	2000	2005	2010	2015	2016	2020	2025	2030
2015 NIR	−30,122	−30,852	−32,368	−28,817	−30,614	−23,783				
Without measures	−30,122	−30,840	−31,945	−27,874	−28,363	−21,321	−19,655	−10,728	1,055	1,350
Upper-removal projection						−23,783	−27,943	−23,959	−5,938	−7,792
Midpoint-removal projection						−23,783	−24,014	−15,694	−3,400	−4,043
Lower-removal projection						−23,783	−17,613	−10,541	2,732	638

Note: Projected scenarios include ‘without measures’ upper, midpoint and lower scenarios of net removals, on a UNFCCC basis. Calculations use UNFCCC reporting methods, not Kyoto Protocol or Paris accounting rules. kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry; NIR = National Inventory Report; UNFCCC = United Nations Framework Convention on Climate Change.

Figure 5.10: New Zealand’s estimated historical net removals, 1990–2015, and projected net removal scenarios, 2016–30



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

5.3.6 Waste

Projections

Table 5.9 and figure 5.11 present actual and projected greenhouse gas emissions from the waste sector. From 2015, emissions from waste are projected to decrease to 3977 kt CO_2-e by 2020 (3 per cent below 1990 levels, or 2 per cent below 2015 levels) and to 3978 kt CO_2-e by 2030 (3 per cent below 1990 levels, or 2 per cent below 2015 levels).

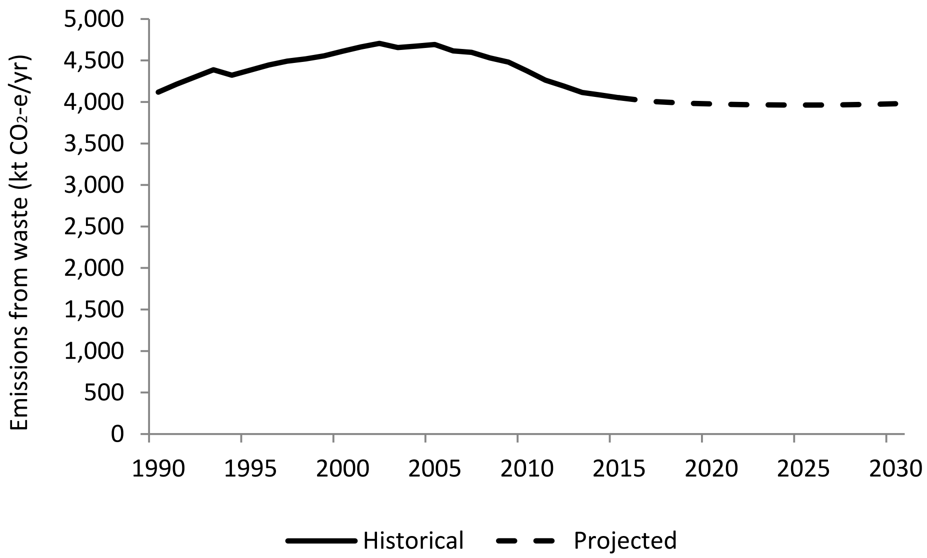
Carbon dioxide emissions from waste remain at steady levels from 2016–30; whereas CH_4 emissions are expected to decrease from 2016–25 but slightly increase out to 2030. Nitrous oxide emissions increase by 2020, but remain at static levels out to 2030. Table 5.9 and figure 5.11 present actual emissions from 1990–2015 and projected emissions from 2016–30.

Table 5.9: Historical and projected greenhouse gas emissions from waste by gas, under a 'with measures' scenario, 1990–2030

	Waste gas emissions (kt)									
	Historical						Projected			
Gas type	1990	1995	2000	2005	2010	2015	2016	2020	2025	2030
CO_2	13	13	12	5	1	1	1	1	1	1
CH_4	160	171	180	183	170	157	156	154	153	153
N_2O*	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5
Total (kt CO_2-e)	4,118	4,385	4,611	4,693	4,375	4,052	4,025	3,977	3,963	3,978

Note: * Due to the small amount of emissions determined in the time series, values are presented to one decimal place. All gases are reported in kilotonnes per year (kt/yr) and the totals are reported in kilotonnes of carbon dioxide equivalent (kt CO_2-e). CH_4 = methane; N_2O = nitrous oxide.

Figure 5.112: Historical and projected gas emissions from waste, 1990–2030



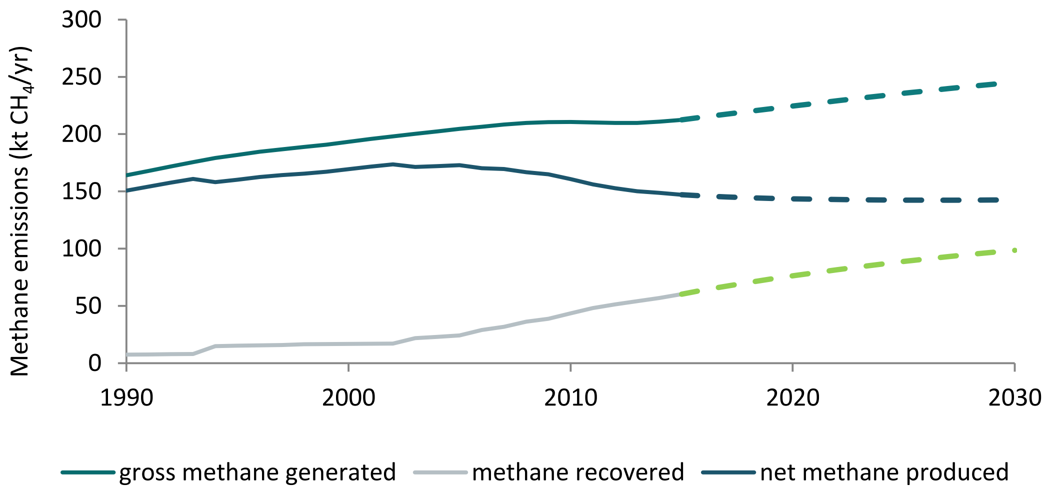
Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

Analysis

The majority of waste emissions are CH_4 emissions resulting from disposal of solid waste to land. Although gross CH_4 emissions from the waste disposed at landfills are expected to steadily increase relative to the increase in population from 2016–30, recovered CH_4 from landfills is also projected to increase out to 2030. This means that net CH_4 emissions produced from solid waste landfill sites are projected to slightly decrease from 2016–30.

Landfills throughout New Zealand have been using CH_4 capture technology and, subsequently, net emissions from landfills have peaked around 2002 (see figure 5.12). Since 2002 a greater proportion of CH_4 from landfills was captured. Methane capture (methane recovery) from landfills is projected to gradually improve out to 2030 as policies, such as the National Environmental Standards for Air Quality, the Waste Minimisation Act 2008 and the NZ ETS, are in place to ensure that the emissions from large landfills continue to be effectively managed.

Figure 5.12: Gross methane generated from landfills, methane recovered from landfills and net methane emissions produced based on historical emissions, 1990–2015, and projected emissions, 2016–30



Note: kt CH_4 = kilotonnes of methane.

Methodology

Solid waste

Forecast solid waste disposal data are used to estimate CH_4 emissions for each projected year. Methane emissions are determined by using the IPCC first-order decay model from solid waste disposal to land[143] and this is consistent with the approach used in the NIR.

Forecast municipal (managed) and non-municipal (unmanaged) solid waste disposal data are determined for each projected year from historical trends in solid waste disposal. Municipal solid waste disposal is proportioned (based on projected historical trends in waste disposal) into solid waste disposed at both managed sites with CH_4 recovery systems and those sites with no such recovery systems. Solid waste disposal data are then determined for each managed solid waste site containing CH_4 recovery systems for each projected year.

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143 Intergovernmental Panel on Climate Change. 2006. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe (eds). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Hayama: Institute for Global Environmental Strategies.

The proportions of CH_4 recovered by landfills that operate CH_4 recovery systems have been determined up to 2015. This is assumed to remain fixed out to 2030.

Domestic wastewaters

Estimated greenhouse gas emissions from domestic wastewaters are forecast based on total national population estimates and regional population growth for each projected year. This method is now consistent with the approach used for estimating domestic wastewater greenhouse gas emissions in the NIR. The biochemical oxygen demand value is selected from the 2017 NIR and is assumed to remain static across the projected time series.

Total national population forecasts are used to estimate total nitrogen in effluent for each projected year. Based on regional population forecasts for each projected year, these are used to estimate the total organic product in wastewaters as well as the proportion of waste in each type of treatment system. This allows for the estimation of both CH_4 and N_2O emissions for each projected year.

Industrial wastewaters

Estimated gas emissions from industrial wastewaters are now forecast based on projections in:

- processed animal numbers (bulls, steers, calves and vealers, cows, heifers, adult sheep, lambs, goats, deer, pigs and poultry)
- dairy milk production
- the production of wine
- the production of wood pulp and paper and paperboard.

This method is now consistent with the approach used for estimating industrial wastewater emissions in the NIR. Forecasts in the above activity data are used to determine the total amounts of organic product and nitrogen in wastewaters. This allows for the estimation of both CH_4 and N_2O emissions for each projected year.

Forecasts of processed animal numbers (bulls, steers, calves and vealers, cows, heifers, adult sheep, lambs, goats, deer, pigs and poultry) and processed dairy milk volumes used in the 'with measures' scenario from the agriculture greenhouse gas model are obtained from the forecasts of activity data produced from the Ministry for Primary Industries' PSRM. They are then modified through the assumed effects of the NPS-FM, as discussed in section 5.3.4.

Wine production estimates for 2016 and 2017 are taken from New Zealand wine reports[144] and then production is forecast to 2021 based on trends in export volumes as projected by the *Situation Outlook for Primary Industries*.[145] It is then assumed that production levels remain static out to 2030. Wine production forecasts are used to determine CH_4 emissions for each projected year, using the same approach as in the NIR. Methane emissions are estimated by determining annual biodegradable chemical oxygen demand loads and then selecting country-

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144 New Zealand Wine. Vineyard reports. Retrieved from www.nzwine.com/en/news-media/statistics-reports/vineyard-reports.

145 Ministry for Primary Industries. 2017. *Situation Outlook for Primary Industries*. Retrieved from www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/situation-and-outlook-for-primary-industries-data.

specific emission factors.[146] The emission factors used are assumed to remain static across the entire projected time series.

Wood pulp and paper, and paperboard forecasts from 2016–30 are obtained from estimated amounts of harvested wood used in projections. Forecasting CH_4 emissions from the production of wood pulp and paper and paperboard for each projected year uses the same approach as the NIR, in which CH_4 emissions are determined from estimating annual biodegradable chemical oxygen demand loads and by using country-specific emission factors for wastewater treatment.[147]

Forecast amounts of processed leather and skins, scoured wool, and wine are held at constant values throughout the projected time series, consistent with the approach taken for the treatment of industrial wastes in the NIR.

Incineration

Incineration of waste comprises a small proportion of total emissions from the waste sector, as the 2017 NIR reports. Emissions from the incineration of wastes are based on the 2015 levels and are assumed to be constant from 2016–30.

5.4 Changes since the *Sixth National Communication* and *Second Biennial Report*

This section covers the differences in modelling parameters and methodologies that have arisen since the 6NC and BR2. Across all sectors, differences in modelling approaches include:

- making improvements or corrections to errors in inventory reporting (for more detail, see the discussion on each sector that follows)
- including gas emissions for 2014 and 2015, as reported in the 2017 NIR submission
- applying the 2006 IPCC guidelines – for more information on these changes, see the 2015 NIR
- using global warming potentials from the IPCC's *Fourth Assessment Report* (AR4).

Tables 5.10 and 5.11 set out the differences in emissions projections for 2020 and 2030 as reported in the BR2 compared with those in this report, the *Seventh National Communication* (7NC). Appendix C.3 (in annex C) lists the differences in emissions projections in the 6NC (reported in both AR2 and AR4 GWPs) compared with current projections from this chapter.

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146 Cardno. 2015. Greenhouse gas emissions from industrial wastewater treatment. Unpublished report commissioned by the Ministry for the Environment.

147 Cardno. 2015. Greenhouse gas emissions from industrial wastewater treatment. Unpublished report commissioned by the Ministry for the Environment.

Table 5.10: Differences in emissions reported in the 7NC and BR2 for the year 2020

Sector	Projected emissions 2020 (kt CO_2-e) 7NC Total (kt CO_2-e)	BR2 Total (kt CO_2-e)	Difference Absolute (kt CO_2-e)	Difference Percentage (%)
Energy	16,418	18,007	–1,588	–8.8
Transport	16,188	13,822	2,365	17.1
IPPU	5,487	5,744	–257	–4.5
Agriculture	37,888	40,418	–2,530	–6.3
LULUCF	–15,694	–24,215	8,521	35.2
Waste	3,976	4,946	–970	–19.6
Total gross emissions (excluding LULUCF)	79,958	82,937	–2,979	–3.6
Total net emissions (including LULUCF)	64,264	58,722	5,542	9.4

Note: BR2 emissions are given using the IPCC's *Fourth Assessment Report* GWPs (as reported in the BR2). 7NC = *Seventh National Communication*; BR2 = *Second Biennial Report*; GWP = global warming potentials; IPCC = Intergovernmental Panel on Climate Change; IPPU = industrial processes and product use; kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

Table 5.11: Differences in emissions reported in the 7NC and BR2 for the year 2030

Sector	Projected emissions 2030 (kt CO_2-e) 7NC Total (kt CO_2-e)	BR2 Total (kt CO_2-e)	Difference Absolute (kt CO_2-e)	Difference Percentage (%)
Energy	14,324	18,115	–3,791	–20.9
Transport	15,014	13,996	1,018	7.3
IPPU	6,185	6,600	–414	–6.3
Agriculture	37,737	42,036	–4,299	–10.2
LULUCF	–4,043	–11,433	7,391	64.6
Waste	3,978	5,281	–1,302	–24.7
Total gross emissions (excluding LULUCF)	77,239	86,028	–8,789	–10.2
Total net emissions (including LULUCF)	73,196	74,594	–1,398	–1.9

Note: BR2 emissions are given using the IPCC's *Fourth Assessment Report* GWPs (as reported in the BR2). 7NC = *Seventh National Communication*; BR2 = *Second Biennial Report*; GWP = global warming potentials; IPCC = Intergovernmental Panel on Climate Change; IPPU = industrial processes and product use; kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

5.4.1 Energy

Expected stationary fuel demand growth and emissions intensity of energy use is lower in the 7NC than in the BR2. Energy projections have been based on the EDGS 2016 whereas the energy projections produced for the *Second Biennial Report* were based upon the draft EDGS 2015.[148] Between these two versions a number of changes were made, and projected 2030

[148] For further information see: www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/modelling/electricity-demand-and-generation-scenarios/draft-edgs-2015.

emissions reduced from 32,111 kt CO_2-e in the draft EDGS to 30,392 kt CO_2-e in the final EDGS. This accounts for most of the difference with the *Second Biennial Report* projections for 2030. Specific changes between EDGS include reductions of 850 kt CO_2-e from gas-fired electricity generation, 672 kt CO_2-e due to reduced methanol production, and 493 kt CO_2-e due to reduced coal usage for manufacturing.

Energy projections are based on historic fuel demand data to 2015. The reported fuel demand in 2015, particularly for industrial and primary sector fossil fuel use, is in most cases lower than the forecast used in the *Second Biennial Report* modelling for 2015. This means the latest industrial fuel demand forecasting builds from a lower starting point and results in lower demand and emissions, particularly in the short term. For example our aggregated industrial and primary fossil fuel demand is 5 PJ lower in the 2015 data than was previously forecast.

Projections out to 2030 also show further reductions in emissions for the primary and manufacturing sectors compared to the EDGS 2016. This is partly due to reduced energy use combined with fuel switching to less carbon-intensive fuels. Fuel switching occurs due to the dynamic interplay between supply and demand and their impact on the relative prices of fuels. A key driver is the price of natural gas, which also strongly influences the price of electricity. Due to a relative increase in the price of natural gas, the model results for the later years show a reduction in demand from industry and the primary sectors for natural gas and electricity, which are offset by increases in demand for solid fuels, geothermal and wood.

In addition, there have been improvements in emission factors and activity data since the 6NC and BR2, along with a shift to the 2006 IPCC guidelines. The combination of these changes has had an impact on both historical estimates and projections. The most significant difference was the change in oxidation factors, which has resulted in an increase in historical emissions figures. For further details, see chapter 10 of the 2015 NIR.

5.4.2 Transport

The transport sector also incorporates the improvements that were made to the energy projections outlined above. Road transport projections were based on the latest road transport statistics available at the time. Historical road transport demand for petrol and diesel increased significantly between 2014 and 2015. Forecasts of petrol and diesel for road transport are based on the historical data and are higher in the short term in the 7NC modelling than in the 2BR scenario modelling. However, demand in the longer-term forecasts of petrol and diesel for road transport decline from 2022 due to uptake of electric vehicles. By the mid-2030s, modelling indicates a lower liquid fossil fuel demand for transport than has previously been forecast.

5.4.3 Industrial processes and product use

In line with 2006 IPCC guidelines, the solvents sector has been merged into the IPPU sector since the 6NC. The CO_2 component of IPPU incorporates the same changes as the energy sector. Since the BR2, CH_4 emissions have been based on the maximum value across the historical time series from the 2017 NIR and then these gas emissions are phased down out to 2030, consistent with how CO_2 emissions are phased down in the projections. The latest activity data have been included, and all the above noted changes have led to a slight decrease in projected emissions since the BR2 (see tables 5.10 and 5.11).

The CO_2 component of IPPU incorporates the same changes as the energy sector.

5.4.4 Agriculture

The differences between the projected emissions and removals in the 7NC and 6NC for the agriculture sector are due to improvements in methodologies, emission factors and projections of future agricultural activity. In addition, the new 'with measures' forecasts now incorporate the effects of implementing the NPS-FM, and the effects of forestry policies and schemes on agricultural land use. Some of the more significant changes are summarised below. For more detailed explanations on methodological and emission factor changes, see New Zealand's NIRs from 2014–17.

Changes in methodologies and emission factors

The following changes to New Zealand's agriculture inventory were implemented after the publication of the 6NC, but before the publication of the 2BR:

- the inclusion of a new equation for partitioning nitrogen in excreta between dung and urine from dairy, beef, sheep and deer
- improvement of the parameters for calculating nitrogen retention in milk from beef cattle and deer velvet.

The three changes to New Zealand's agriculture inventory described below were implemented after the publication of the 2BR:

- a correction to the methodology used to calculate the amount of nitrogen retained in wool from sheep
- adoption of new country-specific N_2O emission factors for urea fertiliser and dairy cattle manure applied to soils (farm dairy effluent)
- the implementation of new equations for calculating enteric CH_4 emissions from sheep.

Projections of future agricultural activity

The 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. Recent projections from this model have a much flatter trend 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, it is now projected that dairy cattle populations will plateau in the late 2020s due to constraints on land availability and the introduction of water quality objectives.[149] Sheep populations will continue to decline while beef populations will remain similar to 2015 levels, as section 5.3.4 has outlined.

Effect of policy measures

Previous projections of agricultural emissions did not analyse the potential effect of policy measures on emissions. The 'with measures' modelled scenario now incorporates the anticipated effects of the NPS-FM. It is expected that this measure will reduce animal numbers and overall production.

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149 Ministry for Primary Industries. 2017. *Situation Outlook for Primary Industries*. Retrieved from www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/situation-and-outlook-for-primary-industries-data.

The new projections also account for the expected indirect effects of the Government's schemes and policies (such as the Afforestation Grant Scheme, Hill Country Erosion Programme and the NZ ETS) that encourage the use of potential agricultural land for forestry. In line with the conclusion of the 2015–2017 NZ ETS review, the projections do *not* assume that surrender obligations will be imposed on agricultural emissions in the NZ ETS.

5.4.5 Land use, land-use change and forestry

The differences between the *Second Biennial Report* and the *Seventh National Communication* LULUCF projections are due to a combination of continued improvements in the NIR and new research into projected forest management activities; such as rates of afforestation, deforestation and harvest.

In summary, the main contributing factors are:

- revised inventory data from 1990–2015, with revised afforestation, deforestation and harvested area data and improved forest carbon stock yield tables, as detailed in New Zealand's 2016 and 2017 NIRs
- updated estimated actual afforestation, deforestation and harvesting areas in 2016 and 2017, and updated projections from 2018–30 based on the latest research findings and surveys
- including sensitivity in carbon uptake in the lower- and upper-removal scenarios for regenerating areas of pre-1990 natural forests, based on research completed in 2015
- updated methods and assumptions for harvested wood products to ensure consistency with the 2015 NIR. New research findings on New Zealand's wood export product mix and half-lives[150] are included in the lower-removal scenario only (given this research has not yet been included in the NIR)
- updated planted forest harvesting projections from 2016–30,[151] which include:
  - revised estimated actual afforestation, deforestation and harvesting activity data to be consistent with the 2015 NIR
  - revised projections of afforestation and deforestation to be consistent with recent research/survey findings
  - research undertaken by Scion Research that estimates a small portion of the production planted forest estate area is likely to be uneconomical to harvest in the future[152]
  - revised yields and age-class distributions for pre-1990 planted forests.

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150 B Manley, D Evison. 2016. *Material Flow and End-use of Harvested Wood Products Produced from New Zealand Log Exports*. Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/document-vault/13912.

151 S Wakelin. 2017. Pre-1990 forest harvest and carbon uptake projections.

152 B Hock, D Harrison, R Yao. 2016. Predicting harvesting and deforestation of radiata pine forest blocks using national spatial datasets. Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/document-vault/13903.

5.4.6 Waste

A number of amendments (including corrections in errors) have been made in estimating the activity data used for calculating projected greenhouse gas emissions from the waste sector since the 6NC and the BR2. Since the 6NC, these amendments include:

- including non-municipal landfills and on-site farm fills,[153] which have approximately doubled waste emissions since the 6NC (see table 4.6 from BR2)
- incorporating waste placement data, collected under the Waste Minimisation Act 2008 and the NZ ETS, into historical and projected emissions (as reported in the BR2).

Since the BR2, additional amendments include the following:

- Forecasted solid waste disposal amounts are now based on projected historical trends in solid waste disposal, which has decreased waste emissions by approximately 19 per cent in both 2015 and 2020 and 25 per cent in 2030 (see tables 5.12). This includes disposal data from non-municipal landfill and on-site farm fills. These changes have increased waste emissions by 1 per cent in 2020 and have decreased waste emissions by 1 per cent in 2030 (see table 5.12).
- Forecasted regional population growth and forecasted total national population are now used in projecting domestic wastewater greenhouse gas emissions. This change has resulted in an increase in waste emissions by 43 per cent to 264 kt CO_2-e in 2016, 43 per cent to 281 kt CO_2-e in 2020 and 47 per cent to 314 kt CO_2-e in 2030 (see table 5.12).
- Emission factors, source data and methods for estimating emissions have been updated from the treatment and discharge of industrial wastewater emissions used since the 2016 NIR.[154]
- For industrial wastewater projections, processed animal numbers and milk processing forecasts used in greenhouse gas projections from the agriculture sector are now used as input data. Projected pulp and paper and paperboard outputs from forestry projections are now used in wastewater projections. Wastewater emissions from wine production are determined through a combination of updated activity data,[155] using export trends out to 2021 from the *Situation Outlook for Primary Industries*[156] and then assuming production levels remain static out to 2030. These changes have decreased waste emissions by approximately 48 per cent to 108 kt CO_2-e in 2015, 52 per cent to 103 kt CO_2-e in 2020 and 56 per cent in 2030 (see table 5.12)
- For 2015, the value for CH_4 emissions produced from solid waste disposal was extrapolated from the historical time-series in the 2017 NIR. This inconsistency was explained during the 2017 NIR review. In this projections chapter, the 2015 value from solid waste disposal emissions was corrected and included in the historical time series.

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[153] For further details, see section 1.11 of New Zealand's 2014 NIR and section 1.10 of New Zealand's 2015 NIR.

[154] www.mfe.govt.nz/publications/climate-change/new-zealand-greenhouse-gas-inventory-1990-2014

[155] New Zealand Wine. Vineyard reports. Retrieved from www.nzwine.com/en/news-media/statistics-reports/vineyard-reports.

[156] Ministry for Primary Industries. 2017. *Situation Outlook for Primary Industries*. Retrieved from www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/situation-and-outlook-for-primary-industries-data.

Emissions projections from both the 6NC and the BR2 for solid waste disposal were estimated from forecast national population growth. Emissions calculations assumed fixed values of solid waste disposal per person and both CH_4 emissions and CH_4 recovery rates as determined from the latest NIR.

Emissions projections from both the 6NC and the BR2 for domestic and industrial wastewaters were previously based on projecting historical trends in emissions from each category.

Since the BR2, the differences in total projected waste emissions from the current projections (7NC) are –955 kt CO_2-e (–19 per cent) for 2015, –972 kt CO_2-e (–20 per cent) for 2020 and –1,279 kt CO_2-e (–25 per cent) for 2030, as summarised in table 5.12. The differences in total projected waste emissions between the current projections (7NC) and those from the 6NC are summarised in appendix C.3 (annex C).

Table 5.12: Absolute and percentage differences between current estimates of waste emissions and those from the *Second Biennial Report*, 2015, 2020 and 2030

Waste sector category (comparing 7NC relative to BR2)	Year and estimated difference (diff; kt CO_2-e) and percentage (%) difference in reported emissions											
	2015				2020				2030			
	BR2	7NC	diff	%	BR2	7NC	diff	%	BR2	7NC	diff	%
Total	5,006	4,052	955	–19	4,946	3,974	–972	–20	5,281	3,984	–1,297	–25
Solid waste disposal	4,535	3,677	–858	–19	4,451	3,588	–863	–19	4,744	3,564	–1,180	–25
Non-municipal and farm fills	2,509	2,509	0	0	2,497	2,520	23	1	2,626	2,606	–20	–1
Domestic wastewater treatment	185	264	79	43	196	281	85	43	214	314	101	47
Industrial wastewater treatment	208	109	–99	–48	217	105	–112	–52	235	105	–131	–56

Note: 7NC = *Seventh National Communication*; BR2 = *Second Biennial Report*; diff = estimated difference; kt CO_2-e = kilotonnes of carbon dioxide equivalent.

5.5 Total effect of policies and measures

Although a range of policies and measures affects greenhouse gas emissions, not all of their impacts can be accurately measured or modelled. Table 5.13 shows which measures are included in the 'with measures' and 'without measures' projection scenarios (see chapter 4 for more details). It is difficult to model the emissions response to policies and measures, particularly as there are insufficient data to accurately project how sectors will respond to the policies and measures noted; for this reason, this limitation should be considered when reading this section.

Total 'with measures' and 'without measures' projections are compared in table 5.13. As the 'with measures' scenario includes only key quantifiable policies, the difference between the 'with measures' scenario and the 'without measures' scenario does not demonstrate the full impact of the Government's policies and measures. Please refer to the subsection for each sector that follows for more information on policies and measures.

Table 5.13: Policies and measures included in the 'with measures' and 'without measures' projections

Sector	Policy or measure	Timeframe implemented*	With measures	Without measures
Energy	EECA Efficient Products Programme	2002	Yes	No
	EECA ENERGYWISE™ homes	2009–18	Yes	No
	NZ ETS	2010	Yes	No
	EECA Business Programmes	2012	Yes	No
Transport	Vehicle fuel economy labelling	2008	Yes	No
	NZ ETS	2010	Yes	No
	Electric Vehicles Programme	NE	Yes	Yes
IPPU	NZ ETS	NE	Yes	Yes
Agriculture	National Policy Statement for Freshwater Management	2016	Yes	No
	Indirect effects of combined forestry land-use policies on agricultural land use (see LULUCF below)	2016	Yes	No
LULUCF	Erosion Control Funding Programme	1992	Yes	No
	NZ ETS	2008	Yes	No
	Afforestation Grant Scheme	2008	Yes	No
	Hill Country Erosion Programme	2008	Yes	No
	Permanent Forest Sink Initiative	2008	Yes	No
Waste	National Environmental Standards for Air Quality	2005	Yes	No
	waste disposal levy	2009	Yes	No
	NZ ETS	NE	Yes	Yes

Note: * This represents the starting year that the listed policy or measure was included and when it has been ended in the projections modelling, if applicable. It is not the specific year that the policy was implemented. EECA = Energy Efficiency and Conservation Authority; IPPU = Industrial processes and product use; LULUCF = land use, land-use change and forestry; NE = not estimated (the policy or measure was not modelled in either the 'with measures' or 'without measures' scenario); NZ ETS = New Zealand Emissions Trading Scheme.

As at July 2017, the total effects of implemented policies and measures on New Zealand's gross emissions (excluding LULUCF) from the 'without measures' scenario are projected to be:

- 81,682 kt CO_2-e in 2020 (an absolute difference of 1724 kt CO_2-e or 2.2 per cent greater than the 'with measures' scenario)
- 81,792 kt CO_2-e in 2030 (an absolute difference of 4554 kt CO_2-e or 5.9 per cent greater than the 'with measures' scenario).

Total net emissions (ie, including LULUCF emissions and removals) from the 'without measures' scenario are projected to be:

- 70,954 kt CO_2-e in 2020 (an absolute difference of 6690 kt CO_2-e or 10.4 per cent greater than the 'with measures' scenario)
- 83,142 kt CO_2-e in 2030 (an absolute difference of 9946 kt CO_2-e or 13.6 per cent greater than the 'with measures' scenario).

Table 5.14 summarises the emissions and removals from the 'without measures' scenario for each sector and for each gas.

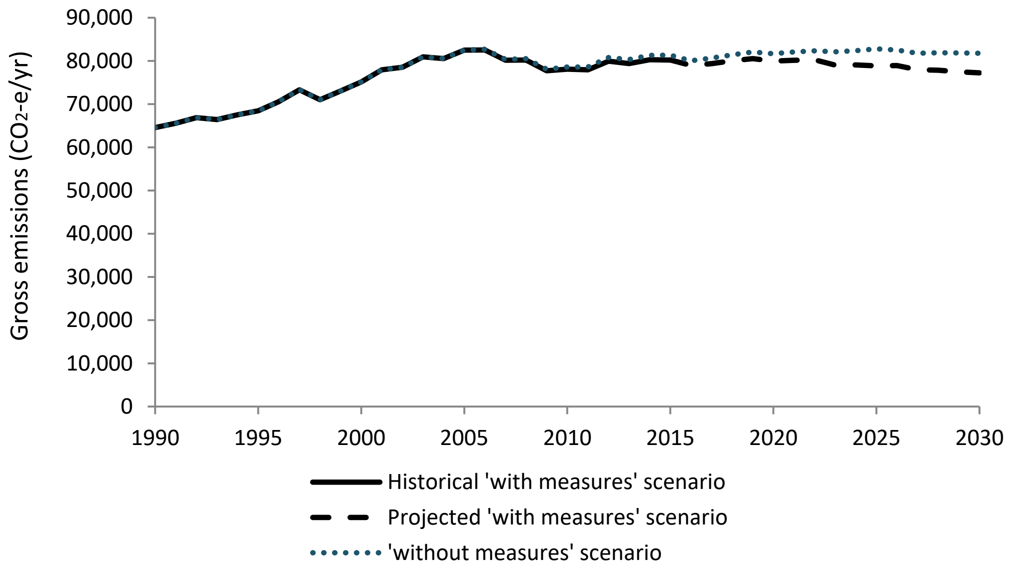
Table 5.14: New Zealand's historical and projected 'without measures' scenario emissions and removals by sector and gas, 1990–2030

	Emissions and removals (kt CO_2-e)									
	1990	1995	2000	2005	2010	2015	2016	2020	2025	2030
Category	Historical							Projected		
Sector										
Energy	14,984	14,911	17,579	20,689	18,202	18,267	16,693	16,950	16,790	15,925
Transportation	8,765	10,959	12,423	13,902	14,153	14,765	15,602	16,290	16,230	15,137
IPPU	3,584	3,209	3,462	4,113	4,655	5,280	5,187	5,487	5,843	6,185
Agriculture	33,123	34,984	37,067	39,115	36,862	38,420	37,958	38,242	39,084	39,561
LULUCF	–30,122	–30,840	–31,945	–27,874	–28,363	–21,321	–19,655	–10,728	1,055	1,350
Waste	4,118	4,385	4,611	4,714	4,709	4,589	4,612	4,714	4,851	4,984
Gas										
CO_2 emissions including net CO_2 from LULUCF	–4,964	–2,997	127	9,471	6,551	14,953	15,321	25,129	36,694	35,035
CO_2 emissions excluding net CO_2 from LULUCF	25,429	28,152	32,359	37,659	35,176	36,455	35,168	36,044	35,826	33,873
CH_4 emissions including CH_4 from LULUCF	32,615	33,709	35,384	36,030	34,502	34,890	34,876	35,293	36,038	36,483
CH_4 emissions excluding CH_4 from LULUCF	32,522	33,597	35,297	35,891	34,392	34,811	34,797	35,214	35,959	36,403
N_2O emissions including N_2O from LULUCF	5,870	6,664	7,354	8,324	7,935	8,557	8,545	8,571	8,776	8,892
N_2O emissions excluding N_2O from LULUCF	5,693	6,467	7,153	8,149	7,784	8,455	8,432	8,463	8,668	8,784
HFCs	0	58	246	738	1,159	1,524	1,601	1,915	2,306	2,697
PFCs	910	150	68	69	47	59	33	24	17	12
SF_6	20	24	20	26	24	18	23	23	23	23
Total with LULUCF	34,451	37,608	43,198	54,658	50,218	60,000	60,399	70,954	83,852	83,142
Total without LULUCF	64,574	68,448	75,143	82,533	78,582	81,321	80,054	81,682	82,798	81,792

Note: CH_4 = methane; CO_2 = carbon dioxide; HFCs = hydrofluorocarbons; IPPU = Industrial processes and product use; kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry; N_2O = nitrous oxide; PFCs = perfluorocarbons; SF_6 = sulphur hexafluoride.

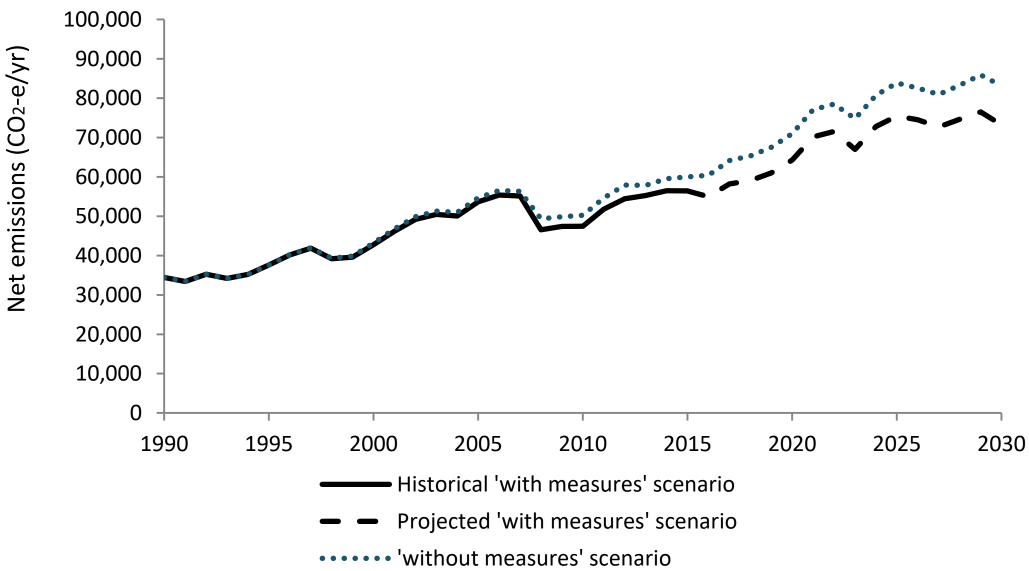
Figures 5.13 and 5.14 illustrate the differences between the 'with measures' and 'without measures' scenarios in terms of gross and net emissions respectively.

Figure 5.13: New Zealand's historical and projected 'with measures' and 'without measures' scenarios for gross emissions (kt CO_2-e), 1990–2030



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

Figure 5.14: New Zealand's historical and projected 'with measures' and 'without measures' scenarios for net emissions (kt CO_2-e), 1990–2030



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

In total, the impact of New Zealand's policies and measures were estimated to reduce gross emissions by 6.2 Mt CO_2-e between 1990 and 2015 and by 41.8 Mt CO_2-e from 2016–30. The impact of New Zealand's policies and measures reduced net emissions by 31.0 Mt CO_2-e between 1990 and 2015 and by 113.2 Mt CO_2-e from 2016–30. Policies and measures (historical and projected) for each sector are discussed further in the following subsections.

5.5.1 Energy

Table 5.15 sets out the estimated actual and projected impact of the Government's various policies on energy emissions.

Most of this estimated mitigation is achieved through fuel switching, as the development and uptake of low-emissions technologies are difficult to predict and include in projections. Demand from the energy sector is inelastic to fuel and carbon prices, partly because viable substitutions are lacking currently.

The 'without measures' scenario also excludes the modelled historical effect of the NZ ETS. Current modelling capability is insufficient to accurately capture the historical impacts on fuel demand and fuel switching and the economy-wide changes that have occurred due to the carbon price signal. Our short-term focus will be on improving that capability to understand how best to transition to a low-carbon economy.

Table 5.15: Estimated historical (up to 2015) and projected (2016–30) impact of the New Zealand Government's policies and measures on energy emissions (kt CO_2-e)

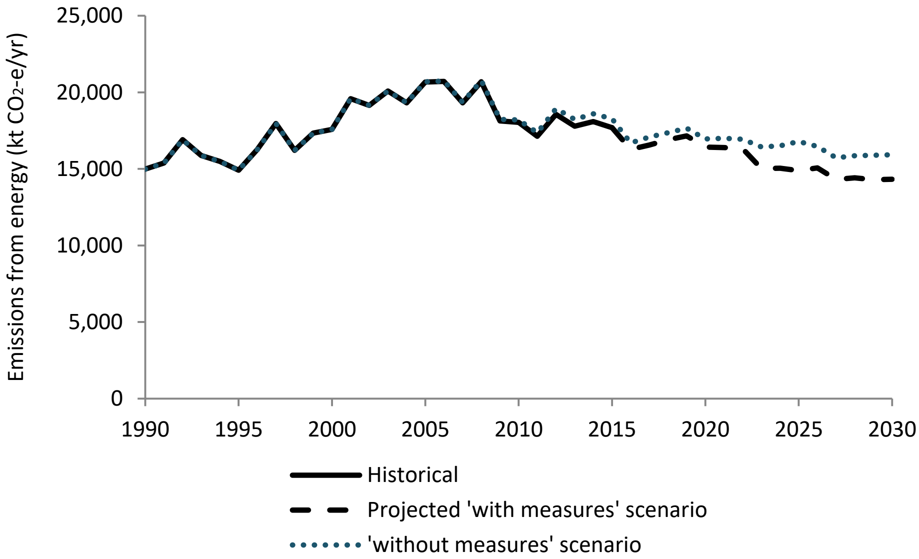
Policy or measure in the energy sector	Cumulative historical emissions up to 2015 Absolute (kt CO_2-e)	Cumulative projected emissions, 2016–30 Absolute (kt CO_2-e)	Total (kt CO_2-e)
EECA Efficient Products Programme	997	4,445	5,442
EECA ENERGYWISE™ homes	1,178	4,058	5,236
EECA Business Programmes	422	1,764	2,186
NZ ETS	NE	5,627	5,627
Total (kt CO_2-e)	2,597	15,895	18,492

Note: EECA = Energy Efficiency and Conservation Authority; IPPU = Industrial processes and product use; kt CO_2-e = kilotonnes of carbon dioxide equivalent; NE = period when policy or measure from the energy sector was not estimated; NZ ETS = New Zealand Emissions Trading Scheme.

It is estimated that policies and measures have reduced emissions in the energy sector by a cumulative total of 2597 kt CO_2-e up to 2015. Thereafter policies and measures are estimated to reduce emissions by cumulative total of 15,895 kt CO_2-e from 2016–30.

Projected emissions under the 'without measures' scenario are estimated to be 531 kt CO_2-e (3 per cent) greater than projected emissions under the 'with measures' scenario in 2020, and 1601 kt CO_2-e (11 per cent) greater than projected emissions under the 'with measures' scenario in 2030. Figure 5.15 illustrates the differences between the 'with measures' and 'without measures' scenarios.

Figure 5.15: Estimated historical energy emission, 1990–2015, and the projected 'with measures' and 'without measures' scenarios, 2016–30 (kt CO_2-e)



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

5.5.2 Transport

The estimated actual and projected impact of the Government's various policies on transport emissions is provided in table 5.16.

Demand from the transport sector is inelastic to fuel and carbon prices, partly due to the current lack of viable substitutes. The models assume significant uptake of biofuels in the transport sector only occurs with an effective carbon price greater than NZ$25.

Fuel Efficient Tyres programme

Previous estimates of carbon savings from the Fuel Efficient Tyres programme were based on an expected increase in the market share of fuel-efficient tyres. Tyre sales data provided by distributors as part of the programme indicated there had been no statistically significant change in the market share over the two years that the programme ran (2014–16). Based on the lack of evidence of an increase in the sale of fuel-efficient tyres, particularly regarding cost-effectiveness and likelihood of success, the programme has been discontinued, and there are no reportable historical or future carbon savings from this measure.

Heavy Vehicle Fuel Efficiency programme

Previous estimates of the carbon savings from the Heavy Vehicle Fuel Efficiency programme were based on seeing a measurable improvement in the fuel efficiency of heavy freight operators. Assumptions used in the analysis of carbon savings were derived from international programmes using similar interventions. Data provided to EECA as part of the programme indicated that while there had been improvements in the fuel-efficiency performance of some fleets, confounding variables meant it was not possible to reliably estimate savings from the programme overall. Based on the findings of a review, this programme has been discontinued, and there are no reportable historical or future carbon savings from this measure.

NZ ETS

As with the energy sector, the ‘without measures’ scenario in the transport sector excludes the modelled historical effect of the NZ ETS. Additionally, the ‘without measures’ scenario excludes the modelled effect of the Electric Vehicles Programme.

Electric Vehicles Programme

The uptake of electric vehicles is expected to contribute to the reduction in transport emissions. In May 2016 the Government announced a range of measures to increase this uptake and set the target of doubling the number of electric vehicles in the fleet to reach approximately 64,000 vehicles by the end of 2021. Uptake to date has been growing strongly, and interim targets of 2000 electric vehicles by the end of 2016 and 4000 electric vehicles by the end of 2017 have been exceeded.

Electric vehicle uptake is estimated to reduce greenhouse gas emissions in 2030 by between 739 kt CO_2-e (slow-uptake scenario) and 2056 kt CO_2-e (fast-uptake scenario), with a reduction of 1772 kt CO_2-e under a base case scenario. However, it is difficult to accurately determine what proportion of this projected uptake is due to the measures put in place by the Government to encourage electric vehicle uptake, and what proportion will occur anyway as a result of factors like the greater availability and reduced price of electric vehicles and increasing consumer awareness of their reduced running costs and environmental impacts. Work to attempt to isolate these influences is ongoing.

Table 5.16: Estimated historical (up to 2015) and projected (2016–30) impact of New Zealand Government’s policies and measures on transport emissions (kt CO_2-e)

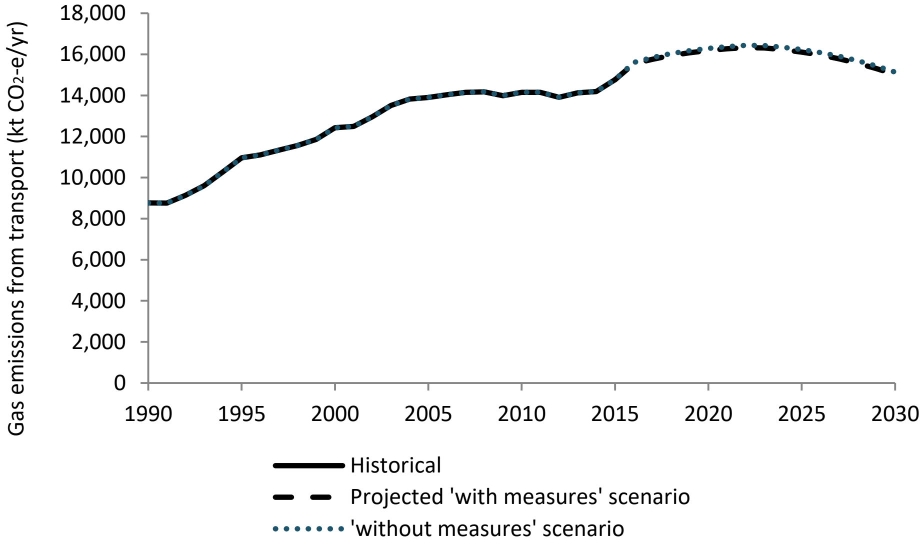
Policy or measure in the transport sector	Cumulative historical emissions up to 2015 Absolute (kt CO_2-e)	Cumulative projected emissions 2016–30 Absolute (kt CO_2-e)	Total (kt CO_2-e)
NZ ETS	NE	1,007	1,007
Vehicle fuel economy labelling	26	615	641
Electric Vehicles Programme	NO	NE	NE
Total (kt CO_2-e)	26	1,622	1,648

Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent; NE = period when policy or measure was not estimated; NO = period when policy or measure was not in effect or not occurring; NZ ETS = New Zealand Emissions Trading Scheme.

It is estimated that policies and measures have reduced emissions in the transport sector by a cumulative total of 26 kt CO_2-e up to 2015. Policies and measures are estimated to reduce emissions by a cumulative total of 1005 kt CO_2-e from 2016–30.

Projected emissions under the ‘without measures’ scenario are estimated to be 102 kt CO_2-e (0.6 per cent) greater than projected emissions under the ‘with measures’ scenario in 2020 and 123 kt CO_2-e (0.8 per cent) greater than projected emissions under the ‘with measures’ scenario in 2030. Figure 5.16 illustrates the differences between the ‘with measures’ and ‘without measures’ scenarios.

Figure 5.16: **Estimated historical transport emissions, 1990–2015, and projected 'with measures' and 'without measures' scenarios, 2016–30 (kt CO_2-e)**



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

5.5.3 Industrial processes and product use

Estimates of the effect of policies and measures on IPPU emissions are not made as there is insufficient information to accurately quantify these.

5.5.4 Agriculture

It has been assumed that New Zealand's future agricultural emissions will be affected by:

- government schemes and policies designed to incentivise the use of land for forestry
- the implementation of the National Policy Statement for Freshwater Management
- the ongoing improvements in emissions intensity and farm management efficiency, which are in part supported by a range of Government measures.

The 'with measures' projection includes the expected effect of the first two measures above, while the 'without measures' projection excludes the expected effect of the first two measures. The third component – ongoing efficiency improvements – cannot currently be quantified and is therefore included within the 'without measures' and the 'with measures' projections.

In 2030 the projected emissions for the 'without measures' scenario are estimated to be 1824 kt CO_2-e (4.8 per cent) greater than projected emissions for the 'with measures' scenario. The modelling assumed that the effects of the measures are independent, although there is likely to be a small amount of interaction between them.

Incentivising land-use conversions to forestry

A number of measures incentivise the conversion of land to forestry, some of which will be at the expense of pastoral agriculture. This will result in lower agricultural emissions. The various schemes are described in more detail in section 5.5.5. Their expected effect on future land use in dairy, sheep, beef and forested land is shown in table 5.17.

Table 5.17: Land-use scenario assumptions used in the projections of agricultural emissions from the 'with measures' and 'without measures' scenarios

Year	Absolute land-use areas (hectares)			
	Dairy	Sheep and beef	Forestry	Other
1990	1,023,545	12,054,139	1,261,000	3,150,714
2005	1,398,966	9,825,432	1,811,000	2,270,445
2015	1,751,704	8,415,447	1,717,715	2,044,509
Scenario assumptions at 2030				
With measures	1,952,722	7,554,127	1,834,418	1,862,508
Without measures	2,036,917	7,602,692	1,726,618	1,838,804
'Without measures' scenario compared with the 'with measures' scenario at 2030				
Percentage difference (%)	4.3	0.6	–5.9	–1.3

National Policy Statement for Freshwater Management

It is expected that the implementation of the NPS-FM will result in lower agricultural emissions, which is assumed to occur linearly from 2016. Findings from an analysis by Motu Economic and Public Policy Research[157] were used to help model the expected effect of the NPS-FM on forecast agricultural activity and emissions. Relative to the situation where the NPS-FM was not in place, the 'with measures' projection assumed that the:

- dairy cattle population will be 2 per cent lower (compared with the situation in which there is no NPS-FM) by 2030
- beef cattle population will be 3 per cent lower by 2030
- sheep population will be 3 per cent lower by 2030
- deer population will be 3 per cent lower by 2030
- use of synthetic nitrogen fertiliser will be 5 per cent lower by 2030.

The estimated actual and projected impact of the Government's various policies on agriculture emissions is provided in table 5.18.

Table 5.18: Estimated historical (up to 2015) and projected (2016–30) impact of New Zealand Government's policies and measures on agriculture emissions (kt CO_2-e)

Policy or measure in the agriculture sector*	Cumulative historical emissions up to 2015 Absolute (kt CO_2-e)	Cumulative projected emissions, 2016–30 Absolute (kt CO_2-e)
Forestry sector policies and measures	NE	4,694
National Policy Statement for Freshwater Management	NO	7,286
Total (kt CO_2-e)	NE	11,980

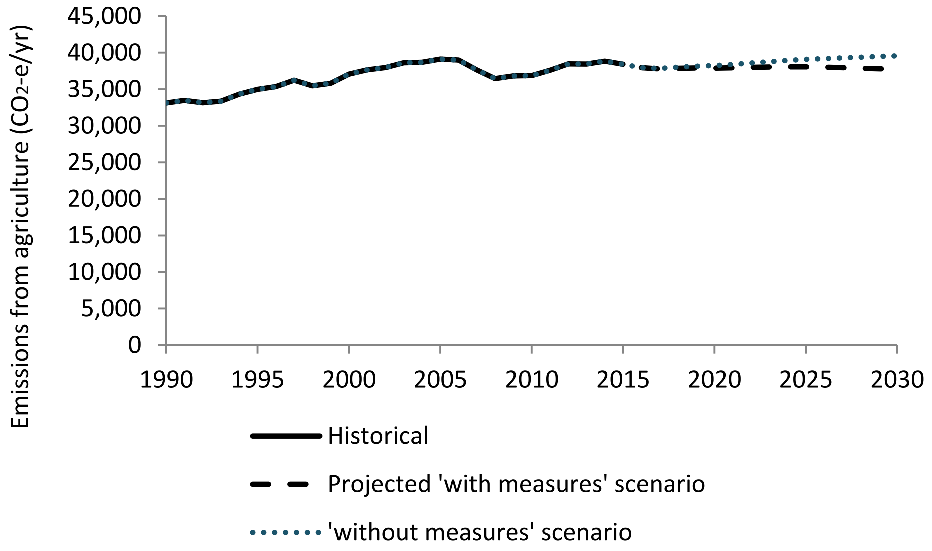
Note: * Policies and measures for the agriculture sector were assumed to start at 2016 and modelled from that time. kt CO_2-e = kilotonnes of carbon dioxide equivalent; NE = period when policy or measure was not estimated; NO = period when policy or measure was not in effect or not occurring.

157 A Daigneault, S Elliot, S Greenhalgh, S Kerr, E Lou, L Murphy, L Timar, S Wadhwa. 2016. *Modelling the Potential Impact of New Zealand's Freshwater Reforms on Land-based Greenhouse Gas Emissions*. Wellington: Ministry for Primary Industries.

Cumulative emissions for the 'with measures' scenario over 2016–30 are projected to be 568,885 kt CO_2-e, compared with projected gas emissions of 580,565 kt CO_2-e for the 'without measures' scenario. Without the inclusion of New Zealand Government policies and measures related to agriculture, projected emissions would be around 2 per cent higher in total over the 2016–30 period.

Projected emissions under the 'without measures' scenario from the agriculture sector are estimated to be 38,242 kt CO_2-e (1 per cent) greater than projected emissions under the 'with measures' scenario in 2020 and 39,561 kt CO_2-e (5 per cent) greater relative to the 'with measures' scenario in 2030. Figure 5.17 illustrates the differences between the 'with measures' and 'without measures' scenarios.

Figure 5.17: Estimated historical agricultural emissions, 1990–2015, and the projected 'with measures' and 'without measures' scenarios, 2016–30 (kt CO_2-e)



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

5.5.5 Land use, land-use change and forestry

The 'without measures' projection excludes the estimated actual and projected effects of the NZ ETS and Government forestry initiatives on net LULUCF removals.

Methodology

The methods used in determining the carbon impact of each policy are briefly described below.

New Zealand Emissions Trading Scheme

The 'without measures' scenario excludes the estimated impact of the NZ ETS on levels of afforestation and on any pre-1990 planted forest deforestation. The assessment of the historical and projected impact is based on a combination of NZ ETS registration data, annual evaluation surveys, research and modelling conducted by the University of Canterbury's School of Forestry.

Annual deforestation intentions surveys conducted by the University of Canterbury[158] 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 ETS' were then correlated with actual and projected deforestation rates to determine the impact of the NZ ETS at that time.

Historical afforestation that can be attributed to the NZ ETS from 2008–16 is limited to forests planted and registered since the establishment of the NZ ETS in 2008. This then creates a distinction between forests that were established before and those established after the Government initiative commenced, and ensures only forests registered in the NZ ETS directly after its establishment are included. NZ ETS afforestation projections from 2017 are based on research conducted by the University of Canterbury, which estimated the impact of carbon price on afforestation rates in New Zealand.[159] The research findings provide estimated afforestation 'with' and 'without' carbon prices, and are used as a measure of the 'additional' afforestation that can be attributed to the establishment of the NZ ETS.

The NZ ETS estimates in table 5.19 are a combination of 'additional' afforestation and 'reduced' deforestation that could be attributed to the NZ ETS. The impact the NZ ETS has had on afforestation and deforestation varied between 2008 and 2015 with the carbon price. Using the midpoint carbon price scenario, the NZ ETS is projected to provide additional net removals of 46,306 kt CO_2-e over the 2016–30 period.

Government-funded forestry initiatives

The 'without measures' scenario also assumes the exclusion of afforestation as a direct result of government forestry initiatives, such as the Afforestation Grant Scheme (AGS), Permanent Forest Sink Initiative (PFSI), Hill Country Erosion Programme (HCEP) and Erosion Control Funding Programme (ECFP). Removals for the PFSI, HCEP and AGS are only counted since the initiatives were established in 2008. In contrast, removals from the ECFP are calculated from 1992 as the date from which New Zealand Government has provided funding to landholders to prevent and control erosion. See section 4.3.6 for further details of these government-funded forestry initiatives.

The estimated actual and projected impact of the various government forestry initiatives is provided in table 5.19. Net removal estimates for forests established due to the AGS, PFSI, HCEP and ECFP are based on methodologies in the NIR. They are a function of the forest area and year planted attributed to each initiative, the year the initiative was established, and the forest species (rate of sequestration).

Estimated afforestation resulting from the AGS[160] is included for the 2016–20 period. Funding is also available under the ECFP and HCEP, but cannot be translated into future afforestation rates at this time. This is because afforestation targets are not defined beyond current funding contracts and the programmes provide a flexible range of land treatments, such as pole treatments or broader community initiatives to address erosion. This means that there is a wide range in removals from planting under these schemes.

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158 B Manley. 2005–2016. Deforestation Intentions Surveys. Retrieved from www.mpi.govt.nz/news-and-resources/publications.

159 B Manley. 2016. Afforestation responses to carbon price changes and market certainties. NZ School of Forestry, University of Canterbury. Retrieved from www.mfe.govt.nz/publications/climate-change/afforestation-responses-carbon-price-changes-and-market-certainties.

160 www.mpi.govt.nz/funding-and-programmes/forestry/afforestation-grant-scheme

Analysis

The inclusion of New Zealand Government-funded policies and measures has increased, and is projected to increase, removals in the LULUCF sector. Using the midpoint scenario, the introduction of the NZ ETS and other Government forestry initiatives results in projected cumulative net removals of 71,404 kt CO_2-e over 2016–30 (see table 5.19).

Table 5.19: Estimated historical (up to 2015) and projected (2016–30) impact of New Zealand Government's forestry policies and measures (kt CO_2-e)

Policy or measure in the forestry sector	Cumulative historical emissions up to 2015 Absolute (kt CO_2-e)	Cumulative projected emissions, 2016–30 Absolute (kt CO_2-e)	Total (kt CO_2-e)
Afforestation Grant Scheme	–734	–9,077	–9,811
Permanent Forest Sink Initiative	–1,385	–2,862	–4,248
Hill Country Erosion Programme	–330	–2,532	–2,862
Erosion Control Funding Programme	–15,756	–10,627	–26,383
New Zealand Emissions Trading Scheme	–6,605	–46,306	–52,912
Total (kt CO_2-e)	**–24,812**	**–71,404**	**–96,215**

Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

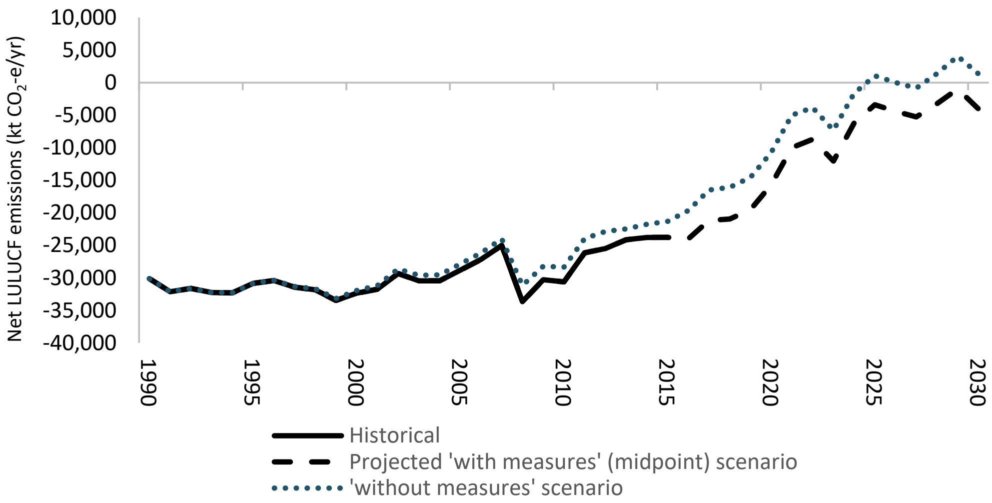
Figure 5.18 compares projected annual net LULUCF removals 'with measures' and 'without measures' for 1990–2030. The combination of Government forestry initiatives and the NZ ETS is projected to make an important contribution to increasing net removals in the future.

Highlighting this contribution, cumulative net LULUCF removals for the 'with measures' midpoint scenario over 1990–2015 are an estimated –769,789 kt CO_2-e, compared with projected net removals of –744,977 kt CO_2-e for the 'without measures' midpoint scenario. This amounts to 3.2 per cent lower net LULUCF removals over the 1990–2015 period.

Cumulative net LULUCF removals for the 'with measures' midpoint scenario over 2016–30 are projected to be –159,691 kt CO_2-e, compared with projected net removals of –88,288 kt CO_2-e for the 'without measures' midpoint scenario. Without the inclusion of New Zealand Government forestry-related policies and measures, projected net LULUCF removals would be 44.7 per cent lower in total over the 2016–30 period.

Net removals under the 'without measures' scenario from LULUCF are an estimated 2462 kt CO_2-e (10 per cent) less than projected emissions under the 'with measures' scenario at 2015; 4966 kt CO_2-e (32 per cent) less relative to the 'with measures' scenario at 2020; and 5393 kt CO_2-e (133 per cent) less at 2030.

Figure 5.18: Estimated historical net LULUCF removals, 1990–2015, and the projected 'with measures' scenario, 2016–30, and 'without measures' scenario, 1992–2030 (kt CO_2-e)



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

5.5.6 Waste

For the waste sector, the following two policy measures have been considered and included in the modelled 'without measures' scenario:

1. National Environmental Standards for Air Quality
2. waste disposal levy.

In 2004 the Government introduced specific standards (National Environmental Standards for Air Quality) for landfills in the Resource Management (National Environmental Standards for Air Quality) Regulations. The policy intent of the Standards is to ensure emissions of greenhouse gases generated from large landfills are effectively managed.

An investigation looked into the incorporation of CH_4 capture technology across managed landfill sites. Estimates of the impact of this policy on CH_4 emissions are summarised in table 5.20. This analysis found that application of the regulation to landfills from 2005–15 decreased CH_4 emissions from solid waste disposal on land by a cumulative total of 3501 kt CO_2-e at 2015 and represents a total reduction in emissions of 24 per cent over the 2005–15 period. For the projected emissions from 2016–30, this regulation is forecast to decrease CH_4 emissions by a cumulative total of 12,081 kt CO_2-e at 2030 and represents an estimated total reduction of 80 per cent up to 2030.

The Waste Minimisation Act 2008 encourages a reduction in the amount of waste generated and disposed of in New Zealand, and aims to lessen the environmental harm of waste. Under this Act, a levy rate (waste disposal levy) of NZ$10 per tonne was imposed on all waste disposed at landfills from 1 July 2009.

For the purposes of quantifying the impact of this measure on emissions so that it could be included in the 'without measures' scenario for the waste sector, an analysis was performed on solid waste disposal data before and after the waste disposal levy was imposed in 2009. It found that the levy had led to a slight reduction in solid waste disposal to landfills. In turn, this was projected to reduce waste disposal emissions. The effect of the waste disposal levy on the amount of waste disposed to landfills and on CH_4 emissions from landfills is summarised in table 5.20.

This analysis found that from 2009–15, the waste disposal levy reduced emissions by a cumulative total of 25 kt CO_2-e at 2015, representing a slight (0.3 per cent) reduction in emissions. Forecast emissions were reduced by a cumulative total of 182 kt CO_2-e at 2030, representing a 1.2 per cent reduction in emissions over the 2016–30 period. Future improvements and refinements to this analysis, specifically trying to measure the impact the waste levy has on solid waste disposal, will be undertaken when better information and/or data become available.

For alignment purposes, the processed animal numbers and milk production data used in the 'without measures' scenario for agriculture were also used as input data to determine emissions produced for the 'without measures' scenario for industrial wastewaters (referred to as indirect agricultural policy impacts in table 5.20). From 2016–30, the difference between emissions estimated for the 'without measures' and the 'with measures' scenarios for industrial wastewaters increases emissions by a cumulative total of 14 kt CO_2-e at 2030 and represents an estimated increase of 0.9 per cent in emissions over the 2016–30 period.

Solid waste disposal at managed sites entered the NZ ETS on 1 January 2013 and currently does not lend itself well to quantifying its impacts on emissions. Research is under way to examine the impact the NZ ETS has had on both solid waste disposal and emissions from solid waste landfills.

Table 5.20: Estimated historical (up to 2015) and projected (2016–30) impact of New Zealand government policies and measures from managed solid waste sites in the waste sector on greenhouse gas emissions (kt CO_2-e)

Policy or measure in the waste sector	Cumulative historical emissions up to 2015 Absolute (kt CO_2-e)	Cumulative projected emissions, 2016–30 Absolute (kt CO_2-e)	Total (kt CO_2-e)
National Environmental Standards for Air Quality	3,509	12,081	15,590
Waste disposal levy	25	182	206
NZ ETS	NE	NE	NE
Indirect agricultural policy impacts	NO	14	14
Total (kt CO_2-e)	**3,533**	**12,276**	**15,810**

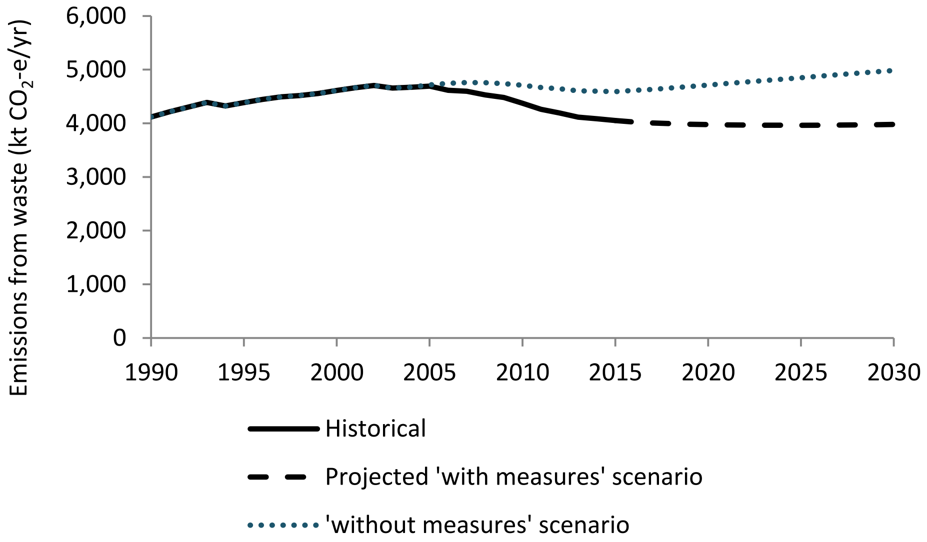
Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent; NE = period when policy or measure was not estimated; NO = period when policy or measure was not in effect or not occurring; NZ ETS = New Zealand Emissions Trading Scheme.

Total cumulative emissions for the 'with measures' scenario over 2005–15 are estimated to be 47,997 kt CO_2-e, compared with cumulative emissions of 51,530 kt CO_2-e for the 'without measures' scenario. This represents a 7 per cent increase in emissions from the 'without measures' scenario over the 2005–15 period.

Additionally, the projected cumulative total emissions for the 'with measures' scenario over 2016–30 are projected to be 59,664 kt CO_2-e, compared with projected cumulative emissions of 71,940 kt CO_2-e for the 'without measures' scenario. This represents a 21 per cent increase in emissions from the 'without measures' scenario over the 2016–30 period.

Emissions under the 'without measures' scenario from the waste sector are estimated to be 538 kt CO_2-e (13 per cent) greater than projected emissions under the 'with measures' scenario in 2015; 737 kt CO_2-e (19 per cent) greater relative to the 'with measures' scenario in 2020; and 1006 kt CO_2-e (25 per cent) greater in 2030. Figure 5.19 illustrates the differences between the 'with measures' and 'without measures' scenarios.

Figure 5.19: Estimated historical waste emissions, 1990–2015, and the projected 'with measures' scenario (2016–30) and 'without measures' scenario (2005–30) (kt CO_2-e)

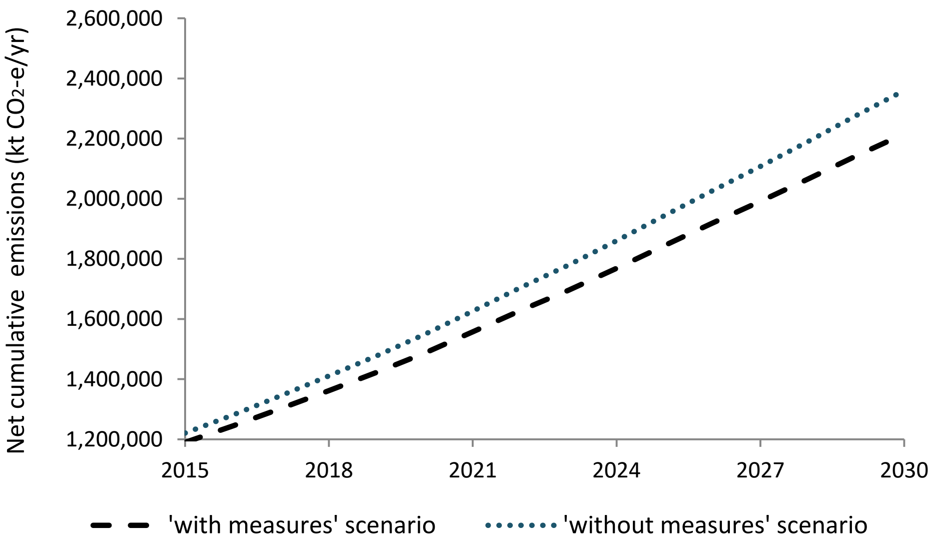


Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

5.6 Cumulative net emissions from 2016–30

Figure 5.20 illustrates the cumulative net emissions from the 'with measures' and 'without measures' scenarios from 2016–30. Policies and measures are estimated to have an overall impact on cumulative net emissions of 61,831 kt CO_2-e (or 4.2 per cent) at 2020 and 144,145 kt CO_2-e (or 6.5 per cent) at 2030.

Figure 5.20: Cumulative net emissions from the 'with measures' and 'without measures' scenario, 2016–30 (kt CO_2-e)



Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

5.7 Sensitivity analyses

Sensitivity analyses have been included in this chapter to demonstrate the effect various parameters have on projected amounts of CO_2-e emissions from the energy, waste and agriculture sectors. The results of these analyses are presented below.

5.7.1 Energy

A major determinant of emissions in the energy sector is the level of demand. New Zealand's energy emissions are low by international standards, because a high proportion of New Zealand's electricity is generated from renewable sources.

Five different scenarios have been modelled as part of the *Electricity Demand and Generation Scenarios*.[161] The scenarios have been developed to explore a plausible range of uncertainty about the future of the energy sector. We have included two of the Electricity Demand and Generation Scenarios in this report – the High Grid scenario and the Tiwai Off scenario – to illustrate the uncertainty in future greenhouse gas emissions from the energy sector. In this section, the High Grid scenario is referred to as a high-demand scenario while the Tiwai Off scenario is referred to as a low-demand scenario, as explained below.

The high-demand scenario assumes high GDP and population growth rates, leading to higher energy demand across all sectors. Grid-connected electricity demand is assumed to grow by 1.3 per cent per year.

In the low-demand scenario, the New Zealand Aluminium Smelter shuts in 2018 and lower GDP growth leads to lower electricity demand across all sectors, averaging 0.4 per cent per year. This scenario is included to indicate sensitivity in the associated gas emissions estimates to a low level of energy demand and does not indicate a likely or planned outcome. Given the New Zealand Aluminium Smelter is the single largest user of electricity in New Zealand, its closure could have a significant impact on future emissions if it were decommissioned.

Table 5.21 provides details of the sensitivity-based scenarios as at 2015 for energy and transport. For the high-demand scenario, an average increase in electricity demand of 1.3 per cent per annum growth from 2015 is estimated to increase emissions by 1130 kt CO_2-e in 2020 (or 3.5 per cent) and by 5084 kt CO_2-e (or 17.3 per cent) in 2030. For the low-demand scenario (representing closure of an aluminium smelting operation in New Zealand), electricity demand is estimated to decrease emissions by 2071 kt CO_2-e in 2020 (or 6.4 per cent) and by 659 kt CO_2-e (or 2.3 per cent) in 2030.

[161] Ministry of Business, Innovation and Employment. 2016. *Electricity Demand and Generation Scenarios 2016*. Retrieved from www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/modelling/electricity-demand-and-generation-scenarios/edgs-2016.

Table 5.21: Actual and projected energy emissions including the 'with measures' reported in chapter 5 (a combination of both energy and transport emissions), an increase in electricity demand and a decrease in electricity demand due to the decommissioning of an aluminium smelter, 2015, 2020 and 2030 (kt CO_2-e)

Energy scenarios	Year and associated emissions (kt CO_2-e) 2015 (base year)	2020	2030
High demand	32,455	33,736	34,422
Low demand (equivalent to decommissioning of an aluminium smelter)	32,455	30,535	28,679
'With measures' scenario (energy and transport sectors)	32,455	32,066	29,338
Absolute difference (kt CO_2-e)			
High demand	0	1,130	5,084
Low demand	0	–2,071	–659
Percentage difference (%)			
High demand	0	3.5	17.3
Low demand	0	–6.4	–2.3

Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent.

5.7.2 Agriculture

A sensitivity analysis estimated the effect of both higher and lower dairy commodity prices on agricultural emissions. The analysis modelled two scenarios under which the price of milk solids and overall dairy returns were assumed to be:

- 20 per cent higher than the base 'with measures' scenario for all years from 2017–30
- 20 per cent lower than the base 'with measures' scenario for all years from 2017–30.

Twenty per cent was chosen to test the sensitivity of dairy emissions in response to a long-term change in prices based on analysis of historical commodity price trends between 1985 and 2015.

The effects of the price changes on land use and animal numbers were modelled in the PSRM model. The anticipated effects of the NPS-FM and forestry sector policies and measures were also taken into account to ensure comparability with the 'with measures' scenario. The results of this analysis for 2020–30 are presented in table 5.22.

Table 5.22: Actual and projected agricultural emissions including the 'with measures', low dairy price and high dairy price scenarios, 2015–30 (kt CO_2-e)

Year	Scenario and associated emissions (kt CO_2-e) 'With measures'	'Decreased dairy price'	'Increased dairy price'
2015	38,420	NA	NA
2020	37,888	37,585	38,166
2025	38,056	37,625	38,505
2030	37,737	37,192	38,263
Difference relative to the 'with measures' scenario at 2030 (%)			
		–1.4	1.4
Absolute change (kt CO_2-e) from 2015–30			
	–683	–1,228	–157
Change (%) from 2015–30			
	–1.8	–3.2	–0.4

Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent; NA = not applicable.

This analysis suggests that dairy emissions are relatively unresponsive to changes in dairy commodity prices. Relative to the 'with measures' scenario, agriculture emissions are 1.4 per cent higher under the 'increased dairy price' scenario and 1.4 per cent lower under the 'decreased dairy price' scenario.

The change in projected emissions under the 'increased dairy price' scenario is due to a combination of higher stocking rates (number of cattle per unit of land) along with greater land area relative to the stocking rates and land areas observed in the 'with measures' scenario.

5.7.3 Waste

A sensitivity analysis estimated the effect of increasing the waste disposal levy rate on CH_4 emissions from the disposal of solid waste to landfills has been performed. This scenario is adopted from a recent report, which used a solid waste disposal levy rate of up to NZ$140 per tonne.[162] From 2024 onwards, the waste disposal levy was assumed to be capped at NZ$140 per tonne. Table 5.23 summarises the levy rates and the assumed reduction in solid waste disposal used for modelling purposes.

Table 5.23: Waste disposal levy rates and assumed rate changes used in the sensitivity analysis, 2017–24

Waste disposal levy assumptions	Year 2017	2018	2019	2020	2021	2022	2023	2024
Solid waste levy rates (NZ$)	10	15.42	20.83	26.25	54.69	83.13	111.56	140.00
Cumulative reductions in solid waste disposal (%)	0	3	5	7	14	19	22	25

Source: Eunomia Research and Consulting. 2017. The New Zealand waste disposal levy: Potential impacts of adjustments to the current levy rate and structure. Unpublished report.

162 Eunomia Research and Consulting. 2017. The New Zealand waste disposal levy: Potential impacts of adjustments to the current levy rate and structure. Unpublished report.

It is important to note this sensitivity analysis assumes that the levy increase does not impact on how solid waste is disposed of (ie, that managed solid waste is still disposed of at managed landfill sites and not diverted to other solid waste sites or to waste incineration facilities) and that no changes to the sites used in the analysis took place (ie, closures, openings or improvements in each site's CH_4 capturing technology). To estimate this effect, it was assumed that the impact of the waste levy would create an additional 25 per cent reduction in waste disposal to landfills. The current 'without measures' scenario (that accounts for no waste levy) was used to measure the impact of removing the current waste levy pricing on solid waste disposal emissions generated from landfills.

Table 5.24 compares the difference in terms of the estimated CO_2-e emissions between the 'with measures' estimate and a waste levy increase to NZ$140 per tonne (as explained above). This analysis spans from the time that the original waste levy policy was implemented (ie, 2009) to 2030.

Table 5.24: Summary of the impact of waste levy pricing on methane emissions from solid waste disposal landfills, 2009–30 (kt CO_2-e)

Scenarios, and solid waste disposal emissions estimates	Year 2015	2020	2025	2030
Scenario A (base scenario): the 'with measures' estimate at NZ$10/tonne waste levy (kt CO_2-e)	1,123	1,034	978	938
Scenario B: a waste levy increase to NZ$140/tonne (kt CO_2-e)	1,123	1,030	936	857
Scenario C: no waste levy (kt CO_2-e)	1,130	1,045	991	953
Difference between scenarios B and A (%)	0.0	–0.4	–4.2	–8.6
Total cumulative difference between scenarios B and A (kt CO_2-e)	0.0	–6	–123	–455
Difference between scenarios C and A (%)	0.6	1.0	1.4	1.6
Total cumulative difference between scenarios B and A (kt CO_2-e)	25	72	134	206

Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent; NA = not applicable.

Relative to the current levy rate, a rate increase to assist in reducing solid waste disposal at landfills could generate a further reduction in CH_4 emissions of up to:

- 0.4 per cent (or a total cumulative reduction of 6 kt CO_2-e emissions) in 2020
- 4.2 per cent (or a total cumulative reduction of 123 kt CO_2-e emissions) in 2025
- 8.6 per cent (or a total cumulative reduction of 455 kt CO_2-e emissions) in 2030.

Removing the levy rate could generate an increase in CH_4 emissions of up to:

- 1 per cent (or a total cumulative increase of 72 kt CO_2-e emissions) in 2020
- 1.4 per cent (or a total cumulative increase of 134 kt CO_2-e emissions) in 2025
- 1.6 per cent (or a total cumulative increase of 206 kt CO_2-e emissions) in 2030.

6 Vulnerability assessment, climate change impacts and adaptation measures

Key developments since the *Sixth National Communication*

A Climate Change Adaptation Technical Working Group was set up by the Minister for Climate Change Issues to provide advice on options for how New Zealand can adapt to the effects of climate change.

Updated climate projections for New Zealand were produced based on the Intergovernmental Panel on Climate Change's *Fifth Assessment Report*.

The Royal Society of New Zealand Te Apārangi identified six key risks for New Zealand in its report *Climate Change Implications for New Zealand*.

The Resource Legislation Amendment Act 2017 introduced "the management of significant risks from natural hazards" as a new matter of national importance in section 6 of the Resource Management Act 1991.

This chapter also serves as New Zealand's first adaptation communication under the Paris Agreement. The chapter has been prepared using the national communication guidelines. New Zealand's next adaptation communication will take into account any guidance adopted for adaptation communications by the COP/CMA.

6.1 Introduction

A low population density (and related long-distance infrastructure), a long coastline, varied landscape and an economy reliant on the primary production sector make New Zealand vulnerable to risks associated with extreme weather, sea-level rise and shifts in climatic conditions. Climate change is expected to exacerbate these risks.

Information on future climate change scenarios for New Zealand is contained in the Ministry for the Environment's 2016 report *Climate Projections for New Zealand*.[163] These projections are based on the Intergovernmental Panel on Climate Change's (IPCC's) *Fifth Assessment Report*. For more information about projected changes in climate, see section 2.3.2. Key points are as follows.

- Best estimates suggest that New Zealand will experience temperature increases of between:
  - about 0.7°C (low-emissions scenario) and 1.0°C (high-emissions scenario) by 2040
  - about 0.7°C (low-emissions scenario) and 3.0°C (high-emissions scenario) by 2090.

[163] Ministry for the Environment. *Climate Projections for New Zealand*. Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate-change/climate-change-projections-new-zealand.

- There are likely to be slight gradients from north to south and from east to west, with the greatest warming experienced in the northeast.
- The rate of temperature increase is expected to be higher than a linear extrapolation of the historical New Zealand temperature record for the 20th century, but the rise in temperature is still projected to be less than the global average.
- Projected rainfall and wind patterns show a marked seasonality. Increased northeasterly airflow is projected in summer and stronger westerlies in winter, particularly in the south. Increased summer rainfall is projected in the north and east of the North Island, and increased winter rainfall in many parts of the South Island. Decreased spring rainfall is projected in the north and east of the North Island, and in the south and east of the South Island.
- Global sea level is projected to rise by 0.2–0.4 metres by 2060 and 0.3-1.0 metres by 2100, depending on the emissions scenario.[164] However, the collapse of parts of the Antarctic ice sheets could substantially increase this range. Sea level in the New Zealand region is expected to rise slightly faster than the global average.
- Under the high-emissions scenario, by 2110 the mean sea-surface temperature in the New Zealand region is expected to increase by 2.5°C. Additionally, by 2100 the pH of surface water is expected to decline by 0.33 under the high-emissions scenario.
- Other changes expected are: decreased frost risk, increased frequency of high temperatures, increased frequency of extreme daily rainfalls, increased frequency of dry days, decreased seasonal snow cover, increased frequency and intensity of droughts, and a possible increase in strong winds.

The regional distribution of climate change impacts is illustrated in figure 6.1.

Significant investment has been made over the reporting period into research programmes studying the impacts of climate change on New Zealand (see section 8.4.3 for further detail). Section 6.2 summarises the key research findings in specific areas of climate change impacts in New Zealand.

The Government's Conservation and Environment Science Roadmap (2017)[165] identifies future science priorities and capability needs to facilitate strategic, evidence-based management and policy development on New Zealand's big environmental issues. Climate change has been identified as a major cross-cutting research theme. Specific research activities and science needs identified for the next 20 years include "improved monitoring and modelling of observed and expected changes and their environmental, social and economic impacts; development of mitigation and adaptation options; tools and approaches to reduce emissions".

Research during the reporting period has also looked at vulnerabilities in coping with the adverse impacts of climate change and means of adapting to climate change. Section 6.3 reviews specific work to identify community vulnerabilities to climate change, and vulnerabilities in the tourism and transport sectors. Different groups have different levels of vulnerability (section 6.3.3). For example, Māori[166] are more likely to be vulnerable to climate change as a greater proportion of Māori live in regions where the most warming is projected

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164 IPCC. 2013. *Fifth Assessment Report*. Retrieved from www.ipcc.ch/report/ar5.

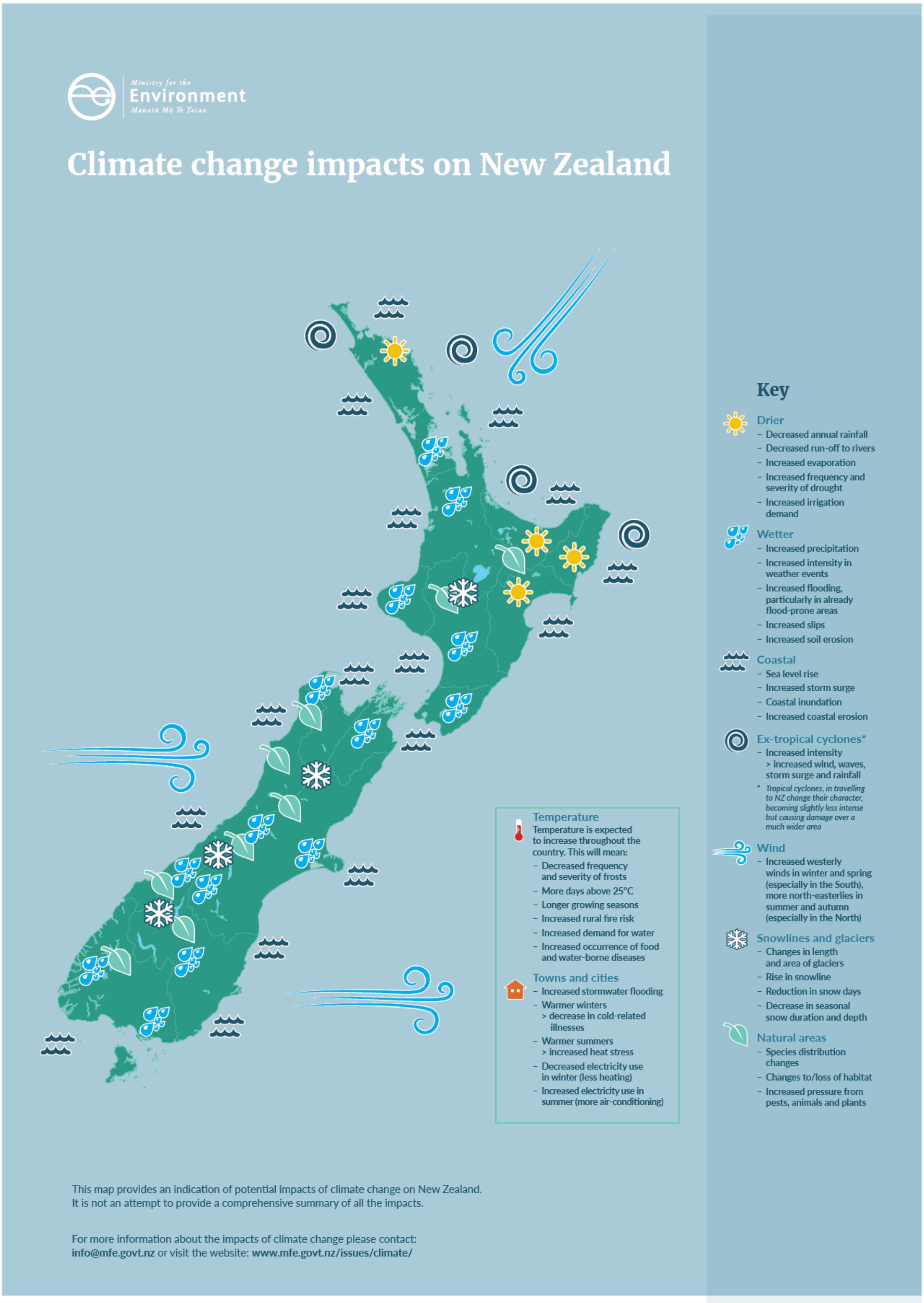
165 www.mfe.govt.nz/sites/default/files/media/About/cesr-at-a-glance.pdf

166 Māori are the indigenous people of New Zealand.

to occur and where rainfall is expected to decrease, and also because the Māori economy is heavily reliant on climate-sensitive primary industries.

Section 6.4 discusses the steps taken to adapt to the risks, challenges and opportunities of climate change.

Figure 6.1: Spatial distribution of climate change impacts across New Zealand



6.2 Research on climate change impacts

This section summarises the findings of key research on climate change impacts undertaken by the New Zealand Government during the reporting period in the following areas:

- agriculture and forestry
- biodiversity and natural ecosystems
- coastal zones
- fresh water and glaciers
- human health
- infrastructure and economy
- the marine environment and fisheries
- cultural heritage.

There has also been cross-cutting research on the key impacts of climate change on New Zealand as a whole. In its report *Climate Change Implications for New Zealand*,[167] the Royal Society of New Zealand Te Apārangi identified six key risks that New Zealand faces:

- risks to our coastal margins
- flooding from rivers
- availability and competition for fresh water
- changes to our surrounding oceans
- threats to unique ecosystems
- flow-on effects from climate change impacts and responses elsewhere.

Many New Zealanders live on the coast. These populations are already exposed to coastal inundation and erosion – coastal hazards that will be exacerbated by rising sea levels and stronger storms as a result of climate change. Infrastructure, assets and community values will all be affected by changes to the coast as a result of sea-level rise.

Along with increased coastal inundation, increased flooding of rivers is also likely to occur as a result of an increase in the frequency and severity of extreme rainfall events under a changing climate. Many New Zealanders live on floodplains, and are vulnerable to these damaging flood events. At the coast, floods will interact with rising sea levels and higher storm surges.

Increased pressure on freshwater resources is another expected impact of climate change. New Zealand is sensitive to pressures on freshwater resources given that our economy is tied to primary industries that rely on freshwater availability. Annual average rainfall is projected to decrease in the north and east of the North Island and this trend, coupled with higher temperatures, means our freshwater supply is likely to be threatened by an increasing frequency and intensity of droughts.

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167 The Royal Society of New Zealand. 2016. *Climate Change Implications for New Zealand.* Wellington: Royal Society of New Zealand. Retrieved from https://royalsociety.org.nz/assets/documents/Climate-change-implications-for-NZ-2016-report-web3.pdf.

As an island nation, New Zealand is surrounded by ocean. Ocean warming and acidification as a result of climate change could threaten our fishing, aquaculture, marine recreational use and iconic habitats and wildlife.

New Zealand also has a number of unique indigenous ecosystems, and changing temperatures and water availability as a result of climate change will impact on where these species are able to be located. These ecosystems are already under pressure from pests, diseases and changes in land use and water quality. Climate change will exacerbate these issues.

Finally, we live in an interconnected world. New Zealand is an open economy with important trading links with Europe, Australia, the United States and China. The impacts that climate change has on our trading partners and on the rest of the world can impact on New Zealand's ability to sell goods overseas, as well as on migration and social and cultural ties. Patterns of international trade and tourism could change substantially as a result of climate change. New Zealand will also be affected by the commitments it makes to international climate treaties.

6.2.1 Agriculture and forestry

The research programme within the Ministry for Primary Industries' (MPI's) Sustainable Land Management and Climate Change Plan of Action (SLMACC) supports climate change adaptation research in the agriculture and forestry sectors. Over the past 10 years research has been undertaken on the impacts of climate change on the land-based sectors. During the reporting period, over 50 reports focused on impacts and adaptation have been commissioned. The majority of these studies explore the impacts on the major agriculture sectors of future climate scenarios out to 2050 and 2100.

The effects of climate change on crop/pasture productivity and persistence, pollinators, water resources, forest productivity, soil ecosystem services, erosion, pest and disease incidence, biocontrol systems and subtropical grass boundaries have been investigated. Research also covers the likely impacts from droughts, fire incidence, extreme winds, floods and frosts. Some work has been undertaken on wider social and economic implications, including rural water infrastructure, global trade and farm finance systems, and farmer resilience.

The New Zealand Government has issued a comprehensive review report supported through SLMACC entitled *Impacts of Climate Change on Land-based Sectors and Adaptation Options*.[168] It outlines the impacts of climate change on the land-based sectors in New Zealand and various adaptation options.[169]

Each year the SLMACC programme holds funding rounds to establish new projects. In 2016, 13 research projects received funding approvals through the SLMACC programme, totalling $3.1 million. Three of the projects had an adaptation theme:

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168 The full technical report is: Clark AJ, Nottage RAC, Wilcocks L, et al. 2012. *Impacts of Climate Change on Land-based Sectors and Adaptation Options.* AJ Clark, RAC Nottage (eds). Technical Report to the Sustainable Land Management and Climate Change Adaptation Technical Working Group, Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/news-and-resources/publications.

169 For a summary report, see: AJ Clark, RAC Nottage, L Wilcocks, et al. 2012. *Impacts of Climate Change on Land-based Sectors and Adaptation Options*. Clark AJ, Nottage RAC (eds). Stakeholder Report to the Sustainable Land Management and Climate Change Adaptation Technical Working Group, Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/news-and-resources/publications.

- analysis of potential climate change impacts on horticulture's spatial footprint
- integrating extension and land management networks with enabling policy environments to support action to mitigate and adapt to climate change at a catchment scale
- the economics and carbon impacts of transitioning clear-fell planted forests to permanent cover forests on severely erosion-prone steep land.

According to the New Zealand Climate Change Centre's 2014 summary of the New Zealand findings in the IPCC *Fifth Assessment Report*, agricultural production zones and the timing of some activities are expected to shift as a result of rising temperatures and changing rainfall patterns.

Some of the expected impacts of climate change on agriculture and horticulture include:

- a shift in agricultural and horticultural production zones, changed timing of some activities, and reduced crop quality and yield as a result of rainfall changes, and rising humidity and temperatures
- a short-term benefit from climate change and increases in atmospheric carbon dioxide (CO_2) in some areas if farm management practices change to make the most of increased pasture production
- increased drought and flooding risk for some regions
- as a result of higher temperatures, a greater range and higher incidence of many pests and diseases, with a risk of new invasive species establishing
- erosion potentially becoming an increasing problem on farms
- some short-term opportunities, particularly where impacts may be mitigated by commodity price rises[170]
- potential for increased demand for irrigation and fertiliser leading to other downstream issues[171]
- early flowering as a result of increased temperature, which will increase the chance of frost damage in spring
- a higher risk, due to increased flooding and ponding, that surface water will contaminate produce.

Dairy

The land and climate in large parts of New Zealand are well suited to pasture-based dairy systems. Potential changes in pasture growth rates are already well understood in New Zealand. The combined effects of rainfall changes, temperature shifts and increasing CO_2 fertilisation were assessed through literature review and whole-farm models. They are likely to be manifested as:

170 New Zealand Climate Change Centre. 2014. *Climate Change: IPCC Fifth Assessment Report – New Zealand findings*. New Zealand Climate Change Centre. Retrieved from www.niwa.co.nz/sites/niwa.co.nz/files/NZCCC%20Summary_IPCC%20AR5%20NZ%20Findings_April%202014%20WEB.pdf.

171 P Gluckman. 2017. *New Zealand's Fresh Waters: Values, State, Trends and Human Impacts*. Wellington: Office of the Prime Minister's Chief Science Advisor.

- changes in the seasonal timing of production (eg, changes in calving dates)
- increased seasonal pasture growth rates during late autumn, winter and early spring due to warmer temperatures
- shorter spring seasons, but with higher potential pasture growth
- earlier summer onset, with more water deficiencies and more variable autumns
- an increase in pasture growth rate variability, bringing additional deficits and higher surpluses of feed.

Sheep and beef

To identify potential climate change impacts on the sheep and beef sector, a farm modelling approach was used to project future pasture growth rates, availability and variability under a range of future climate scenarios. To provide a sample of the production diversity in the sector, three farm types were carefully selected: an extensive finishing-breeding operation in Southland, a hill country farm in Hawke's Bay and an unimproved hill country farm in Waikato. These three farm types account for nearly 70 per cent of New Zealand farm types but focus on higher-performing units.

The analysis revealed the following.

- In Southland, the total annual dry-matter production increased with climate change, allowing more stock to be carried. There was a marked shift in the seasonality of the pasture growth curves, with the spring peak occurring earlier, as well as a drop in dry-matter production in late summer and autumn.
- In Hawke's Bay, farm production in the late summer and autumn increased only slightly with climate change. As in Southland, there was a marked shift in the seasonality of pasture growth curves; the most obvious was a decrease in summer dry-matter production.
- In Waikato, annual dry-matter production increased by just over 10 per cent. As with the other two sites, there was a change in seasonality, with more growth in spring and lower growth rates in the autumn.

Broad acre cropping

Simulation modelling indicates that climate change is likely to affect both the yield and quality of broad acre crops in New Zealand, including wheat, barley and forage crops. Assuming adequate water and soil nutrient supply, potential yields of temperate cereal and forage crops could increase by as much as 20 per cent under future temperature and CO_2 concentrations. However, in some cases, yields of other crops such as maize, peas and potatoes could slightly decrease, because high temperatures shorten the crop cycle and reduce the time available for sunlight interception and photosynthesis. Realising these potential increases or minimising the negative impacts will mean adapting crop management, including rotation, nutrients and water. New Zealand's wheat yields could increase if appropriate cultivars and sowing dates are chosen.[172]

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[172] New Zealand Climate Change Centre. 2014. *Climate Change: IPCC Fifth Assessment Report – New Zealand findings*. New Zealand Climate Change Centre. Retrieved from www.niwa.co.nz/sites/niwa.co.nz/files/NZCCC%20Summary_IPCC%20AR5%20NZ%20Findings_April%202014%20WEB.pdf.

Horticulture

The expected impacts of climate change on horticultural species (such as apple, kiwifruit and grapes) were modelled. Variables included temperature rises, CO_2 increases and rainfall changes. Climate change is likely to affect plant development, flowering and bud break, as well as increase vegetative biomass and increase pest and disease risk. For vegetable production, under IPCC modelling scenarios to 2040 and 2090, climate change is likely to extend the potential growing season, increase yields for some crops, and increase pest and disease risk. Some cooler and more elevated sites could become suitable for growing grapes for wine, under a changing climate.[173]

Forestry

Managed plantation forestry in New Zealand has a different impact profile and planning horizon to the other land-based sectors at around 30 years, due to its relatively slow biological response rate and long harvest cycle. The most certain direct impact of climate change under scenarios modelled to 2040 and 2090 is increased yield of *Pinus radiata* in many plantations with no moisture or nutrient limitations. Under these scenarios, forestry also faces less predictable, but expected, increases in risks of secondary impacts from pests and diseases, fire and extreme wind and storms, which may reduce productivity and compromise wood quality.

According to the New Zealand Climate Change Centre,[174] a reduction in the plant disease *Dothistroma* blight is expected in the central North Island and in the South Island.

Some of the expected impacts of climate change on forestry include:

- increased *Pinus radiata* growth in cooler regions due to enhanced CO_2 levels where other elements, water and nutrients are less limiting
- significantly increased fire risk in some areas
- greater impact of pests on forest health, habitat loss and unstable land, which have been identified as primary risks[175]
- greater exposure to climate risks for the forestry sector, compared with some other sectors, due to the long production cycles.[176]

6.2.2 Biodiversity and native ecosystems

New Zealand has been geographically separated from other land masses for over 80 million years so its biodiversity is unique. It has a high percentage of endemic species (that is, species found nowhere else in the world) in the terrestrial, freshwater and marine environments. Many aspects of New Zealand's biodiversity will experience climate change impacts. A Royal Society report identifies ecosystem change as one of six key risks to New Zealand from climate

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173 Ibid.

174 Ibid.

175 J Lawrence, P Blackett, N Cradock-Henry, S Flood, A Greenaway, A Dunningham. 2016. *Synthesis Report RA4: Enhancing Capacity and Increasing Coordination to Support Decision Making. Climate Change Impacts and Implications (CCII) for New Zealand to 2100.* MBIE contract C01X1225. Retrieved from http://ccii.org.nz/wp-content/uploads/2017/01/RA4-Synthesis-report.pdf.

176 Ibid.

change.[177] The effects of climate change will interact with and exacerbate existing environmental stresses. The report emphasises that the key drivers of ecosystem change are likely to be the indirect effects of climate change, which include increased range and abundance of pest and weed species, new diseases and disease vectors, increased fire risk, and land-use change as a response to climate impacts. It identifies alpine, freshwater, forest and coastal ecosystems as likely to be particularly affected. However, it also notes that the direct effects of climate change on native ecosystems in New Zealand have been difficult to establish for a number of reasons, including a lack of historical data and an already variable climate.

A Department of Conservation report proposes a framework made up of five strategies.[178] It acknowledges that the capacity of native species and ecosystems to adapt to climate change is unknown. However, many of New Zealand's unique species are highly specialised (eg, tuatara[179]), limited in number (eg, takahē) and/or have specialised habitat requirements (eg, frogs and lizards), factors that will reduce their capacity to adapt to a changing climate. Expected direct impacts identified in the report include a shift in species distributions, changes in species abundances, changes in the timing of annual and seasonal events, changes in the timing of life-cycle events, and the potential for seasonal cycles of interdependent species to lose their synchrony.

For the marine environment, another report commissioned by the Department of Conservation[180] made general predictions for climate change impacts on marine ecosystems, including the following.

- There will be increased smothering of coastal and estuarine habitats from terrestrial sedimentation as a result of more intense rainfall events, and increased inland and coastal erosion.
- Increasing temperatures are likely to result in cooler water-adapted species with a lower temperature tolerance either moving southward or suffering increased rates of mortality during extreme heat events. It is also likely that invasion of tropical and subtropical species will increase.
- Ocean acidification will cause declines in calcifying organisms, with cold-water species (including deep-sea corals) likely to decline first.
- Sea-level rise will reduce coastal habitats (especially coastal wetland habitats such as salt marsh), changing inundation patterns and increasing vulnerability to storm surges and tides.

The Department of Conservation is developing a suite of ecological indicators as part of an outcomes-based framework for monitoring marine protected areas. This includes indicators and measures directly relating to climate change, with the outcome being resilience to climate change. Monitoring of measures associated with the climate change indicators (climate

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177 The Royal Society of New Zealand. 2016. *Climate Change Implications for New Zealand.* Wellington: Royal Society of New Zealand. Retrieved from https://royalsociety.org.nz/assets/documents/Climate-change-implications-for-NZ-2016-report-web3.pdf.

178 Department of Conservation. 2014. *Adapting to a Changing Climate*. Wellington: Department of Conservation.

179 Warmer temperatures have resulted in changes in tuatara sex ratios to increasingly male.

180 TJ Willis, SJ Handley, FH Chang, CS Law, DJ Morrisey, AB Mullan, et al. 2007. *Climate Change and the New Zealand Marine Environment.* Prepared for the Department of Conservation by the National Institute of Water and Atmospheric Research. Retrieved from www.niwa.co.nz/our-science/climate/information-and-resources/clivar/climate_change.

variables and biological responses to climate change) will inform our understanding of climate change impacts on ecological integrity in the marine environment. Furthermore, there will be recognition that climate change will impact on and interact with all indicators that are being measured within the monitoring framework.

In 2015 New Zealand introduced a new environmental reporting regime. The New Zealand Government's environment report, *Our Marine Environment*, released under the Environmental Reporting Act 2015, identified ocean acidification and warming as top issues facing the oceans.[181] It noted that marine and coastal species with carbonate shells, such as pāua, mussels and oysters, and the plankton that support all life in the oceans are particularly vulnerable to climate change as increased acidity interferes with the formation of shells.[182]

A strengthening East Auckland Current[183] is expected to allow some new species of fish to establish here.[184] Some species that presently live in lower latitude regions may migrate into New Zealand waters in response to rising temperatures and changing ecological community structures.[185]

More information about research in the marine environment is discussed in section 6.2.7.

Predation and competition for food sources by invasive (non-native) species are key causes of native animal extinction in New Zealand and also have an impact on native plant life. Climate change may have two kinds of impact on invasive species. First, a number of invasive species (including ship rats, hedgehogs, rabbits and wasps) are limited in their range and/or abundance by temperature and may be able to respond quickly to changes in climate. For example, in response to warming temperatures, ship rats may increase their distribution into higher-elevation forests and alpine zones. Controlling ship rats is a large cost to the Department of Conservation. In addition, climate change is expected to increase the potential for a range of new plant and animal pests and diseases to become established in New Zealand and to impact on biodiversity.

The second potential impact is indirect, through mast-seeding events in beech forests and grasslands. Mast-seeding is the production of unusually high quantities of seed that occurs in some plants in some years. It is quite common in New Zealand plants, including New Zealand's native beech trees. The occasional large flower and seed crops usually lead to large increases in populations of invasive pest animals that feed on the seed (mice and rats) and consequently drive predator populations up (eg, stoats and feral cats). When the populations of introduced rodents and other mammal predators in New Zealand ecosystems increase, they generally consume more native birds and insects.[186]

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181 Ministry for the Environment, Statistics New Zealand. 2016. New Zealand's Environmental Reporting Series: Our Marine Environment 2016. Retrieved from www.mfe.govt.nz and www.stats.govt.nz.

182 CS Law, GJ Rickard, SE Mikaloff-Fletcher, MH Pinkerton, R Gorman, et al. 2016. *The New Zealand EEZ and South West Pacific. Synthesis Report RA2, Marine Case Study. Climate Changes, Impacts and Implications (CCII) for New Zealand to 2100*. MBIE contract C01X1225.

183 An ocean current that passes along the north and east of New Zealand's North Island.

184 New Zealand Climate Change Centre. 2014. *Climate Change: IPCC Fifth Assessment Report – New Zealand findings*. New Zealand Climate Change Centre. Retrieved from www.niwa.co.nz/sites/niwa.co.nz/files/NZCCC%20Summary_IPCC%20AR5%20NZ%20Findings_April%202014%20WEB.pdf.

185 GJ Molinos, BS Halpern, DS Schoeman, CJ Brown, W Kiessling, et al. 2015. Climate velocity and the future global redistribution of marine biodiversity. *Nature Climate Change* doi:10.1038/nclimate2769.

186 See www.landcareresearch.co.nz/about/news/media-releases/new-research-assists-predictions-for-mast-seeding-and-predator-explosions.

Mast-seeding events occur in response to temperatures in the previous summer. If temperature extremes become the norm, mast-seeding events may become more common,[187] with the additional loss of associated functions such as pollination and seed dispersal, implying potentially serious adverse impacts of climate change for biodiversity and ecosystem function.[188] Rapid expansions of stoat and rodent populations have become more frequent since 1999/2000 in forests with mast-seeding tree species because of an increase in these partially temperature-driven events.[189]

6.2.3 Coastal zones

Global sea-level rise resulting from climate change is expected to affect New Zealand. Long-term continuous tide gauge records from four New Zealand ports, and fragmented observations from six others, indicate a historical average rise in relative mean sea level (with respect to the land surface) of 1.8 ± 0.2 millimetres per year (or 0.18 metres per century) in the 100 years up to 2015.[190] This result is consistent with the worldwide average for the 20th century of 1.4–1.9 millimetres per year, and according to the IPCC's *Fifth Assessment Report* future sea-level rise in the New Zealand region is expected to be up to 10 per cent more than the global average.[191]

New Zealand is a tectonically active country as it sits on the boundary of two tectonic plates. A study of vertical land movement found that although some sites are experiencing uplift or subsidence of several millimetres per year when measured over a few years, on long timescales in most places it is less than 1 millimetre a year.[192] This means that in most places the effect of sea-level rise will be greater than the movement of the land.

The lower North Island is subsiding presently on average at 1–3 millimetres a year due to interseismic slow-slip activity.[193] The Kaikōura coast recently experienced uplift of up to 1–2 metres as a result of the 14 November 2016 earthquake.

Several local councils in New Zealand have commissioned studies to investigate the impacts of sea-level rise and coastal hazards in their areas. Depending on the land forms, infrastructure

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187 D Kelly, A Geldenhuis, A James, EP Holland, MJ Plank, RE Brockie, et al. 2013. Of mast and mean: differential-temperature cue makes mast seeding insensitive to climate change. *Ecology Letters* 16: 90–98.

188 DM Tompkins, AE Byrom, RP Pech. 2013. Predicted responses of invasive mammal communities to climate-related changes in mast frequency in forest ecosystems. *Ecological Applications* 23(5). Retrieved from www.esajournals.org/doi/abs/10.1890/12-0915.1.

189 Department of Conservation. 2017. pers. comm.

190 MfE coastal hazards guidance, Hannah (2016).

191 New Zealand Climate Change Centre. 2014. *Climate Change: IPCC Fifth Assessment Report – New Zealand findings*. New Zealand Climate Change Centre. Retrieved from www.niwa.co.nz/sites/niwa.co.nz/files/NZCCC%20Summary_IPCC%20AR5%20NZ%20Findings_April%202014%20WEB.pdf.

192 RJ Beavan, NJ Litchfield. 2012. *Vertical Land Movement around the New Zealand Coastline: Implications for Sea-level Rise*. Wellington: Institute of Geological and Nuclear Sciences Limited Science Report 2012/29. Retrieved from www.gns.cri.nz.

193 RJ Beavan, NJ Litchfield. 2012. *Vertical Land Movement around the New Zealand Coastline: Implications for Sea-level Rise*. Wellington: Institute of Geological and Nuclear Sciences Limited Science Report 2012/29. Retrieved from www.gns.cri.nz; J Hannah. 2016. *Updated historic sea-level rise trends in New Zealand up to 2015: MfE Guidance Manual*. Report to NIWA by Vision New Zealand Ltd.; N Houlié, TA Stern. 2016. Vertical tectonics at an active continental margin. *Earth and Planetary Science Letters* 457: 292–301. Retrieved from http://dx.doi.org/10.1016/j.epsl.2016.10.018.

and assets present in each region, these studies have examined changing sea level, wave height, storm surge and coastal erosion. Climate change is expected to affect New Zealand's coastal margins through:

- increased coastal erosion
- more frequent and extensive coastal inundation
- higher storm surge flooding
- increased drainage problems in adjacent low-lying areas
- seawater reaching further inland in estuaries and coastal aquifers
- changes in surface water quality, groundwater characteristics and sedimentation
- increases in seawater temperatures
- changes in seawater acidity towards a lower pH (acidification).

6.2.4 Fresh water and glaciers

Climate change is set to modify the average – and most importantly the variability of – water availability in catchments by mid-century. River flows are likely to increase on the West Coast of the South Island and in rivers draining the eastern flank of the Southern Alps, and are likely to decrease on the east coasts of both islands as well as in Waikato and Northland.[194] More extreme rainfall events are expected, particularly in the west and south, along with more frequent and intense droughts, especially in the east.[195]

According to the report of the Prime Minister's Chief Science Advisor on the state of New Zealand's fresh water, climate change is expected to result in:

- greater variability in river flows over time, with increased frequency of extreme floods and prolonged droughts. The degree of this variation will be different across the country due to New Zealand's complex geography
- intensified stratification in deep lakes, and possibly intensified wind-driven mixing in shallow lakes
- changes in the distributions of native species, valued introduced species, and invasive pests, as well as in the timing and severity of phytoplankton blooms. Warmer habitats are likely to favour the colonisation and spread of invasive species
- increased need for water storage in eastern areas to meet growing irrigation demands due to projected warming and drying
- salinisation of coastal wetlands as sea level rises and seawater reaches further inland.

As noted in section 6.2.1, droughts and floods cause significant damage to the land-based sector and create risks for water resource infrastructure.[196] Average temperatures will be higher, increasing evaporation rates. Changes in seasonal rainfall patterns and extreme weather events will create secondary effects of increased erosion and sedimentation to

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[194] P Gluckman. 2017. *New Zealand's Fresh Waters: Values, State, Trends and Human Impacts*. Wellington: Office of the Prime Minister's Chief Science Advisor.

[195] Ministry for the Environment. *Climate Projections for New Zealand*. Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate-change/climate-change-projections-new-zealand.

[196] Ministry for Primary Industries. 2012. *Impacts of Climate Change on Land-based Sectors and Adaptation Options: Stakeholder Report*. Wellington: Ministry for Primary Industries, p 53.

waterways, affecting freshwater ecosystems. Lower river flows in summer will raise water temperatures and exacerbate water quality problems, such as through increased algae growth leading to more algal blooms and eutrophication of lakes. Intensified stratification in deep lakes may occur, along with wind driven mixing in shallow lakes.[197] New Zealand catchments show variation in water volumes, so these general impacts need to be considered alongside local hydrological properties.

Water demand is expected to increase, for both production and in-stream uses, such as hydropower, as well as recreational uses including fishing and boating.[198] It is almost certain that there will be increased pressure on water resources in the future, as a result of urban expansion and increased demand for water from the agriculture sector along with increasing reliance on irrigation (particularly as temperatures rise and in areas where average rainfall is expected to decrease).[199]

Increased erosion and sedimentation rates, along with more frequent and extreme flooding, will have significant effects on infrastructure such as bridges and flood protection works. This will result in additional maintenance and operation costs in affected areas. Reservoirs and other water supply systems and infrastructure are also likely to be affected by these hazard events and require additional maintenance.

The National Institute of Water and Atmospheric Research (NIWA) has conducted annual monitoring of 50 South Island glaciers in New Zealand since 1977. There has been a clear decrease in ice volume at most of the glaciers, with permanent ice loss occurring over the course of the 39-year monitoring period.[200] The results indicate a loss of 24 per cent of glacier ice volume since monitoring began.[201] The surface area of large glaciers has remained almost constant over the past 39 years, but it is the thinning of the ice layer that has caused the loss in volume. In New Zealand an estimated 90 per cent of ice loss from glaciers since 1977 is due to thinning and ice breaking into lakes. NIWA's snowline surveys show an overall decrease in the glacier mass balance (and thereby volume) over the past 39 years, but this is punctuated by periods where the prevailing weather conditions have caused the glacier mass balance to increase for a few years.[202] The Franz Josef and Fox glaciers have lost around 3 kilometres in length and at least 3–4 square kilometres in area since the 1800s.[203]

The New Zealand Government's environment report *Our Fresh Water* states that climate change is projected to increase pressure on water flows and water availability.[204] Higher

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197 P Gluckman. 2017. *New Zealand's Fresh Waters: Values, State, Trends and Human Impacts*. Wellington: Office of the Prime Minister's Chief Science Advisor.

198 Ministry for Primary Industries. 2012. *Impacts of Climate Change on Land-based Sectors and Adaptation Options: Stakeholder Report*. Wellington: Ministry for Primary Industries, p 53.

199 The Royal Society of New Zealand. 2016. *Climate Change Implications for New Zealand.* Wellington: Royal Society of New Zealand. Retrieved from https://royalsociety.org.nz/assets/documents/Climate-change-implications-for-NZ-2016-report-web3.pdf.

200 A Willsman. 2017. *Annual Glacier Ice Volumes, 1977–2016*. NIWA Client Report.

201 Ibid.

202 T Chinn, BB Fitzharris, A Willsman, MJ Salinger. 2012. Annual ice volume changes 1976–2008 for the New Zealand Southern Alps. *Global and Planetary Change* 92–93: 105–118.

203 H Purdie, B Anderson, T Chinn, I Owens, A Mackintosh, W Lawson. 2014. Franz Josef and Fox Glaciers, New Zealand: historic length records*. Global and Planetary Change* 121: 41–52.

204 Ministry for the Environment and Statistics NZ. 2017. New Zealand's Environmental Reporting Series: Our Fresh Water 2017. Retrieved from www.mfe.govt.nz and www.stats.govt.nz.

temperatures and lower rainfall, along with increased frequency and intensity of droughts, are expected to reduce soil moisture, groundwater supplies and river flows for some areas. Greater variability in river flows over time is expected, as the frequency and intensity of droughts and floods are expected to increase over time.[205] In addition, loss of snow and ice cover in alpine areas, as well as increased melting of remaining snow and ice, has flow-on effects on alpine and lowland freshwater bodies, which are characterised by a significant ice-melt component. Water from melting ice and snow represents a major contributor to the discharge in some rivers during the drier summer months.

A report was commissioned by MPI through the SLMACC research programme investigating climate change impacts on agricultural water resources and flooding.[206] The results are described below.

Changes to the global climate system will have implications for New Zealand's agriculture sector in terms of both productivity and hazard exposure; these will vary across the country, over the course of the century, and among scenarios of climate change. Building on the assessment of future changes in New Zealand's climate, the report addresses potential impacts of climate change on the components of hydrology related to the agriculture sector.

The effects of climate change were examined using NIWA's national hydrological model with downscaled Global Climate Model outputs from 1971–2099 under different global warming scenarios. Using a combination of six Global Climate Model outputs and four warming scenarios, it was possible to consider a plausible range of future trajectories of greenhouse gas emissions and climatic responses. The detailed hydrological effects were aggregated into a suite of statistics related to agricultural water supply, soil moisture conditions and flood hazard exposure, for the purpose of comparing mid- and late-century conditions with recent historical conditions.

The projected effects of climate change on New Zealand's agricultural hydrology are complex and difficult to generalise across the country and within regions due to the interactions among climate, topography, geology and land use. It is also impossible at this stage to attribute the modelled differences between two time periods solely to climate change, as natural climate variability is also present and may add to or subtract from the climate change effect. With these caveats in mind, the changing climate over this century is projected to lead to the following hydrological effects.

- Average river flows will tend to increase in the west and south of the South Island and decrease in the east and north of the North Island.
- Low flows are expected to become even lower and dry conditions reached earlier following the wet season over most of the country, with the exception of the west of the South Island. This leads to general declines in flow reliability and hence in the duration of irrigation takes from rivers that have no limits.
- Floods, in contrast, are expected to become larger and more frequent, particularly in the south.

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205 P Gluckman. 2017. *New Zealand's Fresh Waters: Values, State, Trends and Human Impacts*. Wellington: Office of the Prime Minister's Chief Science Advisor. This report confirms the climate change impacts on our waterways.

206 NIWA Client Report. 2016. *Climate change impacts on agricultural water resources and flooding.* Prepared for the Ministry for Primary Industries.

- Soil conditions are projected to become drier over much of the country during spring and summer, with earlier onset of dry conditions, while soil conditions are expected to become wetter during winter.

The implications for agricultural water resource and hazard management vary with the hydrological changes. In most cases water demand is projected to increase, but the opportunity to abstract water in these areas is generally expected to decline, putting greater pressure on water resource management and agricultural productivity. The flood hazard is projected to remain about the same or increase; in some areas the increases are substantial. Increased exposure to flooding events is projected for areas with minimal increases in water shortage as well as those with severe increases, potentially compounding the challenges faced by local agricultural activities.

6.2.5 Human health

Some of the impacts of climate change on public health will be direct, such as injury and illness from extreme weather events or increased heat-related deaths (although winter-related deaths are expected to decline), while others will be indirect. These indirect impacts include increased incidences of existing and new diseases.[207] Climate change brings changes to disease vectors worldwide. A warmer and wetter New Zealand means that we may experience diseases not currently present in New Zealand, such as dengue fever, and potentially more frequent pandemics. These impacts will lead to intensified pressures on our health system.

Other indirect risks include increasing stress and mental health issues as a consequence of, for example, extreme weather events, sea-level rise or loss of livelihoods.[208] These events can lead to increased migration and displacement internally, which have implications for stress levels and mental health. They can also lead to an increased risk of household overcrowding as well as other accommodation and housing issues. International migration is also likely to increase as a result of climate change impacts on other parts of the world, which may contribute to housing issues in New Zealand and has the potential to increase the incidence of some infectious diseases, such as tuberculosis (as the risk of infection is increased by household crowding).

Some populations are likely to be more vulnerable than others to the health impacts of climate change. These include Māori (see section 6.3.3), rural communities and lower socioeconomic communities. This vulnerability can result from increased exposure and sensitivity to the effects of climate change and/or a reduced capacity to respond. For example, people on lower incomes are generally less able to protect themselves from extreme weather because they have fewer resources.[209]

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[207] For example: potential increase in food- and water-borne disease (eg, giardiasis and salmonellosis) as a result of changing rainfall, drought and temperature patterns; potential increase in respiratory illnesses as a result of changes in the pollen season; increases in mosquito vectors establishing in warmer regions (eg, malaria).

[208] New Zealand College of Public Health Medicine. 2013. *Climate Change and Health in New Zealand*. Wellington: New Zealand College of Public Health Medicine Retrieved from www.nzcphm.org.nz/media/74098/1._nzcphm_climate_change_policy__final_comms_version2_pdf.

[209] Environment Health Indicators New Zealand. 2017. Climate change is a health issue. Retrieved from www.ehinz.ac.nz/indicators/climate-change/climate-change-is-a-health-issue.

In its policy statement on climate change, the New Zealand College of Public Health Medicine acknowledges the increased likelihood that mosquito vectors could establish in New Zealand as temperatures warm due to climate change, leading to local transmission of diseases such as dengue fever, Ross River virus and West Nile virus.[210] It also discusses the likely impact of climate change on food- and water-borne diseases. For example, heavy rainfall events can transport faecal contaminants into waterways, while temperature increases have been correlated with increased incidences of food-borne diseases such as salmonella (salmonellosis). Increased temperature and changes in rainfall may also impact on parasitic diseases such as crypto (cryptosporidiosis) and giardia (giardiasis). In addition, drier conditions affecting household water supplies may increase the risk of diseases related to hygiene (eg, enteric diseases[211]). Increased food insecurity may also compromise nutrition, especially for vulnerable populations.

The Ministry for Primary Industries has commissioned a report on the impacts of climate change on the food system, particularly looking at food safety through the SLMACC research fund. The report is expected to be completed in 2019.

The Royal Society of New Zealand released a review summary of current evidence around the impacts of climate change on health in New Zealand in 2017.[212] The review outlines the evidence for potential health impacts in New Zealand as a result of climate change.

6.2.6 Infrastructure and economy

Most of New Zealand's major urban centres and the majority of its population are located on the coast or floodplains of major rivers.[213] Communities, homes, commercial assets and infrastructure are exposed to flooding, sea-level rise, storm surge and inundation from rising groundwater levels. A 2015 report from the Parliamentary Commissioner for the Environment contains elevation maps showing that at least 9000 homes lie less than 50 centimetres above spring high-tide levels.[214] Homes, businesses and infrastructure worth billions of dollars have been built on low-lying coastal land in New Zealand.[215]

The agriculture, horticulture, fisheries, aquaculture, forestry and tourism sectors are all significant contributors to New Zealand's economy, and all are dependent on natural resources

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210 New Zealand College of Public Health Medicine. 2013. *Climate Change and Health in New Zealand*. Wellington: New Zealand College of Public Health Medicine Retrieved from www.nzcphm.org.nz/media/74098/1._nzcphm_climate_change_policy__final_comms_version2_pdf.

211 Diseases typically transmitted via ingestion of food or water or exposure to objects contaminated by pathogens. Enteric diseases are frequently characterised by diarrhoea, nausea, vomiting, abdominal cramps, fever and other symptoms.

212 The Royal Society of New Zealand. 2017. *Human Health Impacts of Climate Change for New Zealand.* Wellington: Royal Society of New Zealand. Retrieved from https://royalsociety.org.nz/what-we-do/our-expert-advice/all-expert-advice-papers/climate-change-and-health.

213 Two-thirds of our population live in areas prone to flooding: The Royal Society of New Zealand. 2016. *Climate Change Implications for New Zealand.* Wellington: Royal Society of New Zealand. Retrieved from https://royalsociety.org.nz/assets/documents/Climate-change-implications-for-NZ-2016-report-web3.pdf. Further, 75 per cent of New Zealanders live within 10 kilometres of the coast: Statistics New Zealand. 2006. Are New Zealanders living closer to the coast. Retrieved from www.stats.govt.nz/browse_for_stats/population/Migration/internal-migration/are-nzs-living-closer-to-coast.aspx.

214 Parliamentary Commissioner for the Environment. 2015. *Preparing New Zealand for Rising Seas: Certainty and Uncertainty*. Wellington: Parliamentary Commissioner for the Environment.

215 Ibid.

and the ability to function within the current climate range. They are therefore exposed to climate change impacts. Climate change has the potential to negatively impact on New Zealand's economy as a whole.

The primary industries are particularly exposed to the impacts of climate change. In addition to impacts such as extreme weather events, wildfires and increased competition for water resources as outlined in section 6.2.1, all primary sectors will be affected by impacts that interfere with the ability to get primary products from the farm to processing facilities and then to markets or ports. Climate change impacts may affect transport routes (eg, due to storms and slips closing down transport routes) and also the operation of processing facilities (eg, interruption to the supply of energy or water required for processing).

The Ministry for Primary Industries has also commissioned a number of targeted reports to assess the likely impacts of climate change on critical infrastructure for the rural economy and to assess likely trade impacts. These include:

- impacts on rural water infrastructure
- physical impacts on primary sector infrastructure beyond the farm gate
- climate change and trade
- trends in land use with climate change.

While the impacts on parts of some sectors and communities have been assessed, the financial implications of climate change impacts and adaptation have not been assessed at the national level. This is a gap in New Zealand's knowledge that was identified by the Parliamentary Commissioner for the Environment in her 2015 report on sea-level rise.[216]

6.2.7 Marine environment and fisheries

The New Zealand Government's environment report, *Our Marine Environment*, identified ocean acidification and warming as top issues facing our oceans.[217] The Government has funded a number of research projects to progress the development of a national Marine Environmental Monitoring Programme and to examine the impacts of climate change on New Zealand's marine resources. These include impacts on commercial fish stocks and shellfish behaviour and life history development. The research, commissioned by the Ministry for Primary Industries, 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 (eg, aquaculture).

The mean sea-surface temperature has increased in New Zealand by about 0.71°C in the 100 years up to 2009,[218] and under a high-emissions scenario by 2110 the mean sea-surface temperature is expected to increase by 2.5°C. The north Tasman Sea is expected to experience greater warming than the rest of our surrounding ocean, which could drive regional change in marine ecosystems in the form of fewer temperate species, increased subtropical species and

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216 Ibid.

217 Ministry for the Environment, Statistics New Zealand. 2016. New Zealand's Environmental Reporting Series: Our Marine Environment 2016*.* Retrieved from www.mfe.govt.nz and www.stats.govt.nz.

218 Ibid.

more nutrient-poor conditions.[219] Some species that presently live in lower-latitude regions may migrate into New Zealand waters in response to rising temperatures and changing ecological community structures.[220]

Work is under way to characterise impacts of climate change on commercially caught fish species in the New Zealand region.[221] The clearest example of a link between coastal sea-surface temperature and fish recruitment and growth concerns northern stocks of snapper (*Pagras auratus*), where relatively high recruitment and faster growth rates have been correlated with warmer conditions.[222] Other species where fisheries indices appear to be linked to sea-surface temperature include elephantfish, southern gemfish, hoki, red cod, red gurnard, school shark, stargazer and tarakihi.[223] The causal mechanisms for some of these species are not well understood.

New Zealand's subantarctic waters have become more acidic since measurements were first taken in 1998, and the pH of surface water is expected to decline by 0.33 under the highest emissions scenario by 2100, a rate of change that is unprecedented in the last 25 million years. Marine and coastal species that produce shells or skeletal structures of calcium carbonate, such as pāua, mussels and oysters, and the plankton that support all life in the oceans are particularly vulnerable to climate change because increased acidity interferes with the formation of shells.[224] Organisms most likely to be affected are those at the base of the food chain (bacteria, protozoa and plankton), coralline algae, rhodoliths (maerl), shallow and deep-water corals, echinoderms, molluscs, and possibly cephalopods (such as squids) and high-activity pelagic fish (such as tuna).[225] The New Zealand Ocean Acidification Observing

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219 CS Law, GJ Rickard, SE Mikaloff-Fletcher, MH Pinkerton, R Gorman, et al. 2016. *The New Zealand EEZ and South West Pacific. Synthesis Report RA2, Marine Case Study. Climate Changes, Impacts and Implications (CCII) for New Zealand to 2100*. MBIE contract C01X1225.

220 GJ Molinos, BS Halpern, DS Schoeman, CJ Brown, W Kiessling, et al. 2015. Climate velocity and the future global redistribution of marine biodiversity. *Nature Climate Change* doi:10.1038/nclimate2769.

221 JA Renwick, RJ Hurst, JW Kidson. 1998. Climatic influences on the recruitment of southern gemfish (*Rexea solandri*, Gempylidae) in New Zealand waters. *International Journal of Climatology* 18: 1655–1667; MP Beentjes, JA Renwick. 2001. The relationship between red cod, *Pseudophycis bachus*, recruitment and environmental variables in New Zealand. *Environmental Biology of Fishes* 61: 315–328; M Dunn, R Hurst, J Renwick, C Francis, J Devine, A McKenzie. 2009. *Fish Abundance and Climate Trends in New Zealand.* New Zealand Aquatic Environment and Biodiversity. Report No. 31. Wellington: NIWA.

222 From the Leigh Sea Surface Temperature series. See: MP Francis. 1993. Does water temperature determine year class strength in New Zealand snapper (*Pagrus auratus*, Sparidae)? *Fisheries Oceanography* 2(2): 65–72; MP Francis. 1994. Growth of juvenile snapper, *Pagrus auratus* (Sparidae). *New Zealand Journal of Marine and Freshwater Research* 28: 201–218.

223 RJ Hurst, JA Renwick, PJH Sutton, MJ Uddstrom, SC Kennan, CS Law, et al. 2012. Climate and oceanographic trends of potential relevance to fisheries in New Zealand region. *New Zealand Aquatic Environment and Biodiversity Report* No. 90. Wellington: Ministry for Primary Industries.

224 CS Law, GJ Rickard, SE Mikaloff-Fletcher, MH Pinkerton, R Gorman, et al. 2016. *The New Zealand EEZ and South West Pacific. Synthesis Report RA2, Marine Case Study. Climate Changes, Impacts and Implications (CCII) for New Zealand to 2100.* MBIE contract C01X1225.

225 See RA Feely, CL Sabine, K Lee, W Berelson, J Kleypas, VJ Fabry, et al. 2004. Impact of anthropogenic CO_2 on the CaCO3 System in the oceans. *Science* 305(5682): 362–266, and references therein; JC Orr, VJ Fabry, O Aumont, L Bopp, SC Doney, RA Feely, et al. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. *Nature* 437: 681–686; J Barcelos e Ramos, H Biswas, KG Schulz, J LaRoche, and U Riebesell. 2007. Effect of rising atmospheric carbon dioxide on the marine nitrogen fixer Trichodesmium, *Global Biogeochem Cycles* 21, GB2028, doi: 10.1029/2006GB002898; G Langer, M Geisen, KH Baumann, J Klas, U Riebesell, S Thoms, et al. 2006. Species-specific responses of calcifying algae to changing seawater carbonate chemistry. *Geochemistry, Geophysics, Geosystems* 7, Q09006. doi: 10.1029/2005GC001227.

Network has been established to determine local conditions at a network of coastal sites around the country, and to provide a baseline against which to measure future change.[226]

In deep-sea habitats, increasing acidification may lead to biogenic structures (features that are caused by living organisms or biological processes), such as cold-water corals moving to the tops of seamounts, or widespread die-back.[227] Changes to biogenic structures may have an impact on the organisms that live on or near the seabed, and perhaps also on deep-sea ecosystems in New Zealand waters, and this could potentially affect New Zealand's deep-water fisheries. For example, these biogenic structures are deep sea habitats for commercial fish species, including orange roughy.[228] Conversely, some species, including phytoplankton (microscopic plants drifting or floating in the sea) and sea-grass, may benefit from the increase in dissolved CO_2 due to increased photosynthesis.

The Ministry for Primary Industries has commissioned a range of research that includes exploring the vulnerability of shellfish and echinoderms to ocean acidification in Antarctica, integrated studies of rocky reef systems in New Zealand, and offshore fishery-scale trophic studies. The effects of ocean climate change and ocean acidification on shellfish, rhodolith communities, plankton productivity and the microbial productivity of polar waters are being explored. A major project to investigate shelf communities in relation to climate over the past 1000 years has resulted in the development of new methods, as well as insights into past changes to and human impacts on New Zealand's marine environment.

Modelling work to underpin downscaling from global models to regional models has been supported and experimental work on deep-sea corals completed. While the focus has been ocean acidification and temperature change, oxygen depletion is emerging as an important factor in terms of biomass and ocean productivity under a changing climate.

6.2.8 Culture and cultural heritage

The impact of climate change on New Zealand's culture and cultural heritage is not well understood. Most research has focused on archaeological sites, particularly the ongoing loss of coastal archaeological sites to sea erosion and inundation.[229] Around 50 per cent of recorded archaeological sites are within 1 kilometre of the coast. In addition, numerous Māori cultural heritage and food gathering sites, which are deeply connected with Māori identity, are located in coastal low-lying areas and these sites are more exposed to the impacts of climate change as a result of their location. There is little known about the impact of climate change on New Zealand's built historical environment. Climate change is also likely to have an impact on New Zealand's wider cultural life, for example through its effects on sporting and recreational activities, other cultural events or festivals. In the area of sport, increasing temperatures and more extreme rainfall events could affect where and when sporting events are able to take place, and may result in a requirement for more resilient sporting venues.

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226 www.niwa.co.nz/coasts-and-oceans/research-projects/new-zealand-ocean-acidification-observing-network-nzoa-on

227 RE Thresher, JM Guinotte, R Matear, S Fallon. 2012. *Adapting to the Effects of Climate Change on Australia's Deep Marine Reserves*. Fisheries Research and Development Corporation / National Climate Change Adaptation Research Fund Report 2010/510.

228 DM Tracey, AA Rowden, KA Mackay, T Compton. 2011. Habitat-forming cold-water corals show affinity for seamounts in the New Zealand region. *Marine Ecology Progress Series* 430: 1–22.

229 S Bickler, R Clough, S Macready S. 2013. *The Impact of Climate Change on the Archaeology of New Zealand's Coastline*. Wellington: Department of Conservation. Retrieved from www.doc.govt.nz/documents/science-and-technical/sfc322high_res.pdf.

This will particularly impact on local government, which is responsible for managing many of the parks and reserves.

Snow sports add significantly to the New Zealand economy through tourism. Warm conditions have the potential to affect the availability and cost of winter sport (eg, the cost of making and preserving artificial snow). Summer sports can be affected by extreme heat, creating a health risk.

In 2017/18 the Ministry for Culture and Heritage is beginning a piece of work focusing on the notion of cultural resilience and what it means in the New Zealand context, drawing on recent experiences of disasters, and looks at how cultural resilience contributes to wider community and national resilience. It will provide an overview of the current state of cultural resilience in New Zealand and what a future improved state might look like. The overview will include:

- an environmental scan of the known shocks and stresses to which the cultural sector is exposed
- a discussion of where research needs to be undertaken to understand the current capacity of the cultural sector to deal with such shocks and stresses and what could be done to mitigate such risks
- a consideration of possible issues or barriers to progress and any opportunities.

The work aims to develop a draft action plan proposing a number of actions that together would represent progress from 'current' to 'future' state, and work towards a framework for assisting central and local government and cultural agencies in making investment decisions to improve cultural resilience. The framework would include alignment to Government priorities and actions and take into account the type of risks that the cultural environment faces. Part of this work would include developing proposed indicators for measuring cultural resilience in New Zealand. Climate change will be considered as part of the risks to New Zealand's culture and cultural heritage. Section 6.3.3 has further information on community vulnerability, resilience and adaptation to climate change.

6.3 Vulnerability assessments

In addition to the research described in section 6.2, the New Zealand Government has undertaken work to identify vulnerabilities in the tourism and transport sectors, as well as supporting a community vulnerability research project. These studies are discussed below.

6.3.1 Tourism

The *Preparing the Tourism Sector for Climate Change* project[230] ran over 2009–12 and developed a computer simulation for modelling impacts on the New Zealand tourism sector. The programme, which remains the most up-to-date research on this subject in New Zealand, modelled the long-term effects of changes in prices for a variety of inputs, such as the oil price and exchange rate.

A key part of the research programme was a national-level screening exercise to assess vulnerability to climate change in the tourism sector. A background paper was produced,

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230 This project was funded by the Foundation of Science, Research and Technology and conducted by Lincoln University. See www.lincoln.ac.nz/Research-Centres/LEaP/Tourism-Business--Communities/Projects/Adaptation-to-Climate-Change-in-New-Zealand.

which identified several vulnerabilities. The most significant of these were the skifields around the country, which could be severely affected by climate change. The value of Queenstown as a tourist destination is dominated by the presence of skifields and, because of this vulnerability, it was used as a case study in the report.

The sensitivity of tourism to climate change impacts depends on a range of factors, including:[231]

- how tourists respond to certain climatic conditions
- how important weather and weather-related natural hazards are to tourism businesses in terms of carrying out specific activities
- how infrastructure or wider natural resources relevant to the operation of tourism businesses might be affected by climatic events.

Cultural heritage and visitor assets will be affected by climate change. Both Fox and Franz Josef glaciers are under pressure due to the glaciers receding in response to climate change, in combination with an increase in helicopter activity and landings in response to increasing visitor pressure.[232] The number of international visitors to New Zealand is expected to rise to 4.5 million a year over the next five years, so visitor pressures are expected to continue to increase.[233]

The ski industry is one of the most climate-dependent tourism subsectors, and as such more research has focused on the impacts of climate change on this subsector than on others. While it is hard to predict future tourist behaviour, climate change may bring benefits for ski tourism in the short term due to less snow in Australia. However, in the long term, higher temperatures and fewer snow days will negatively impact on the industry, particularly those in lower-elevation sites. Tourism at Fox and Franz Josef glaciers will also be at risk as these glaciers further recede.

The impacts of climate change can also result in new opportunities. For example, the melting of the Tasman Glacier in Aoraki National Park has created a terminal lake. Tourism boating operations on this new lake are creating millions of dollars of revenue for New Zealand.[234] Conversely routes accessing Mount Cook have changed significantly over time, creating new risks or limiting options for climbers.[235]

6.3.2 Transport

In 2009 the New Zealand Transport Agency published a report on a two-stage project to identify and assess the impacts climate change may have on New Zealand's land transport networks (road, rail, ports and coastal shipping).[236] The project examined the regional effects

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231 S Becken, G Butcher, J Edmonds, J Hendrikx, K Hughey, et al. 2010. A national-level screening exercise to assess tourism's vulnerability to climate change. Retrieved from www.lincoln.ac.nz/PageFiles/6750/NationalScreeningOverview.pdf.

232 Department of Conservation. 2017. pers. comm.

233 Ibid.

234 Ibid.

235 Ibid.

236 MWH New Zealand Limited, NIWA, SmartAlliances Ltd. 2009. *Climate change effects on the land transport network.* Report 378. Wellington: New Zealand Transport Agency. Retrieved from www.nzta.govt.nz/resources/research/reports/378.

of climate extremes on transport networks, how these vary by region, when and where these risks emerge, and which parts of the land transport networks are most vulnerable. The study describes three national climate change profiles, covering rail heat buckle from extreme temperature, flood risk from extreme rainfall, and coastal inundation risk from low-lying sections of the networks.

Data from transport agencies and port authorities were used to assess the current vulnerability of networks to extreme weather. Extrapolation was used to predict future effects based on modelling of climate extremes for 10-, 50- and 100-year projections using a mid-range emissions scenario from the IPCC *Fourth Assessment Report*. Regional impacts were determined on maps by overlaying climate change projections with transport infrastructure. Priority adaptation responses were discussed for each national profile in the context of design, operation, research and policy issues, and related emerging climate change research.[237]

The Parliamentary Commissioner for the Environment investigated the exposure of transport networks to sea-level rise in her 2015 report. In the main urban centres of Auckland, Wellington, Christchurch, Dunedin and Tauranga, 89 kilometres of roads are less than 50 centimetres above the mean high-water spring.[238] Nationally, 2121 kilometres of roads are located in areas less than 1.5 metres above the mean high-water spring, as are five airports and 46 kilometres of railways.[239]

Auckland Airport has commissioned two studies to better understand and manage the risk of sea-level rise and inundation. One study is on sea-level rise (2016) and the other on the impact of sea-level inundation on their storm water network.

6.3.3 Community vulnerability, resilience and adaptation to climate change

The *Community vulnerability, resilience and adaptation to climate change, 2008–2013* research programme is still the most comprehensive study produced on this subject in New Zealand. The key findings of that programme included:[240]

- Community vulnerability will be affected by warmer temperatures, more intense flooding and a significant rise in sea level, occurring as a result of climate change. However, magnitudes and rates of change of these impacts cannot be defined precisely. Planning for the future will therefore be carried out in the knowledge of likely impacts but with uncertainty about their onset and magnitude.
- Vulnerability will be further exacerbated by extreme events, which are likely to become more frequent and may start creating conditions that have not been experienced previously. The role that flexible and anticipatory land-use planning can play in addressing a range of climate conditions was highlighted, consistent with the findings in the IPCC's

[237] Ibid.

[238] Parliamentary Commissioner for the Environment. 2015. *Preparing New Zealand for Rising Seas: Certainty and Uncertainty*. Wellington: Parliamentary Commissioner for the Environment.

[239] Ibid.

[240] www.victoria.ac.nz/sgees/research-centres/ccri/research/community-vulnerability,-resilience-and-adaptation-to-climate-change,-2008-2013.

special report, *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*.[241]

- Potential damages can be underplayed in risk communications, with implications for vulnerability.
- Changes in sea level and flooding highlight the value to local government of new assessment and planning methods that address changing risk over long timeframes for assets and settlements that have long lifetimes.
- Water security at the local level was identified as an issue. Greater efficiency of use through a wider range of measures to support water conservation, metering and distributed water provision is needed.
- Changes in public health risks were explored, and the programme has started specific monitoring of heat exposure in outdoor workers, developed empirical models for relating communicable disease to social and climatic factors, and assessed the effect of rainfall variability on households and others relying on rainwater tanks.
- The Māori community research led to the identification of four principal determinants of community sensitivity and adaptive capacity, in line with previous studies: social networks, conventions and transformation; knowledge, skills and expertise; resourcing and finance; and institutions, governance and policy.
- The adaptive capacity of New Zealand communities is deeply connected to existing socio-economic, political and environmental conditions. This requires further analysis to integrate information from scientists, policy analysts and decision-makers to develop strategies and policies that can tackle vulnerability and enhance the ability to adapt.

The Massey University Centre for Public Health released a factsheet on New Zealand's vulnerability to climate change in 2014.[242] Potentially vulnerable groups highlighted in the factsheet include babies and young children, the elderly, indigenous populations and those living in poverty. The factsheet emphasises that identification of the location, size and type of vulnerable groups in a community is needed in order to help plan what additional support might be required for these groups to adapt to climate change.

The analysis suggests that Māori are more likely to be vulnerable to climate change as a greater proportion of Māori live in the north and east, where the most warming is projected to occur and where rainfall is expected to decrease, and also because the Māori economy is heavily reliant on climate-sensitive primary industries. However, it is also noted that factors such as whānau (extended family) support will increase adaptive capacity of Māori.

In summary, the following communities are considered to be more vulnerable to the impacts of climate change.

- **Māori** – their significant reliance on the environment as a cultural, social and economic resource makes Māori vulnerable to the impacts, some of which they are already experiencing,[243] as their livelihoods are exposed to the impacts of climate change on the

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[241] IPCC. 2012. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge and New York: Cambridge University Press. Retrieved from www.ipcc.ch/report/srex.

[242] www.ehinz.ac.nz/assets/Factsheets/Released-2014/EHI-VulnerabilityToClimateChange2013-released201407.pdf

[243] For example, erosion at the coast revealed human bones from a sacred Māori burial site in the Waimea inlet in January of this year.

natural environment. For example, the Māori economy relies heavily on primary industries. Different Māori communities face different climate change risks, as some communities will be more vulnerable to the impacts of climate change than others.

- **Communities in low-lying areas** – people living close to the coast and on floodplains are more exposed to flooding and other coastal hazards, the frequency and intensity of which are expected to increase as a result of climate change. Not all of these communities are equally vulnerable as their ability to adapt will differ.
- **Rural communities dependent on non-reticulated water resources** (eg, rainwater tanks) – increased pressure on freshwater resources is an expected impact of climate change,[244] and the reductions in drinking-water availability due to changing hydrological regimes are expected to seriously affect these places and populations.[245]

6.3.4 Primary sector

A wide range of central government–funded research has been undertaken on the implications of climate change for the primary sector and options for how to adapt. Most of this information has been collated into one website (the Climate Cloud[246]) for ease of accessibility.

A review of existing research on the impacts and implications of climate change for the primary sector is currently under way to identify key messages, areas of focus, outcomes achieved to date and gaps in knowledge. This review will be completed in June 2018.[247]

The Government is currently funding a three-year research programme to evaluate the risks and opportunities for the seafood sector that will result from climate change effects in the ocean. The project will produce a technical overview of changes in the ocean and a stakeholder report that will provide current risk assessments of the vulnerability of fisheries to climate change effects in New Zealand waters.

6.4 Adaptation measures

6.4.1 Overview

The role of the New Zealand Government in adapting to climate change is focused on:

- setting the legislative and policy framework
- providing information and guidance to support local government and private parties to make effective adaptive decisions
- funding research and publishing information to understand climate change impacts and support climate change adaptation
- preparing for and responding to major natural hazard events.

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244 The Royal Society of New Zealand. 2016. *Climate Change Implications for New Zealand.* Wellington: Royal Society of New Zealand. Retrieved from https://royalsociety.org.nz/assets/documents/Climate-change-implications-for-NZ-2016-report-web3.pdf

245 Ibid. Ministry of Health. 2016. *New Zealand Health Strategy: Future Direction*. Wellington: Ministry of Health.

246 http://climatecloud.co.nz/Pages/default.aspx

247 Mind the Gaps: Synthesis and Systematic Review of Climate Change Adaptation in New Zealand's Primary Industries study led by Landcare Research with other collaborators. It involves assessing SLMACC adaptation research projects from 2008 to current projects and will be completed by June 2018.

Framework

New Zealand has a devolved system of resource management. The key piece of legislation is the Resource Management Act 1991, which sets out how New Zealand manages its environment. The Act requires all persons exercising duties and functions under the Act to have particular regard to the effects of climate change. Managing the effects of climate change in New Zealand is undertaken as part of wider natural hazards management. Natural hazards management in New Zealand is a function of local authorities under the Act.[248] The Resource Legislation Amendment Act 2017 introduced "the management of significant risks from natural hazards" as a new matter of national importance in section 6 of the Resource Management Act.

The Government also provides national policy direction to local government under the Resource Management Act. The National Policy Statement for Freshwater Management has been produced during the reporting period (in 2014) and is discussed below.

Climate Change Adaptation Technical Working Group

In November 2016 the Minister for Climate Change Issues appointed the Climate Change Adaptation Technical Working Group.[249] The Group is made up of technical experts across government and the private sector, and its mandate is to provide advice on options for adapting to the effects of climate change. The Group, whose work is funded for a period of 18 months, will provide advice on options for building New Zealand's resilience to the effects of climate change while sustainably growing the economy. The Group began its work with a stocktake of existing adaptation work across central and local government and the private sector. Building on the stocktake, the Group will produce a draft report by November 2017 containing options and recommendations for how New Zealand can build resilience to the effects of climate change while growing our economy sustainably. A final report is due with the Minister of Climate Change Issues in March 2018.

Information and guidance

The New Zealand Government provides information and guidance on the climate change effects considered most likely to have a significant impact at a regional, national or sectoral level, and the expected timing of these effects. This information and guidance is provided so that local government, engineers, businesses and individuals have access to the information they need in order to adapt.

The Ministry for the Environment has produced technical guidance manuals that provide detailed information on climate change impacts and help local government and other decision-makers plan for the effects of climate change. The three technical manuals cover information on:

- general climate change impacts
- coastal hazards and climate change
- climate change and flooding.

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248 A natural hazard is defined in section 2 of the Resource Management Act as any atmospheric or earth- or water-related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire or flooding), the action of which adversely affects or may adversely affect human life, property or other aspects of the environment.

249 www.mfe.govt.nz/climate-change/adapting-climate-change/climate-change-adaptation-technical-working-group

Because these manuals contain a large amount of detailed information, summary reports have also been developed that present the key information in an easy-to-understand format.

The technical manual *Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand* (2nd edition, May 2008)[250] was produced for New Zealand's local government and updates the 2004 edition to include the findings of the IPCC's *Fourth Assessment Report*.[251] This manual contains information on trends in New Zealand's historical climate and scenarios of future climate change. *Preparing for Climate Change*[252] (July 2008) is the accompanying summary publication. This is still the most recent edition of this manual, but the projections of future climate it contains were updated during the reporting period and published in the 2016 report *Climate Change Projections for New Zealand.*[253] These projections are based on the IPCC's *Fifth Assessment Report*.[254]

Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand[255] (July 2008) is a technical guidance manual that provides information on planning for climate change in the coastal margins. This report also includes information from the IPCC's *Fourth Assessment Report*. *Preparing for Coastal Change*[256] (March 2009) is the accompanying summary publication.

An update of *Coastal Hazards and Climate Change* was started during the reporting period. The updated guidance includes the latest science and relevant legislation, as well as information from the Parliamentary Commissioner for the Environment's 2015 report on sea-level rise, and feedback from stakeholders. It also contains more information on the planning process than the 2008 guidance. The most important addition is the recommendation of a new "pathways" approach to adaptive planning that is dynamic and flexible. It is designed to be used when there is uncertainty about future physical conditions affecting the coastal environment. This uncertainty is unavoidable in matters involving future climate change, especially on longer timeframes. It should help councils avoid making drastic interventions too early, and help residents accept the need for some action early, as part of long-term adaptation.

The updated guidance also introduces new material on hazard, risk and vulnerability assessments, and collaborative approaches to engaging with communities. In addition, it contains new sections on local government roles and responsibilities, dealing with uncertainty, and the adaptive planning approach.

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250 Ministry for the Environment. 2008. *Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand* (2nd edn). Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate/climate-change-effect-impacts-assessments-may08.

251 IPCC. 2009. *Fourth Assessment Report*. Retrieved from www.ipcc.ch/report/ar4.

252 Ministry for the Environment. 2008. *Preparing for Climate Change*. Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate/preparing-for-climate-change-guide-for-local-govt.

253 Ministry for the Environment. 2016. *Climate Change Projections for New Zealand.* Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/sites/default/files/media/Climate%20Change/nz-climate-change-projections-final.pdf.

254 IPCC. 2013. *Fifth Assessment Report*. Retrieved from www.ipcc.ch/report/ar5.

255 Ministry for the Environment. 2008. *Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand.* Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate/coastal-hazards-climate-change-guidance-manual.

256 Ministry for the Environment. 2009. *Preparing for Coastal Change* Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate/preparing-for-coastal-change-guide-for-local-govt.

The third technical manual, *Tools for Estimating the Effects of Climate Change on Flood Flow: A Guidance Manual for Local Government in New Zealand* (May 2010),[257] describes techniques for including climate change in flood planning, and tools for estimating the effect of climate change on flood flow. The accompanying summary publication is *Preparing for Future Flooding: A Guide for Local Government in New Zealand*, which was also released in May 2010.[258]

The New Zealand Government will continue updating the information contained in the above publications following each assessment report of the IPCC.

During the reporting period, the Ministry for the Environment also released an information sheet entitled *New Zealand's Framework for Adapting to Climate Change* (August 2014). The document, which is available on the Ministry's website, helps create a broader understanding of New Zealand's framework for adapting to climate change and details four areas: information, responsibilities, investment and action.[259]

Research

The New Zealand Government invests in research to better understand the impacts, vulnerabilities and adaptation options for climate changes specific to New Zealand (see also section 8.4.6). Changes in research funding (discussed in section 8.2.2) have made research on the impact of and adaptation to climate change part of the expected work programmes of a number of Crown research institutes and universities. There is an expectation that this research will be conducted together with the end-users of the research who make decisions about how to respond to climate change.

In 2015/16 the Government invested a total of NZ$27.2 million in climate change research. The following research and information work funded by central government is related to impacts and adaptation.

- **National Science Challenges**[260] include a number of Challenges that are relevant to adaptation. One example is the Deep South Challenge, described in more detail below. Another Challenge, Resilience to Nature's Challenges (2014–19), 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.

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257 Ministry for the Environment. 2010. *Tools for Estimating the Effects of Climate Change on Flood Flow: A Guidance Manual for Local Government in New Zealand*. Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate-change/tools-estimating-effects-climate-change-flood-flow-guidance-manual-lo-10.

258 Ministry for the Environment. 2010. *Preparing for Future Flooding: A Guide for Local Government in New Zealand.* Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate-change-hazards/preparing-future-flooding-guide-local-government-new-zealand.

259 Ministry for the Environment. 2010. *New Zealand's Framework for Adapting to Climate Change*. Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate-change/new-zealands-framework-adapting-climate-change.

260 www.mbie.govt.nz/info-services/science-innovation/national-science-challenges

- **The Deep South Challenge** (2015–19)[261] has three research programmes: Processes and Observations, Earth System Modelling and Prediction, and Impacts and Implications. It also has two cross-cutting programmes: Engagement and Vision Mātauranga.[262]
- **The Sustainable Land Management and Climate Change (SLMACC) research programme,** launched in 2007 and ongoing, aims to help the agriculture and forestry sectors address the challenges arising from climate change. Much of the output from the programme has been compiled into a web-based adaptation resource, www.climatecloud.co.nz.
- **The Coastal Acidification – Rate, Impact and Management Project** (2016–19)[263] will provide new knowledge on coastal acidification to enhance the protection and management of coastal ecosystems.
- **The Climate Change Impacts and Implications project** (2012–16)[264] focused on the projected climate conditions and variability, their impacts and implications for New Zealand, and the significance of considering climate change impact in decision-making. It was also concerned with enhancing capacity and increasing coordination to support this.
- **Climate Change Projections for New Zealand** (2016)[265] provides updated projections of atmospheric changes in New Zealand as a result of climate change.
- **Environmental Health Indicators New Zealand** (2014)[266] monitors New Zealand's health through a set of environmental health indicators related to climate change.
- **Natural Hazards Research Platform** (2009–present)[267] provides long-term funding for natural hazards research.

The mission of the **Deep South National Science Challenge**, established in 2015, is to enable New Zealanders to adapt, manage risk and thrive in a changing climate. The Challenge aims to achieve this through a framework that connects society with scientists through the five interlinked research and cross-cutting programmes listed above. Working with communities and industry they will bring together new research approaches to determine the impacts of a changing climate on our climate-sensitive economic sectors, infrastructure and natural resources to guide planning and policy. This will be underpinned by improved knowledge and observations of climate processes in the Southern Ocean and Antarctica – our Deep South –and will include development of a world-class earth systems model to predict Aotearoa New Zealand's climate.

The most relevant of the five programmes in terms of climate change adaptation is Impacts and Implications. The programme aims to understand the potential impacts and implications of climate change for New Zealand in order to support planning and decision-making, and aid adaptation efforts. Four areas of particular interest to New Zealanders have been identified:

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261 www.deepsouthchallenge.co.nz

262 The Vision Mātauranga programme of research is strengthening connections between Māori and the science system to increase knowledge transfer between these groups, and increase iwi- and hapū-led research and development strategies (Deep South Challenge).

263 www.niwa.co.nz/coasts-and-oceans/research-projects/carim-coastal-acidification-rate-impacts-management

264 http://ccii.org.nz

265 www.mfe.govt.nz/sites/default/files/media/Climate%20Change/nz-climate-change-projections-final.pdf

266 www.ehinz.ac.nz/indicators/climate-change

267 www.naturalhazards.org.nz

- extreme weather events
- drought
- changes in typical weather patterns
- sea-level rise.

The Impacts and Implications programme builds on the recently completed Climate Change Impacts and Implications project mentioned above. It consists of three inter-related research themes:

- physical impacts, such as sea-level rise and changing temperatures
- social and socio-economic impacts, such as how the physical changes will impact on different groups within New Zealand society
- environmental impacts, including how climate change will impact New Zealand's natural environment.

In order to effectively model and understand the impacts of climate change, the theme will bring together the different impacts and explore how these interact with each other.

The following projects have been supported as part of the Deep South Science Challenge:

- the impact of climate change on New Zealand's frozen water resources (Core 2017)
- national hydrological and water resource impacts of climate change (Core 2017)
- incorporating climate change impacts in land-use suitability (Core 2017)
- robust adaptation decision-making under uncertainty in the water sector (Core 2017)
- supporting decision-making through adaptive tools in a changing climate (Core 2017)
- climate change and the Earthquake Commission (Core 2017)
- cascading impacts and implications for Aotearoa New Zealand (Contestable 2016)
- emergent exposure of flood inundation hazards under future climate change in New Zealand.

The Government helped to fund the Climate Change Impacts and Implications project, which ran from October 2012 to September 2016. The project generated new knowledge about the potential impacts of climate change on New Zealand's environment, including natural ecosystems and native species, and productive activities. The research was undertaken by Crown research institutes, universities and private research agencies.[268]

The Climate Change Impacts and Implications project covered five inter-related research areas:

- improved climate projections
- case studies of key pressures, critical time steps, and potential responses for five important environments: alpine and high-elevation native forest ecosystems; high- and hill-country environments; lowland environments; coastal and estuarine systems; and marine food webs
- identifying feedbacks, understanding cumulative impacts and recognising limits

268 http://ccii.org.nz/our-partners-2/research-partners

- increasing the relevance of climate change science and decision-making capacity to consider climate change risks through collaborative learning processes
- synthesising the research to support coordinated, evidence-based decision-making and policy development by New Zealand organisations.[269]

The Government established the Natural Hazards Research Platform in 2009 to provide secure, long-term funding for natural hazards research. The initiative also helps research providers and end users to work more closely together. Research undertaken as part of the Platform includes research into hazards expected to be exacerbated or made more frequent by climate change. This includes developing quantitative estimates of flood, snow, wind, rainstorm and landslide activity in New Zealand. The research also evaluates how well New Zealand society is prepared for these hazards. Risk models include data on different vulnerabilities in different parts of New Zealand, and the age and quality of buildings and infrastructure. Social science and land-use planning applied to natural hazards are a distinctive and important part of the research.

The Government has also provided support and funding for *Envirolink*, a regional council-driven investment scheme that supports the uptake of research on environmental issues relevant to regional council management. *Envirolink* grants over the period have supported work on climate issues, including in the area of adaptive risk management as it relates to council decision-making on changing climate risks.[270]

National direction on natural hazards

The Ministry for the Environment is in the early stages of policy development for national direction on natural hazards. National direction would support the inclusion of "the management of significant risks from natural hazards" as a new matter of national importance in section 6 of the Resource Management Act 1991. National direction may take the form of a National Policy Statement and associated guidance on natural hazard risk management. There are significant overlaps between the key challenges for effective climate change adaptation and natural hazard risk management, and the reports produced by the Climate Change Adaptation Technical Working Group may feed into the development of natural hazard policy.

6.4.2 Specific adaptation responses

Agriculture and forestry

Sustainable Land Management and Climate Change Plan of Action

In September 2007 the Government outlined an integrated package for the land-based sectors called the Sustainable Land Management and Climate Change Plan of Action. The Plan of Action, which has been in operation during the reporting period, covers all aspects of climate change in the land-based sectors, including impacts and adaptation. For more information on the Plan of Action, see section 4.3.5.

The Plan of Action has helped to deliver climate change resources and demonstration programmes to rural professionals and land managers through the Climate Change Research and Technology Transfer Fund. In 2010 the Government funded a five-year technology transfer programme to promote more resilient farming practices in New Zealand. The programme:

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[269] http://ccii.org.nz/about-ccii

[270] The results are available on the *Envirolink* website: www.envirolink.govt.nz.

- develops climate change information and provides it to land managers and their advisors
- runs demonstration programmes
- provides programmes on climate change to support and train rural professionals.

As part of the programme a number of reports, factsheets and case studies have been placed on the Ministry for Primary Industries' website, along with a toolbox to help land managers respond to climate change.

There have been eight projects (totalling NZ$3.5 million) contracted since the Fund's inception in 2010. These projects have focused on developing climate change resources, holding sector-specific technology transfer events, and developing the Climate Cloud, a digital library of information related to climate change in New Zealand for land managers. For more information about the Climate Cloud digital library, see section 9.3.4. In addition, one project focuses on upskilling rural professionals throughout New Zealand.

The technology transfer programme complements work already being carried out in a range of primary sector organisations. These organisations fund industry-good research, extension and technology transfer, and provide training for members. Research and technology transfer has also been ongoing under the Sustainable Farming Fund, administered by the Ministry for Primary Industries, which includes work to improve water management and irrigation efficiency.

Adverse events in the primary sector

The New Zealand Government supports rural communities and individuals to recover from adverse events, including climatic events and biosecurity incursions where the impact of the event is beyond the capacity of the community to cope. The first points of contact for help during or after an adverse climatic event include civil defence groups, the local rural support trust (see below), and other sector or social support organisations. Adverse climatic events include storms, droughts, floods and snow. The Ministry for Primary Industries has three classifications for adverse events: localised, medium scale and large scale. This classification helps decide what level of government support will be available. Planning ahead for adverse events is strongly encouraged. Rural communities and individuals are encouraged to adapt and build resilience to adverse events.[271]

Rural support trusts

A nationwide network of rural support trusts has been established to help support rural people and their families during and after extreme weather or other natural disasters that affect their property and livelihoods. This includes pastoral farming, forestry, horticulture and other land-based activities. The trusts work with a range of organisations, including local civil defence organisations,[272] and can provide information and recovery assistance during and following an adverse event. Assistance may include access to financial support, labour, technical information, psychosocial support or help for other needs, depending on the event's scale and severity.

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[271] www.mpi.govt.nz/protection-and-response/responding/adverse-events

[272] Local government in New Zealand is responsible for civil defence in local areas. For more information, see www.civildefence.govt.nz.

Many of the trusts also provide their services in times of general hardship, such as personal and/or financial difficulties. The trusts can generally help rural people by referring them to professional support and advice, such as counselling, financial advice and farm management expertise. Help may also include providing mentors or colleagues from rural backgrounds to talk to, facilitating financial assistance, Work and Income support,[273] and labour assistance.

Irrigation

Irrigation development, particularly water harvesting and storage, also has a climate change adaptation function. Drought risk management and mitigation (future proofing) provides resilience both for farm-level businesses and for regional economies. The Ministry for Primary Industries administers the Irrigation Acceleration Fund (IAF), which is intended to help realise the potential for irrigation infrastructure to contribute to sustainable economic growth throughout New Zealand. It will be a key tool in climate change adaptation.

On 1 July 2016 a Cabinet decision was made to transfer the majority of Crown funds for the development of water storage and distribution infrastructure of large-scale (regional) proposals to Crown Irrigation Investments Limited (CIIL). The Ministry for Primary Industries retains the responsibility for funding Strategic Water Management Studies and developing community-scale irrigation schemes. In order to progress to construction, proposed irrigation schemes must be technically and commercially robust and demonstrate a high level of community support. The proposals will inform the analyses and decision-making of potential investors in both scheme construction and commissioning.

As of 1 July 2016, the IAF and CIIL were allocated NZ$25 million for a new multi-year appropriation. With the transition of regional-scale schemes to CIIL, the development funding for irrigation infrastructure is now split into NZ$22.5 million for CIIL and NZ$2.5 million for the IAF. CIIL has had a successful budget bid for an additional NZ$26 million in grant funds for projects. There is the potential for these funds to develop schemes that will mitigate the effects of climate change, such as the Managed Aquifer Recharge trials.

A significant milestone for the IAF was the funding of two Managed Aquifer Recharge trials. These trials are investigating how water can be stored underground when rain is plentiful, for use as irrigation at times when rain is scarce. While there is still a significant amount of research to be completed, the results have been promising so far, and this infrastructure has the potential to mitigate the effects of increased dry days and extreme rainfall events.

Biodiversity and native ecosystems

In 2014 the Department of Conservation produced a report titled *Adapting to Climate Change: A Proposed Framework for Conservation of Terrestrial Native Biodiversity in New Zealand*.[274] This report outlines how management of climate change impacts should be integrated into the Department's existing natural heritage management framework. This framework seeks to manage the full range of New Zealand's ecosystems and species to encourage resilience against threats such as climate change. Implementing this framework, which includes identifying high-priority issues for climate change adaptation, is in its initial stages. Other

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[273] Work and Income is a service of the Ministry of Social Development. Work and Income provides government support by way of financial assistance and employment services throughout New Zealand.

[274] Department of Conservation. 2014. *Adapting to Climate Change: A Proposed Framework for Conservation of Terrestrial Native Biodiversity in New Zealand* Wellington: Department of Conservation. Retrieved from www.doc.govt.nz/Documents/science-and-technical/sap257.pdf.

work by the Department of Conservation that can also be considered climate change adaptation includes:

- incorporating climate change risks into new national park plans, alongside natural hazard assessments
- more frequent 'Battle for our Birds' landscape-scale pest control in beech forests, in response to mast-seeding events, partially driven by climate, and subsequent predator irruptions
- wilding pine control (in partnership with the Ministries for Primary Industries and the Environment) to improve water yield in dry eastern South Island catchments.

Coastal zones

The *New Zealand Coastal Policy Statement 2010*, published during the previous reporting period, remains in effect during this reporting period.[275] This is a national policy statement under the Resource Management Act 1991 and provides direction to local government on the management of activities in the coastal environment, including the management of coastal hazards and the effects of climate change.

The Coastal Policy Statement includes general principles for the sustainable management of New Zealand's coastal environment along with national priorities for the preservation of its natural character. It also contains specific policies regarding the management of coastal hazards and requires consideration of the effects of climate change. Directions include the following:

- the assessment of coastal hazard risks must take account of climate change.[276]
- a precautionary approach is to be applied in the use and management of coastal resources that are potentially vulnerable to the effects of climate change.[277]
- integrated management of the coastal environment must include considering physical changes to the coast resulting from climate change.[278]
- assessments of areas potentially affected by coastal hazards should use a 100-year risk assessment timeframe and include an assessment of sea-level rise and other climate change effects.[279]

The Department of Conservation has made information on the background and intent behind the above policy directions available on its website.[280] It is also preparing guidance to support interpretation of the policies by local authorities, with guidance on the natural hazards policies scheduled for release in 2017/18. This guidance is complementary to the Ministry for the Environment's updated *Coastal Hazards and Climate Change* guidance, also scheduled for release in 2017/18.

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275 Department of Conservation. 2010. *New Zealand Coastal Policy Statement 2010*. Wellington: Department of Conservation. Retrieved from www.doc.govt.nz/conservation/marine-and-coastal/coastal-management/nz-coastal-policy-statement.

276 Ibid. Objective 5.

277 Ibid. Policy 3.

278 Ibid. Policy 4.

279 Ibid. Policy 24.

280 www.doc.govt.nz/conservation/marine-and-coastal/coastal-management/nz-coastal-policy-statement

As noted above, the Ministry for the Environment provides information and guidance to local authorities planning for climate change in the coastal zone.[281] The 2008 guidance for coastal hazards and sea-level rise uses a risk-based assessment and recommends planning for a base value sea-level rise of 0.5 metres by the 2090s (2090–2099) relative to the 1980–1999 average, along with an assessment of the potential consequences from a range of possible higher sea-level rises. At the very least, all assessments should consider the consequences of a mean sea-level rise of at least 0.8 metres relative to the 1980–1999 average.

For planning for the period beyond 2100, an allowance for sea-level rise of 10 millimetres per year beyond 2100 is recommended.[282] The soon-to-be released update of the coastal hazards guidance will update the sea-level rise allowances to be used in planning (while still advising councils to use a risk-based approach).

The Government supports a number of 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.

Of particular relevance is the four-year Coastal Adaptation to Climate Change project led by NIWA.[283] It was set up to create information and tools to promote adaptation to the impacts of climate-induced change on the coastal environment. The project provided a national perspective on how adaptation to coastal changes can be facilitated at the regional and local levels to address specific local issues.

Key outcomes of the project were to enable more informed communities and to help local authorities develop local adaptation plans that encompass community values. The adaptation guidance *Pathways to Change* was published in November 2011 and is a synthesis of findings from the overall programme.[284]

The Coastal Adaptation to Climate Change project included the development of the Coastal Vulnerability Index and the Coastal Sensitivity Index. These indices were developed as a way of characterising the relative vulnerability of coasts to hazards. The Coastal Sensitivity Index provides a snapshot of the potential sensitivity of New Zealand's non-rocky coastline to coastal inundation (flooding) and coastal erosion as a result of climate change in the future. The index can be viewed online as maps of coastal inundation and coastal erosion. Mapping the Coastal Sensitivity Index for New Zealand is a first step in understanding where the impacts of climate change on the coast may be most significant, and where adaptation activities would be most usefully targeted. It will also raise community awareness about coastal hazards and how they are likely to be affected by climate change.

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[281] Ministry for the Environment. 2008. *Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand*. Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate/coastal-hazards-climate-change-guidance-manual.

[282] Ibid.

[283] This project ran from July 2008 to September 2012 and was funded by the Ministry of Business, Innovation and Employment (MBIE contract C0X0802). For more information, see www.niwa.co.nz/climate/research-projects/coastal-adaptation-to-climate-change.

[284] NIWA. 2011. *Coastal Adaptation to Climate Change: Pathways to Change*. Retrieved from www.niwa.co.nz.

Local government in New Zealand is making efforts to tackle sea-level rise and the increased risk of coastal hazards expected as a result of climate change. Only one council (the Tasman District Council) has removed some coastal areas from residential zoning. However, the Auckland Council now requires that houses built in at-risk coastal zones are raised by 1 metre further than previously required. Additionally, in 2017 Dunedin City Council introduced new minimum floor levels for new residential builds across low-lying parts of the city. This was in response to floods in June 2015. For areas that flooded in 2015, the new minimum floor levels will be set at the height of the floodwaters, plus another 0.4 metres. In other areas identified as flood prone but not affected by the floods, the new minimum floor levels will be ground level plus an additional 0.5 metres.

Emergency management

The Civil Defence Emergency Management Act 2002 provides for the comprehensive management of hazards and risks, and emergency response and recovery, through coordinated and integrated policy, planning and decision-making processes at the national and local levels. It sets out the duties, functions and powers of central government, local government, emergency services, lifeline utilities and the general public. The current National Civil Defence Emergency Management Strategy 2007 is being reviewed and will better reflect the requirements of the United Nations Office for Disaster Risk Reduction's (UNISDR's) Sendai Framework Agreement. A revised Strategy is due to be completed in 2018. The responsible Minister has also established a technical advisory group to review emergency response arrangements at both the national and local levels. The group is to report back in August 2017.

The Ministry of Civil Defence and Emergency Management has integrated preparing for climate change into aspects of its work programmes, including the following:

- climate change and climate variability are included as modifying factors for coastal, weather and climate-related hazards in the *National Hazardscape Report*[285]
- the National Civil Defence Emergency Management Strategy[286] and the National Civil Defence Emergency Management Plan and Guide[287] recognise considering the implications of climate change for civil defence emergency management when undertaking hazard risk reduction, and emergency readiness, response and recovery planning.

In addition, the Ministry of Civil Defence and Emergency Management encourages including messages about climate change adaptation in communications with stakeholders.

285 Officials' Committee for Domestic and External Security Coordination. 2007. *National Hazardscape Report*. Wellington: Officials' Committee for Domestic and External Security Coordination. Retrieved from www.civildefence.govt.nz/resources/national-hazardscape-report.

286 Department of Internal Affairs. 2007. National Civil Defence Emergency Management Strategy. Wellington: Department of Internal Affairs. Retrieved from www.civildefence.govt.nz/assets/Uploads/publications/national-CDEM-strategy-2008.pdf.

287 National Civil Defence Emergency Management Plan Order 2015. Retrieved from www.legislation.govt.nz/regulation/public/2015/0140/latest/DLM6486453.html?src=qs%20.

Department of the Prime Minister and Cabinet. *The Guide to the National Civil Defence Emergency Management Plan 2015*. Wellington: Department of the Prime Minister and Cabinet. Retrieved from www.civildefence.govt.nz/cdem-sector/cdem-framework/guide-to-the-national-civil-defence-emergency-management-plan.

Fresh water

Freshwater management in New Zealand is largely devolved to regional councils 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. See section 4.3.5 for more details.

In 2014 the National Policy Statement for Freshwater Management came into effect. *A Guide to the National Policy Statement for Freshwater Management 2014*[288] states that, in setting limits, it is important to consider matters such as:

- changes in the frequency and severity of droughts
- changes in the frequency and severity of heavy rainfall and flushing or flooding events
- changes in temperatures, which may influence algal blooms, increase pressure from invasive aquatic species or change water quality
- sea-level rise, which may affect salinisation, saltwater intrusion and groundwater quality in some areas
- exacerbation of existing anthropogenic effects (eg, land-use impacts, flooding or nutrient runoff) – degraded ecosystems are less resilient to additional pressures, including those resulting from climate change
- the presence or absence of natural features to mitigate the effects of climate change, including:
  - shading (and cooling) effects provided by riparian vegetation
  - wetlands providing a water source for irrigation
  - deterioration of water quality in some areas as a result of lower flows in freshwater bodies.

Marine environment and fisheries

The *Our Marine Environment 2016* report provides an overview of the pressures on New Zealand's marine environment, how the environment is changing, and the impacts on New Zealand's biodiversity, economy and way of life.[289] The report identifies three key areas that threaten the marine environment:

- ocean acidification and warming
- the status of indigenous marine birds and mammals
- cumulative effects on coastal marine areas.

Management plans have been developed to manage threats to marine seabirds, Hector's and Māui's dolphins and the New Zealand sea lion.

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288 Ministry for the Environment. 2015. *A Guide to the National Policy Statement for Freshwater Management 2014*. Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/fresh-water/guide-national-policy-statement-freshwater-management-2014.

289 Ministry for the Environment, Statistics New Zealand. 2016. New Zealand's Environmental Reporting Series: Our Marine Environment 2016. Retrieved from www.mfe.govt.nz and www.stats.govt.nz.

A number of policies and measures are in place to ensure the sustainable management of fisheries resources in New Zealand. The Government operates a Quota Management System, which controls the total commercial catch for virtually all the main fish stocks found within New Zealand's exclusive economic zone. The Harvest Strategy Standard provides for targets and limits to be set for fisheries and fish stocks in New Zealand waters and to take into account natural fish stock fluctuations that are likely to be environmentally driven. The Harvest Strategy Standard does not explicitly take into account regime shifts or longer-term climate trends.

In 2008 the *Marine Protected Areas: Classification, Protection Standard and Implementation Guidelines* were released. New Zealand has established a network of 44 marine reserves, which collectively protect 10 per cent of New Zealand's territorial sea,[290] along with a range of other types of protected and managed areas in the marine environment.

Human health

The key responsibilities of the health sector in terms of adaptation are to:

- provide primary care and community services to support wellness (including physical, mental and social well-being) and prevent illness, services to help manage long-term conditions, or urgent help to deal with accidents or acute illness[291]
- understand climate change risks for public health and critical health assets, and factor this into planning and decision-making
- share knowledge on public health and equity consequences of climate change.

In addition, OraTaiao: New Zealand Climate & Health Council[292] runs awareness days at hospitals around New Zealand on climate change impacts and health. It is made up of health professionals in New Zealand who are concerned with:

- the negative impacts of climate change on health
- the health gains that are possible through strong, health-centred climate action
- highlighting the impacts of climate change on those who already experience disadvantage or ill health.

Environmental Health Indicators New Zealand, mentioned in section 6.4.1, is funded by the New Zealand Ministry of Health. It is a research, training and consultancy group specialising in environmental health information. Environmental health indicators relating to climate change that it has identified include extremes of temperature and rainfall, as well as changing occurrence of diseases such as cryptosporidiosis, giardiasis and salmonellosis. Population groups more at risk are also identified, such as the young and old, Māori, ethnic minorities and those living in poverty. Environmental Health Indicators New Zealand also provides factsheets on vulnerability and the health effects of climate change.

The Ministry of Health is starting work on an "Environmental health action plan for a changing planet".

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290 www.doc.govt.nz/our-work/monitoring-reporting/national-status-and-trend-reports-20152016/ecosystem-representation-and-protection-status--marine

291 Ministry of Health. 2016. *New Zealand Health Strategy: Future Direction*. Wellington: Ministry of Health.

292 www.orataiao.org.nz

The Ministry of Health notes that any adaptation work should prioritise vulnerable populations. It also considers that more work is needed in:

- development of the health workforce and understanding the risks for the health workforce
- health system planning, to accommodate a potential increase in migrants and refugees
- continuing and improving public health surveillance for current and new or emerging diseases
- continuing and improving vector surveillance and control.

Infrastructure and economy

The *Thirty Year New Zealand Infrastructure Plan 2015*[293] is intended to increase the understanding of how existing infrastructure can be better used, and to update plans for infrastructure needs over the next 30 years. It seeks to provide a common direction for how infrastructure in New Zealand is planned, funded and built.

The Plan is overseen by the National Infrastructure Unit. The Unit is located within the New Zealand Treasury and works with the various agencies responsible for the different infrastructure sectors to ensure a coordinated work programme is in place to deliver the Plan's vision. The Plan recognises the critical role local government and businesses play in delivering it, and the National Infrastructure Unit has extensive networks throughout the infrastructure community.

The Plan sets out a vision that, by 2045, New Zealand's infrastructure is resilient, coordinated and contributes to a strong economy and high living standards. Adaptation to climate change is identified as a key element to achieving this. It outlines what the Plan means for six key sectors: transport, telecommunications, energy, three waters,[294] productive water and social infrastructure.

The Plan provides a new approach to infrastructure management and planning to tackle the challenges of the next 30 years, along with supporting actions. This provides national direction to infrastructure development in New Zealand and confidence to the private sector. The Plan recognises that climate change is an important component of the context in which it will be operating, and that infrastructure needs to be resilient to changes over time. The impacts of climate change and the response in terms of infrastructure is identified in the Plan as one of the important areas that the National Infrastructure Unit will explore further in the near term.

Work has also been done to develop a toolbox to support planners, engineers, asset managers and hazard analysts in New Zealand to understand and evaluate the potential impacts of climate change on cities.[295] The *Impacts of Climate Change on Urban Infrastructure and the Built Environment Toolbox*, launched in 2012, is designed with an overall five-step evaluation framework, represented by the 'trays' in the Toolbox. Within each tray are downloadable reports (or 'tools'), each with a specific purpose.

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[293] National Infrastructure Unit. 2015. *Thirty Year New Zealand Infrastructure Plan 2015*. Wellington: National Infrastructure Unit. Retrieved from www.infrastructure.govt.nz/plan/2015/nip-aug15.pdf.

[294] Drinking water, wastewater and storm water.

[295] 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. Funding for the Toolbox was provided by the Ministry of Business, Innovation and Employment.

Each tool has been written so that it can be read and understood on its own, with references to other tools included. The tools demonstrate, through worked examples, methods and approaches that can be used to perform an assessment of climate change impacts. Readers are encouraged to contact the tools' authors to discuss using specific software or other proprietorial material.

The information in the toolbox is consistent with the Australian and New Zealand Standard for Risk Management, AS/NZS ISO31000:2009, which is widely used in the public and private sectors to guide strategic, operational and other forms of risk management.

Tourism

Research has considered the impacts of climate change on the tourism industry. In its RA4 Synthesis Report, the Climate Change Impacts and Implications project (2016), noted a number of climate change impacts were being observed in the Queenstown and Wanaka regions, which has implications for the tourism sector in these areas. These impacts included projections of reduced snowfall, prompting the local skifield operators to commission a study looking into the impacts and options for changing the way they managed their operations.[296] The researchers developed a framework to understand and inform thinking and strategies on how the tourism industry is currently responding to the weather and how they could respond to climate change in future. This has in turn led to adaptive planning practices being put into place by the skifield operators, in order to manage the changing climate risks.[297]

Transport

The New Zealand Transport Agency is responsible for keeping the state highway network safe, reliable and resilient. The Agency works to benchmark environmentally responsible practice, identify relevant international trends, develop New Zealand-specific standards and guidelines, disseminate information and continuously improve service delivery on an integrated network basis.

The Government Policy Statement (GPS) for Land Transport 2015,[298] which sets out the Government's priorities for expenditure from the National Land Transport Fund over the next 10 years, guides and provides a key context for the Agency's activities. It includes objectives on resilience in its network and for a land transport system that mitigates environmental effects including those arising from climate change.

GPS 2015 is currently being reviewed and a new GPS 2018 is expected to be issued before 30 June 2018. A draft GPS 2018 was circulated for consultation in March 2017.[299] It includes increased priority for investment in resilience. In this area, investment can be made to address gradual risks to access to land transport, including those arising from climate change. It also

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296 J Hendrikx, C Zammit, E Hreinsson, S Becken. 2013. A comparative assessment of the potential impact of climate change on the ski industry in New Zealand and Australia. *Climatic Change* 119: 965–968.

297 J Lawrence, P Blackett, N Cradock-Henry, S Flood, A Greenaway, A Dunningham. 2016. *Synthesis Report RA4: Enhancing Capacity and Increasing Coordination to Support Decision Making. Climate Change Impacts and Implications (CCII) for New Zealand to 2100.* MBIE contract C01X1225. Retrieved from http://ccii.org.nz/wp-content/uploads/2017/01/RA4-Synthesis-report.pdf.

298 To read the GPS 2015, go to the Ministry of Transport website: www.transport.govt.nz/assets/Uploads/Our-Work/Documents/GPS-2015-amended.pdf.

299 The draft GPS 2018 can be found at this link: www.transport.govt.nz/assets/Uploads/Our-Work/Documents/MOT-GPS-2018-web.pdf.

contains a modified national land transport objective that refers to increasingly mitigating the effects of land transport on the environment. This encourages a whole-of-system approach (eg, considering the effects of both the stock and flow of land transport investment) and considering cumulative effects over time.

In 2017 the Agency released its *Coastal Effects Assessment Guideline*,[300] which it developed in response to its focus on long-term climate change impacts, such as sea-level rise, increased inundation and various environmental effects to ensure the resilience of the New Zealand road network. The guide describes a coastal environment risk assessment approach intended to inform the planning, design and management of road assets in coastal environments. Climate change impacts, including sea-level rise, will be assessed as part of the approach, and the anticipated outcome is a process that will be added to asset management systems to assist long-term planning.

Recently the New Zealand Transport Agency has completed a business improvement project, which aims to provide for its project teams a more consistent Business Case approach, tools, guidance and references for resilience issues on the road network. The definition of resilience used by the Agency business improvement project includes the ability to adapt to changing conditions, including climate change.

Finally, KiwiRail[301] is responsible for 3377 kilometres of rail network in New Zealand. Preventive measures are key to KiwiRail's strategy for ensuring the rail network is able to withstand the impact of severe weather events. Measures include:

- strengthening and monitoring programmes that work to prevent rail buckling in high temperatures
- work programmes to maintain and strengthen the rail network in order to reduce vulnerability to floods or tidal surges
- programmes to measure track stability on the rail network, using an automated data collection car.

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[300] Highways and Network Operations. 2017. *Coastal Effects Assessment Guideline.* Wellington: New Zealand Transport Agency.

[301] KiwiRail is a statutory corporation established under the New Zealand Railways Corporation Act 1981. As a state-owned enterprise it is subject to the State-Owned Enterprises Act 1986.

7 Financial resources and technology transfer

Key developments since the Sixth National Communication

Since the *Sixth National Communication*, New Zealand has contributed approximately NZ$454.60 million in climate-related support for developing countries. New Zealand's contribution is an increase of approximately NZ$145.92 million compared with the previous reporting period.

New Zealand's climate-related support is building stronger and more resilient infrastructure, strengthening disaster preparedness and supporting low-carbon economic growth, including through its significant contribution to improving access to affordable, reliable and clean energy. New Zealand is also supporting low-emissions agricultural development, including through the Global Research Alliance on Agricultural Greenhouse Gases. A significant portion of this climate-related support is promoting, financing and transferring climate-friendly technologies for the benefit of developing countries and building the capacities of developing countries to meet the challenges of climate change.

New Zealand's co-hosting of Pacific Energy Conferences with the European Union has enabled us to mobilise finance at scale. Combined, our 2013 and 2016 events mobilised over NZ$2 billion for renewable energy projects in the Pacific.

Due to the challenges Pacific Island countries face in accessing finance from multilateral funds such as the Green Climate Fund, New Zealand launched a Technical Assistance for Pacific Access programme in early 2016. Through this programme New Zealand is supporting national capacity-building workshops and providing targeted technical assistance with preparing project proposals.

7.1 Introduction

New Zealand remains committed to supporting climate change action in developing countries. Its particular areas of focus are the Pacific Island region, renewable energy, agriculture, and disaster risk reduction and management.

This chapter reports on the financial and technological support New Zealand has provided to developing countries for climate change action from 2013–16 (inclusive) since the *Sixth National Communication*. It covers support provided through multilateral, regional and bilateral channels, as well as specific resources provided for mitigation, adaptation and technology transfer.

During the reporting period New Zealand has contributed approximately NZ$454.60 million in financial assistance for climate change outcomes in developing countries, which is an overall increase of approximately NZ$145.92 million compared with the previous reporting period. New Zealand's support has the following main components:

- contributions to a range of multilateral organisations and programmes with a strategic focus on climate change,[302] including special funds under the United Nations Framework Convention on Climate Change (UNFCCC), amounting to total funding of NZ$258.18 million (see tables 7.4a–7.4d), which includes:
  - contributions to the operating entities of the Financial Mechanism of the UNFCCC (Green Climate Fund and the Global Environment Facility), amounting to total funding of NZ$9.18 million
  - funding to regional organisations and activities with a core focus on climate change,[303] amounting to total funding of NZ$45.03 million
- support for bilateral climate-related assistance delivered through the New Zealand Aid Programme, amounting to total funding of NZ$196.43 million (see tables 7.5a–7.5d).

Across these components, New Zealand made and delivered on various undertakings over the 2013–16 period to continue to provide climate-related financial support.

- At the September 2013 Pacific Islands Forum, New Zealand's Prime Minister announced an intention to provide NZ$80 million in climate-related support over the following three years. This figure was significantly exceeded, with total climate-related support expenditure over this period totalling NZ$190 million.
- At the Conference of Parties 21 (COP21), New Zealand committed to providing up to NZ$200 million in climate-related support over the four-year period to 2019. We are on track to deliver on this commitment.

For the period beyond 2019, New Zealand is committed to increasing climate finance beyond current levels. This funding will come from a range of public and private sources, with the quantum of future climate finance contributions to be determined through future budget cycles. The forthcoming Global Environment Facility and Green Climate Fund replenishment cycles will form part of this process.

More broadly, New Zealand remains committed to the global goal of jointly mobilising US$100 billion per year by 2020 from a variety of sources in the context of meaningful mitigation actions by developing countries and transparency on implementation.

7.1.1 New and additional support

New Zealand's approach to determining how financial resources are 'new and additional' has not changed since last articulated in its *Second Biennial Report.* New Zealand's approach has been to report all climate-related assistance provided during the reporting period. Doing so is the most transparent and appropriate way of communicating both trends and new resources provided.

New Zealand's view remains that it is not effective to try to separate climate-related support from other official development assistance (ODA). In practical terms, any climate-related support provided over the reporting period that meets agreed ODA definitions (ie, with a strong concessional element, and a focus on economic development and welfare of developing countries as its main objective) is included in this report.

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[302] These contributions represent the full amounts provided to the organisations for the full range of activities covered by their programmes, which include climate change mitigation and adaptation.

[303] These contributions represent the full amounts provided to the organisations for the full range of activities covered by their programmes, which include climate change mitigation and adaptation.

New Zealand's climate-related support is an increasing part of its growing aid budget. For the 2013–16 reporting period, we estimate that approximately 22 per cent of the ODA managed by the New Zealand Aid Programme had a climate component.

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 finding ways to further improve 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, thereby achieving the most effective outcomes and facilitating further climate finance and investment flows.

New Zealand's aid programme has systems in place to track, measure and record climate-related assistance provided to developing countries. In addition, New Zealand has work under way that will assist us to better capture and report on the results of our climate-related support in the future.

The aid programme's Climate Change Operational Policy details how support for climate change is to be delivered, and describes how that support is to be recorded and quantified in internal systems. The Policy requires activities and programmes to be assessed for climate change risks, and opportunities explored to support adaptation to and mitigation of climate change. The aid programme uses the Organisation for Economic Co-operation and Development's (OECD's) Development Assistance Committee (DAC) 'Rio' markers as a basis for tracking development assistance with climate change adaptation and mitigation outcomes.

While the Rio markers capture the thematic objectives of each activity, they do not attempt to quantify expenditure towards these objectives. New Zealand has therefore initiated a system to quantify our climate-related support from the aid programme, building on the DAC Rio markers.

This system enables climate-related expenditure to be quantified and recorded in the aid programme's climate change inventory, according to the specific classifications and moderation weightings that table 7.1 sets out.

Table 7.1: Classifications and moderation weightings to quantify New Zealand's climate-related expenditure on aid programme activities

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 unless: • A more accurate figure is known or • A different default figure is specified for the particular Activity type

Classification	Where addressing climate change is…	Financial information recorded in the climate change inventory
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 those criteria, some activities supported by the aid programme have specific funding allocations. Table 7.2 provides further guidance on the application of the climate change markers for those activities.

Table 7.2: Markers and classifications to quantify aid programme activities with specific funding allocations

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%
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.	Mitigation: Principal	100%
Energy upgrading	Energy upgrading activities where the outcome of the activity is safer access to energy supplies in the presence of extreme weather events can potentially be marked significant.	Adaptation: Significant	30%

In this *Communication*, New Zealand reports on bilateral, regional and multilateral financial contributions as follows.

- Reported bilateral contributions include funding from the aid programme for activities where addressing climate change is assessed as the ‘principal’ or ‘significant’ outcome of the activity.
- Reported regional and multilateral contributions include core funding provided: to regional organisations with a core focus on climate change; to multilateral agencies for whom climate change is integral to their strategic plans and approaches; and to regional organisations conducting activities in the framework of the Global Research Alliance on Agricultural Greenhouse Gases (GRA). Except for funding to support GRA activities, core funding provided to regional and multilateral organisations is not monitored at a level that tracks specific climate change allocations and actions. As such, some of the figures provided in tables 7.4a–7.4d represent total contributions to multilateral and regional organisations “that Parties cannot specify as being climate-specific”.

For the purposes of this report, ‘provided’ means funds that have been transferred from the New Zealand Government to a recipient, including any multilateral organisation.

7.2 Financial resources

New Zealand's *Seventh National Communication* reports on all climate-related financial support provided by New Zealand since its *Sixth National Communication* for the purpose of assisting developing countries' mitigation and adaptation efforts, and highlights some of the key initiatives that New Zealand has supported.

New Zealand's reporting period covers four calendar years: 2013, 2014, 2015 and 2016. 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 as follows:

- 2013: US$1= NZ$1.2203
- 2014: US$1= NZ$1.2058
- 2015: US$1= NZ$1.4342
- 2016: US$1= NZ$1.4365

New Zealand has adopted the UNFCCC agreed common tabular format from the draft revised National Communication guidelines (FCCC/SBI/2016/L.22) for the *Seventh National Communication* to ensure transparency in reporting financial data and promote consistency across all financial contributors.

7.2.1 Multilateral support

Global Environment Facility

The Global Environment Facility (GEF) is an operating entity of the UNFCCC's Financial Mechanism. The GEF distributes financial assistance associated with the major multilateral agreements on climate change, biodiversity, persistent organic pollutants, ozone-depleting substances and desertification, and also supports activities relating to land degradation and international waters.

Tables 7.4a–7.4d provide details of New Zealand's total contributions to the GEF Trust Fund for the 2013–16 reporting period, amounting to NZ$6.18 million.[304] The reporting period encompasses years included in both the fifth and sixth replenishments of the GEF Trust Fund. New Zealand contributed 4 million Special Drawing Rights to each replenishment, equating to a total of NZ$10.68 million for the fifth replenishment and NZ$7.47 million for the sixth replenishment. In 2016 New Zealand contributed NZ$130,000 to the GEF's Capacity Building Initiative for Transparency (CBIT). Established at COP21, the CBIT will support developing country Parties in meeting enhanced transparency arrangements under the Paris Agreement.

Green Climate Fund

The Green Climate Fund (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

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[304] 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.

development. The GCF has committed to aim for 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 (SIDS), and African states.

New Zealand contributed NZ$3 million to the initial resource mobilisation of the GCF in May 2015.

Other multilateral support

New Zealand continues to support 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 (see tables 7.4a–7.4d). This includes, for instance, the World Bank, the Asian Development Bank and the United Nations Development Programme.

During the reporting period New Zealand contributed NZ$20,000 to the UNFCCC Trust Fund for Participation to assist developing countries' participation in UNFCCC meetings. In addition, it contributed NZ$444,000 to the UNFCCC Trust Fund for Supplementary Activities to: support the international consultation and analysis processes in developing countries; support the implementation of national greenhouse gas inventories by developing country Parties, including training on the use of the 2006 Intergovernmental Panel on Climate Change (IPCC) inventory guidelines; support the implementation of the Cancun Adaptation Framework and the Nairobi work programme on impacts, vulnerability and adaptation to climate change; and support the March 2017 intersessional workshop on Article 13 of the Paris Agreement (transparency), including for participation by developing country parties.[305]

7.2.2 Regional support

New Zealand is a major donor partner and funder of the Pacific regional organisations that have a core focus on climate change, as detailed in tables 7.4a–7.4d. These organisations include:

- the Secretariat of the Pacific Regional Environment Programme (SPREP) (www.sprep.org), which has the lead responsibility for coordinating the region's response to climate change and provides policy and technical support to its Pacific Island country and territory members to meet their commitments under the UNFCCC, and to support climate adaptation actions
- the Pacific Community (SPC) (www.spc.int), which provides assistance to its 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 (www.forumsec.org), 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 funding provided to Pacific regional organisations contributes to programmes and projects identified in their strategic plans. This core, untagged funding to regional organisations (as for multilateral core contributions) is not monitored at a level that tracks specific climate change activities. The figures provided in tables 7.4a–7.4d are therefore total allocations to multilateral and regional agencies, rather than estimates of expenditure on specific climate change actions.

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[305] Although the intersessional workshop took place in 2017, the transfer of funding took place in 2016.

New Zealand is also supporting a range of climate change efforts in the Pacific through several regional initiatives. The following are some examples.

- The SPREP-led New Zealand Pacific Partnership on Ocean Acidification is helping to raise awareness and build resilience in the Pacific region. New Zealand is providing NZ$2.1 million over four years (2015–19) to help address this emerging threat, which is also due to the build-up of carbon dioxide (CO_2) in the atmosphere. The partnership is poised to become an even larger Pacific-wide initiative and is likely to form part of a GCF project proposal.
- In partnership with SPC, New Zealand is supporting a five-year (2014–19), NZ$5 million project to strengthen water security in five low-lying Pacific islands and atolls that are subject to drought and water shortages (Tuvalu, Tokelau, Kiribati, Cook Islands and the Republic of the Marshall Islands). This partnership is working to improve awareness and understanding of water security issues, develop drought management plans and improve water management practices.
- Through our GCF Board seat constituency, New Zealand is working to ensure effective outcomes for the Pacific and other small island developing states. In addition, and following conversations with our partners in the region about their challenges in accessing GCF funding, in early 2016 New Zealand launched a Technical Assistance for Pacific Access programme (TAPA). TAPA is providing rapid deployment of technical support to develop project proposals from the Pacific. For example, TAPA provided engineering assistance in support of Samoa's US$57.7 million flood management project that was approved by the GCF Board in December 2016. New Zealand has also funded national GCF workshops in Kiribati, Tuvalu, Tonga and Niue, aimed at bolstering national capacities and understanding of the GCF.
- New Zealand has partnered with the European Union to mobilise finance at scale for renewable energy across the Pacific region (see 'Mitigation' in section 7.2.3 for more details).
- New Zealand is keen to build on our experience of adopting a regional approach in renewable energy partnerships to facilitate access to finance flows, and support the Pacific to access climate finance at scale through the GCF and other funding mechanisms. To that end, New Zealand is looking to identify national priorities and develop regional programmes and partnerships to access climate finance in order to strengthen resilient and low-carbon development in the Pacific.
- In 2016 New Zealand renewed and expanded our core funding to the International Monetary Fund's Pacific Financial Technical Assistance Centre, committing NZ$12 million over five years. Part of this funding is helping Pacific Island countries build a stronger foundation from which to apply for climate finance.
- New Zealand supports the development and implementation of regional frameworks, policies and action plans designed to address climate change and disaster risk management. It does this through its membership of the Pacific Islands Forum, which is the Pacific region's intergovernmental and economic policy organisation. As part of this support, New Zealand was actively involved in developing the Framework for Resilient Development in the Pacific 2017–2030. This Framework aims to better integrate the agendas of climate change adaptation and disaster risk reduction and brings these two communities together through the Pacific Resilience Partnership.

New Zealand has provided support to the following regional low-emissions livestock development projects during the reporting period.

- New Zealand's Ministry for Primary Industries has provided NZ$1.1 million in funding to the Inter-American Development Bank's Regional Fund for Agricultural Technology (FONTAGRO) through the Global Research Alliance on Agricultural Greenhouse Gases. This funding will support the implementation of three projects assisting 12 Latin American and Caribbean countries to improve their national livestock greenhouse gas inventories and to develop mitigation options suitable for their farming conditions. Implementation of the projects was supported by the Inter-American Institute for Cooperation in Agriculture (IICA) and the Centre for Tropical Agriculture Research and Education (CATIE). Following the successful completion of these projects, New Zealand, FONTAGRO and CATIE are supporting the establishment of a Latin America and the Caribbean Sustainable Livestock Production Platform: Greater Productivity with Lower Greenhouse Gas Emissions. The Platform's main objective is to sustainably intensify livestock production systems as a strategy to mitigate and adapt to the effects of climate change in Latin America and the Caribbean. The Platform will coordinate a regional research agenda, share knowledge, and build the capacities of farmers and key stakeholders in the public and private sectors.
- New Zealand's Ministry for Primary Industries provided NZ$403,000 to a major regional capability-building project through the GRA's Livestock Research Group work programme. This project is aimed at identifying regionally appropriate low emissions pathways for livestock development in South America, Sub Saharan Africa and South Asia. The project has enabled participating countries to identify and model cost-effective mitigation options that will significantly improve the efficiency of livestock production, and reduce the intensity of enteric NH_4 emissions. Technical input to the project was led by the FAO and the New Zealand Agricultural Greenhouse Gas Research Centre, with support from the World Bank. Co-funding was provided by the Climate and Clean Air Coalition.

7.2.3 Bilateral support

A large proportion of New Zealand's climate-related support is delivered bilaterally through the New Zealand Aid Programme as grant funding. New Zealand contributed approximately NZ$196.43 million in climate-related bilateral assistance during the 2013–16 period.

Consistent with the aid programme's 2015–19 Strategic Plan, New Zealand's climate-related support is primarily delivered as part of activities designed to achieve sustainable, inclusive and resilient development outcomes that meet the priorities and needs identified by partner countries. New Zealand's climate-related support is building stronger and more resilient infrastructure, strengthening disaster preparedness and supporting low-carbon economic growth, including through our significant contribution to improving access to affordable, reliable and clean energy.

Consistent with the aid programme's geographical focus, New Zealand's climate-related support will continue to have a strong focus on supporting activities in the small island developing states in the Pacific. This region's need for climate-related assistance is great, and New Zealand has the relationships and experience to make a practical difference. In the financial year ending June 2016, approximately NZ$38 million of New Zealand's total NZ$44.6 million in climate-related support was directed to the Pacific region. New Zealand also provides climate-related support bilaterally to partner countries in Africa and the Caribbean, and to Association of South East Asian Nations (ASEAN) members.

Country partnerships are at the heart of New Zealand's approach to bilateral assistance, with the same true for New Zealand's climate-related support. The Joint Commitments for

Development agreed with development partners are based on partner countries' national plans and self-identified needs and priorities.

New Zealand follows a number of development principles when providing climate-related support. These include:

- ownership – encouraging and supporting partner Parties to set their own strategies and priorities for responding to the challenge of climate change to create policy certainty, reducing risk and enabling private sector investment
- alignment – aligning support with countries' own identified priorities for climate mitigation and adaptation
- donor harmonisation – partners working together to maximise effectiveness of support being provided
- results focus – delivering projects that can be tracked and reported to ensure the project is delivering.
- transparency – accounting for every dollar spent in the delivery of aid projects.

New Zealand's approach of integrating environmental and climate change objectives as cross-cutting issues in all activities managed by the aid programme, where appropriate, is in keeping with international best practice and, for partner countries, reduces the burden of reporting. Designing development assistance with environment and climate change co-benefits in mind ensures that the development initiatives funded by New Zealand's aid programme support sustainable management of natural assets and address climate change.

Further details of support for country-level mitigation, adaptation and technology transfer actions are provided in the relevant sections below. Tables 7.5a–7.5d contain details of annual financial contributions made from 2013–16 in support of these areas.

Of New Zealand's bilateral support managed and delivered by the aid programme during the reporting period, we estimate that 36 per cent was directed towards supporting adaptation actions and 57 per cent towards mitigation (with 7 per cent directed to both adaptation and mitigation actions). This compares with the previous reporting period, in which 43 per cent of New Zealand's bilateral support was directed towards supporting adaptation actions and 57 per cent towards mitigation (all percentages are approximate).[306] Adaptation comprised a higher percentage in the previous reporting period because our significant support to renewable energy (which increases the mitigation component) did not commence until 2011. In the short term a significant part of our climate-related support will continue to go towards improving access to affordable, reliable and clean energy. As our renewable energy portfolio matures, we will continue to address the mitigation and adaptation elements of our programme, and we are working to improve the balance between our adaptation and mitigation support.

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306 The tables in the *Sixth National Communication* included only adaptation and mitigation columns, with no column for cross-cutting projects. As a result, a small number of cross-cutting projects were recorded under the 'other vulnerability assessment' column in the *Sixth National Communication* and therefore counted towards New Zealand's adaptation totals. The impact of this on the breakdown of New Zealand's bilateral support was minor (41.7 per cent was directed towards adaptation actions, 56.6 per cent towards mitigation and 1.6 per cent towards both adaptation and mitigation actions).

Mitigation

New Zealand's main areas of engagement in terms of mitigation support have been in the energy and agriculture sectors.

A priority for New Zealand has been supporting renewable energy initiatives through the aid programme. Support for affordable, reliable and clean energy sources through direct investment and technology transfer is assisting New Zealand's partner countries to reduce their carbon emissions, improve energy efficiency and to pursue low-carbon development pathways. These measures also have co-benefits, such as increasing energy security, reducing reliance on costly diesel imports and encouraging growth in emerging green industries.

For example, in Samoa, New Zealand invested in 2.58 megawatts of grid-connected solar photovoltaics. This project, completed in 2014, was designed to save 1.1 million litres of diesel, reduce greenhouse gas emissions and contribute 4.5 per cent to Samoa's 100 per cent renewable energy goal. In the Cook Islands, New Zealand has invested in 1 megawatt of grid-connected solar photovoltaics (completed in 2014) and 8 solar diesel mini-grids (completed in June 2015), providing over 95 per cent renewable energy for six outer islands in the Northern Cook Islands.

In addition, New Zealand's Pacific Partnership with the European Union aims to mobilise finance flows to drive the uptake of renewable energy in the Pacific region at scale. The June 2016 Pacific Energy Conference held in Auckland saw donors commit over NZ$1 billion to renewable energy projects in the Pacific out to 2024, including NZ$100 million from New Zealand. Combined with the 2013 Pacific Energy Summit, which saw over NZ$900 million of investments for over 70 projects, these efforts have now mobilised over NZ$2 billion for renewable energy projects in the Pacific. These outcomes highlight the role that developed country partners, such as New Zealand and the European Union, can play in facilitating a significant outcome by drawing on our expertise and relationships in the field to ensure a coordinated, regional approach to renewable energy and energy efficiency. Pacific leaders were connected with finance and private sector expertise to accelerate their national energy plans, and donors were matched with investment-ready projects as outlined in country profiles. Delivery of these projects will accelerate progress towards achieving countries' renewable energy targets, which form a key plank of their Nationally Determined Contributions submitted under the Paris Agreement.

The aid programme's investment priority of renewable energy offers strong opportunities to increase private sector investment and trade in the Asia–Pacific region. New Zealand recognises the importance of private sector investment in contributing to effective climate outcomes in developing countries, and is committed to better understanding what it can do to help mitigate risks to climate-related investment opportunities in developing countries. Work is currently under way to identify how to incentivise greater private sector investment in the renewable energy sector, including by reducing real or perceived risks that are barriers to investments (such as payment guarantee systems) and supporting regulatory system improvements.

The dominance of agriculture in New Zealand's emissions profile has motivated New Zealand to use its expertise to help address the 10–12 per cent of global emissions that come from the agriculture sector. Through the New Zealand Aid Programme we have invested approximately NZ$6.77 million in climate-related agriculture initiatives over the 2013–16 period. 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 initiated the Global Research Alliance on Agricultural Greenhouse Gases in late 2009 to help decouple emissions from food production, and continues to provide a range of support for these efforts, as outlined elsewhere throughout this chapter and other chapters.

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 and climate vulnerability, by increasing community and infrastructure resilience and adaptive capacity. Our support is largely delivered through bilateral assistance to partner countries, with our aid programme having an investment priority specifically focused on 'resilience'. 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 recipient countries and regional agencies to help shape and deliver these actions in response to countries' identified priorities.

Small island developing states, such as those in the Pacific, are especially vulnerable to the impacts of climate change and extreme weather events. Climate change threatens to reduce resilience and exacerbate existing development and environmental challenges. In response, New Zealand is supporting a range of climate change adaptation projects through the activities of the New Zealand Aid Programme, particularly in the small island developing states of the Pacific.

As summarised in tables 7.5a–7.5d, examples of key climate change adaptation, disaster risk management and resilience-building initiatives supported through the aid programme over the reporting period include: projects to strengthen water security and availability across the Pacific; building the resilience of Pacific communities and the environment to ocean acidification; the development and maintenance of early warning systems and National Disaster Management Offices; and related capacity building across the Pacific region and in South East Asia. New Zealand also continues to support offices in Samoa, Tonga, Niue, Tokelau and the Cook Islands to strengthen their preparedness for and responses to natural disasters, including those relating to climate change.

New Zealand has funded the remediation of 'borrow pits' on Tuvalu's main atoll, Funafuti. Excavated during World War II to provide material to construct the airport runway, over time the pits filled with rubbish, were subject to flooding and became a health hazard. This NZ$10 million remediation project carried out in 2015 has increased the available land area of Funafuti atoll by 6 per cent by filling the pits to above the king tide and '100-year sea-level rise' height (3.64m above sea level). The project also involved the repair of the Tegako breach, which is vulnerable to storm surges and extreme weather events.

In addition, New Zealand contributes to disaster risk reduction and resilience building, including work to manage potential impacts of drought associated with El Niño weather events. For example, during the reporting period, New Zealand provided: NZ$6.4 million for two projects in Vanuatu for water and sanitation projects that addressed resilience; approximately NZ$600,000 for improving Fiji's National Disaster Management Office drought response capability; NZ$1.5 million for New Zealand non-government organisations and local implementing partners to support mitigation and preparedness projects across the region in early 2016; and NZ$5 million to tackle the 2015/16 severe drought in Papua New Guinea, including to replace and install more communal water tanks and repair piping to maximise rainwater harvesting in the most badly impacted rural areas.

In Solomon Islands, New Zealand contributed NZ$6.5 million during the reporting period towards the Domestic Maritime Support Programme being implemented by the Asian Development Bank (ADB) in partnership with Solomon Islands Government, and co-financed by Solomon Islands Government and Australia. Thirteen wharves and three landing strips were constructed or rehabilitated by this project, all of which have been designed to withstand rising sea levels.

Adaptation and disaster risk reduction are closely related processes, which both aim to reduce risk to short-term acute hazards and longer-term chronic hazards. New Zealand therefore also supports greater integration of disaster risk reduction and climate change adaptation. New Zealand participates in the annual United Nations Office for Disaster Risk Reduction *Global Platform on Disaster Risk Reduction* and has been a strong supporter of the Framework for Resilient Development in the Pacific.

Table 7.3: Provision of public financial support – summary information, 2013–16

Table 7.3a: Provision of public financial support – summary information, 2013[307]

	New Zealand dollars (millions) Climate-specific						US dollars (millions) Climate-specific					
Allocation channel	**Core/ general**	**Mitigation**	**Adaptation**	**Cross-cutting**	**Other**	**Total**	**Core/ general**	**Mitigation**	**Adaptation**	**Cross-cutting**	**Other**	**Total**
Total contributions through multilateral channels	**60.89**	**0.00**	**0.00**	**0.00**	**0.00**	**60.89**	**49.89**	**0.00**	**0.00**	**0.00**	**0.00**	**49.89**
Multilateral climate change funds	1.43					**1.43**	1.17					**1.17**
Other multilateral climate change funds	0.60					**0.60**	0.49			0.00		**0.49**
Multilateral financial institutions, including regional development banks	29.52					**29.52**	24.19					**24.19**
Specialised United Nations bodies	15.50					**15.50**	12.70					**12.70**
Other multilateral	13.84					**13.84**	11.34					**11.34**
Total contributions through bilateral, regional and other channels[308]		**12.60**	**13.99**	**2.42**		**29.01**	**0.00**	**10.33**	**11.46**	**1.98**	**0.00**	**23.77**
TOTAL	**60.89**	**12.60**	**13.99**	**2.42**	**0.00**	**89.89**	**49.89**	**10.33**	**11.46**	**1.98**	**0.00**	**73.67**

307 Contributions to several organisations and activities have been reported in different ways in New Zealand's *Second Biennial Report* and *Seventh National Communication*, as detailed in tables 7.4a and 7.4b. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

308 Figures have been rounded, which may result in differences between the overall total and the total of the individual items in the tables. The impact of this rounding is minor; for example, the rounded total of bilateral adaptation contributions is 13.99 in table 7.3a while the total of the relevant individual items in table 7.5a amounts to 13.96.

Table 7.3b: Provision of public financial support – summary information, 2014[309]

Allocation channel	New Zealand dollars (millions) Core/ general	Climate-specific Mitigation	Adaptation	Cross-cutting	Other	Total	US dollars (millions) Core/ general	Climate-specific Mitigation	Adaptation	Cross-cutting	Other	Total
Total contributions through multilateral channels:	**64.05**	**0.50**	**0.00**	**1.18**	**0.00**	**65.73**	**53.12**	**0.41**	**0.00**	**0.98**	**0.00**	**54.51**
Multilateral climate change funds	1.05			0.08		**1.13**	0.87			0.07		**0.94**
Other multilateral climate change funds	0.60					**0.60**	0.50					**0.50**
Multilateral financial institutions, including regional development banks	28.60					**28.60**	23.72					**23.72**
Specialised United Nations bodies	15.50					**15.50**	12.85					**12.85**
Other multilateral	18.30	0.50		1.10		**19.90**	15.18	0.41		0.91		**16.50**
Total contributions through bilateral, regional and other channels[310]		**43.69**	**13.78**	**2.43**		**59.90**	**0.00**	**36.23**	**11.43**	**2.02**	**0.00**	**49.68**
TOTAL	**64.05**	**44.19**	**13.78**	**3.61**	**0.00**	**125.63**	**53.12**	**36.64**	**11.43**	**2.99**	**0.00**	**104.19**

309 Contributions to several organisations and activities have been reported in different ways in New Zealand's *Second Biennial Report* and *Seventh National Communication*, as detailed in tables 7.4a and 7.4b. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

310 Figures have been rounded, which may result differences between the overall total and the total of the individual items in the tables. The impact of this rounding is minor; for example, the rounded total of bilateral adaptation contributions is 13.99 in table 7.3a while the total of the relevant individual items in table 7.5a amounts to 13.96.

Table 7.3c: Provision of public financial support – summary information, 2015

Allocation channel	New Zealand dollars (millions) Core/ general	Climate-specific Mitigation	Adaptation	Cross-cutting	Other	Total	US dollars (millions) Core/ general	Climate-specific Mitigation	Adaptation	Cross-cutting	Other	Total
Total contributions through multilateral channels:	**59.94**	**0.50**	**0.00**	**3.13**	**0.00**	**63.57**	**41.79**	**0.35**	**0.00**	**2.18**	**0.00**	**44.33**
Multilateral climate change funds	1.81			3.13		**4.94**	1.26			2.18		**3.45**
Other multilateral climate change funds	0.61					**0.61**	0.42			0.00		**0.42**
Multilateral financial institutions, including regional development banks	27.67					**27.67**	19.30					**19.30**
Specialised United Nations bodies	15.50					**15.50**	10.81					**10.81**
Other multilateral	14.35	0.50				**14.85**	10.00	0.35				**10.35**
Total contributions through bilateral, regional and other channels[311]		**28.34**	**25.37**	**4.04**		**57.74**	**0.00**	**19.76**	**17.69**	**2.82**	**0.00**	**40.26**
TOTAL	**59.94**	**28.84**	**25.37**	**7.17**	**0.00**	**121.31**	**41.79**	**20.11**	**17.69**	**5.00**	**0.00**	**84.59**

311 Figures have been rounded, which may result in a difference between the overall total and the total of the individual items in the tables. The impact of this rounding is minor; for example, in table 7.3a the rounded total of bilateral adaptation contributions is 13.99 while the total of the relevant individual items in table 7.5a amounts to 13.96.

Table 7.3d: Provision of public financial support – summary information, 2016

	New Zealand dollars (millions)						US dollars (millions)					
		Climate-specific						Climate-specific				
Allocation channel	**Core/ general**	**Mitigation**	**Adaptation**	**Cross-cutting**	**Other**	**Total**	**Core/ general**	**Mitigation**	**Adaptation**	**Cross-cutting**	**Other**	**Total**
Total contributions through multilateral channels:	**67.21**	**0.00**	**0.00**	**0.78**	**0.00**	**67.99**	**46.79**	**0.00**	**0.00**	**0.54**	**0.00**	**47.33**
Multilateral climate change funds	1.76			0.38		**2.14**	1.23			0.26		**1.49**
Other multilateral climate change funds	0.87					**0.87**	0.61			0.00		**0.61**
Multilateral financial institutions, including regional development banks	32.87					**32.87**	22.88					**22.88**
Specialised United Nations bodies	15.50					**15.50**	10.79					**10.79**
Other multilateral	16.21			0.40		**16.61**	11.28			0.28		**11.56**
Total contributions through bilateral, regional and other channels[312]		**27.23**	**16.90**	**5.65**		**49.78**	**0.00**	**18.96**	**11.76**	**3.93**	**0.00**	**34.65**
TOTAL	**67.21**	**27.23**	**16.90**	**6.43**	**0.00**	**117.77**	**46.79**	**18.96**	**11.76**	**4.48**	**0.00**	**81.98**

[312] Figures have been rounded, which may result in differences between the overall total and the total of the individual items in the tables. The impact of this rounding is minor; for example, the rounded total of bilateral adaptation contributions in table 7.3a is 13.99 while the total of the relevant individual items in table 7.5a amounts to 13.96.

Table 7.4: Provision of public financial support – contributions through multilateral channels, 2013–16

Table 7.4a: Provision of public financial support – contributions through multilateral channels, 2013

Donor funding	Total amount Core/general NZ$ million	US$ million	Climate-specific NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Multilateral climate change funds									
1. Global Environment Facility[313]	1.43	1.17			Disbursed	ODA	Capital subscription	Cross-cutting	General environment
2. Montreal Protocol (United Nations Environment Programme)	0.60	0.49			Disbursed	ODA	Grant	Cross-cutting	General environment
Subtotal	**2.03**	**1.66**	**0.00**	**0.00**					
Multilateral financial institutions, including regional development banks									
1. World Bank	19.14	15.68			Disbursed	ODA	Capital subscription	Cross-cutting	Cross-cutting
2. Asian Development Bank	10.38	8.51			Disbursed	ODA	Capital subscription	Cross-cutting	Cross-cutting
Subtotal	**29.52**	**24.19**	**0.00**	**0.00**					
Specialised United Nations bodies									
1. United Nations Development Programme	8.00	6.56			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
2. International Fund for Agricultural Development*	1.50	1.23			Disbursed	ODA	Grant	Adaptation	Agriculture
3. World Food Programme*	6.00	4.92			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**15.50**	**12.70**	**0.00**	**0.00**					

[313] This amount is based on the encashment of promissory notes rather than the lodging or commitment of a promissory note, as was reported in New Zealand's *Second Biennial Report*. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

Donor funding	Total amount Core/general NZ$ million	 US$ million	 Climate-specific NZ$ million	 US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Other multilateral[314]									
1. CGIAR Fund*[315]	2.50	2.05			Disbursed	ODA	Grant	Cross-cutting	Agriculture
2. Pacific Islands Forum Secretariat	4.00	3.28			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
3. Secretariat of the Pacific Regional Environment Programme	1.50	1.23			Disbursed	ODA	Grant	Cross-cutting	General environment
4. Pacific Community	5.84	4.79			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**13.84**	**11.34**	**0.00**	**0.00**					
TOTAL	**60.89**	**49.89**	**0.00**	**0.00**					

Note: * Contributions to these organisations were not included in New Zealand's *Second Biennial Report* for the corresponding years. As part of continuous improvements to New Zealand's tracking of climate-related support, these organisations were identified as having climate change components to their work programmes. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*. ODA = official development assistance.

[314] Pacific regional agencies were not reported as other multilateral contributions in New Zealand's *Second Biennial Report*, and were reported under contributions through bilateral, regional and other channels. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

This list excludes one Pacific regional agency (Forum Fisheries Agency) that was included in New Zealand's *Second Biennial Report* but for which we have since reassessed the climate change component as being minimal.

[315] * Contributions to these organisations were not included in New Zealand's *Second Biennial Report* for the corresponding years. As part of continuous improvements to New Zealand's tracking of climate-related support, these organisations were identified as having climate change components to their work programmes. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

Table 7.4b: Provision of public financial support – contributions through multilateral channels, 2014

Donor funding	Total amount: Core/general NZ$ million	US$ million	Climate-specific NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Multilateral climate change funds									
1. Global Environment Facility[316]	1.05	0.87			Disbursed	ODA	Capital subscription	Cross-cutting	General environment
2. UNFCCC Trust Fund for Supplementary Activities		0.00	0.08	0.07	Disbursed	ODA	Grant	Cross-cutting	General environment
3. Montreal Protocol (United Nations Environment Programme)	0.60	0.50			Disbursed	ODA	Grant	Cross-cutting	General environment
Subtotal	**1.65**	**1.37**	**0.08**	**0.07**					
Multilateral financial institutions, including regional development banks									
1. World Bank[317]	18.22	15.11			Disbursed	ODA	Capital subscription	Cross-cutting	Cross-cutting
2. Asian Development Bank	10.38	8.61			Disbursed	ODA	Capital subscription	Cross-cutting	Cross-cutting
Subtotal	**28.60**	**23.72**	**0.00**	**0.00**					
Specialised United Nations bodies									
1. United Nations Development Programme	8.00	6.63			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
2. International Fund for Agricultural Development*	1.50	1.24			Disbursed	ODA	Grant	Adaptation	Agriculture
3. World Food Programme*	6.00	4.98			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**15.50**	**12.85**	**0.00**	**0.00**					

[316] This amount is based on the encashment of promissory notes rather than the lodging or commitment of a promissory note, as was reported in New Zealand's *Second Biennial Report*. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

[317] This amount is based on the encashment of promissory notes rather than the lodging or commitment of a promissory note, as was reported in New Zealand's *Second Biennial Report*. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

Donor funding	Total amount Core/general NZ$ million	US$ million	Climate-specific NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Other multilateral[318]									
1. CGIAR Fund*	7.50	6.22			Disbursed	ODA	Grant	Cross-cutting	Agriculture
2. FONTAGRO*[319]		0.00	1.10	0.91	Disbursed	ODA	Grant	Cross-cutting	Agriculture
3. International Renewable Energy Agency		0.00	0.50	0.41	Disbursed	ODA	Grant	Mitigation	Energy
4. Pacific Islands Forum Secretariat	3.11	2.58			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
5. Secretariat of the Pacific Regional Environment Programme	1.53	1.27			Disbursed	ODA	Grant	Cross-cutting	General environment
6. Pacific Community	6.16	5.11			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**18.30**	**15.18**	**1.60**	**1.33**					
TOTAL	**64.05**	**53.12**	**1.68**	**1.39**					

Note: FONTAGRO = Inter-American Development Bank's Regional Fund for Agricultural Technology; ODA = official development assistance; UNFCCC = United Nations Framework Convention on Climate Change.

318 Pacific regional agencies were not reported as other multilateral contributions in New Zealand's *Second Biennial Report*, and were reported under contributions through bilateral, regional and other channels. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

This list excludes one Pacific regional agency (Forum Fisheries Agency) that was included in New Zealand's *Second Biennial Report* but for which we have since reassessed the climate change component as being minimal.

319 * Contributions to these organisations were not included in New Zealand's *Second Biennial Report* for the corresponding years. As part of continuous improvements to New Zealand's tracking of climate-related support, these organisations were identified as having climate change components to their work programmes. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

Table 7.4c: Provision of public financial support – contributions through multilateral channels, 2015

	Total amount								
	Core/general		Climate-specific						
Donor funding	**NZ$ million**	**US$ million**	**NZ$ million**	**US$ million**	**Status**	**Funding source**	**Financial instrument**	**Type of support**	**Sector**
Multilateral climate change funds									
1. Global Environment Facility	1.81	1.26			Disbursed	ODA	Capital subscription	Cross-cutting	General environment
2. Green Climate Fund		0.00	3.00	2.09	Disbursed	ODA	Grant	Cross-cutting	General environment
3. UNFCCC Trust Fund for Supplementary Activities		0.00	0.13	0.09	Disbursed	ODA	Grant	Cross-cutting	General environment
4. Montreal Protocol (United Nations Environment Programme)	0.61	0.42			Disbursed	ODA	Grant	Cross-cutting	General environment
Subtotal	**2.42**	**1.69**	**3.13**	**2.18**					
Multilateral financial institutions, including regional development banks									
1. World Bank	17.29	12.06			Disbursed	ODA	Capital subscription	Cross-cutting	Cross-cutting
2. Asian Development Bank	10.38	7.24			Disbursed	ODA	Capital subscription	Cross-cutting	Cross-cutting
Subtotal	**27.67**	**19.30**	**0.00**	**0.00**					
Specialised United Nations bodies									
1. United Nations Development Programme	8.00	5.58			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
2. International Fund for Agricultural Development	1.50	1.05			Disbursed	ODA	Grant	Adaptation	Agriculture
3. World Food Programme	6.00	4.18			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**15.50**	**10.81**	**0.00**	**0.00**					

Donor funding	Total amount				Status	Funding source	Financial instrument	Type of support	Sector
	Core/general		Climate-specific						
	NZ$ million	US$ million	NZ$ million	US$ million					
Other multilateral									
1. CGIAR Fund	3.50	2.44			Disbursed	ODA	Grant	Cross-cutting	Agriculture
2. International Renewable Energy Agency	0.08	0.05	0.50	0.35	Disbursed	ODA	Grant	Mitigation	Energy
3. Pacific Islands Forum Secretariat	3.11	2.17			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
4. Secretariat of the Pacific Regional Environment Programme	1.53	1.07			Disbursed	ODA	Grant	Cross-cutting	General environment
5. Pacific Community	6.13	4.27			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**14.35**	**10.00**	**0.50**	**0.35**					
TOTAL	**59.94**	**41.79**	**3.63**	**2.53**					

Note: ODA = official development assistance; UNFCCC = United Nations Framework Convention on Climate Change.

Table 7.4d: Provision of public financial support – contributions through multilateral channels, 2016

Donor funding	Total amount: Core/general NZ$ million	Total amount: Core/general US$ million	Total amount: Climate-specific NZ$ million	Total amount: Climate-specific US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Multilateral climate change funds									
1. Global Environment Facility	1.76	1.23			Disbursed	ODA	Capital subscription	Cross-cutting	General environment
2. GEF Capacity Building Initiative for Transparency			0.13	0.09	Disbursed	ODA	Grant	Cross-cutting	General environment
3. UNFCCC Trust Fund for Participation			0.02	0.01	Disbursed	ODA	Grant	Cross-cutting	General environment
4. UNFCCC Trust Fund for Supplementary Activities			0.23	0.16	Disbursed	ODA	Grant	Cross-cutting	General environment
5. Montreal Protocol (United Nations Environment Programme)	0.87	0.61			Disbursed	ODA	Grant	Cross-cutting	General environment
Subtotal	**2.64**	**1.84**	**0.38**	**0.26**					
Multilateral financial institutions, including regional development banks									
1. World Bank	17.29	12.04			Disbursed	ODA	Capital subscription	Cross-cutting	Cross-cutting
2. Asian Development Bank	15.58	10.84			Disbursed	ODA	Capital subscription	Cross-cutting	Cross-cutting
Subtotal	**32.87**	**22.88**	**0.00**	**0.00**					
Specialised United Nations bodies									
1. United Nations Development Programme	8.00	5.57			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
2. International Fund for Agricultural Development	1.50	1.04			Disbursed	ODA	Grant	Adaptation	Agriculture
3. World Food Programme	6.00	4.18			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**15.50**	**10.79**	**0.00**	**0.00**					

Donor funding	Total amount				Status	Funding source	Financial instrument	Type of support	Sector
	Core/general		Climate-specific						
	NZ$ million	US$ million	NZ$ million	US$ million					
Other multilateral									
1. CGIAR Fund	5.50	3.83			Disbursed	ODA	Grant	Cross-cutting	Agriculture
2. FONTAGRO		0.00	0.40	0.33	Disbursed	ODA	Grant	Cross-cutting	Agriculture
3. International Renewable Energy Agency	0.09	0.06			Disbursed	ODA	Grant	Mitigation	Energy
4. Pacific Islands Forum Secretariat	3.11	2.16			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
5. Secretariat of the Pacific Regional Environment Programme	1.53	1.07			Disbursed	ODA	Grant	Cross-cutting	General environment
6. Pacific Community	5.98	4.16			Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
Subtotal	**16.21**	**11.28**	**0.40**	**0.28**					
TOTAL	**67.21**	**46.79**	**0.78**	**0.54**					

Note: FONTAGRO = Inter-American Development Bank’s Regional Fund for Agricultural Technology; GEF = Global Environment Facility; ODA = official development assistance; UNFCCC = United Nations Framework Convention on Climate Change.

Table 7.5: Provision of public financial support – contributions through bilateral, regional and other channels, 2013–16

Table 7.5a: Provision of public financial support – contributions through bilateral, regional and other channels, 2013

	Total amount						
	Climate-specific						
Recipient country / programme or activity[320]	NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Cook Islands / Renewable Energy	0.62	0.51	Disbursed	ODA	Grant	Mitigation	Energy
Cook Islands / Waste Management and Sanitation	0.66	0.54	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Cook Islands / Water Partnership (Te Mato Vai)	0.36	0.30	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Fiji / Community Shelter upgrade project	0.11	0.09	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Fiji / Flood Recovery - Infrastructure Projects	0.18	0.15	Disbursed	ODA	Grant	Adaptation	Reconstruction relief and rehabilitation
Fiji / Rotahomes Koroipita Project (Phase 2)	0.58	0.48	Disbursed	ODA	Grant	Adaptation	Other social infrastructure and services
Kiribati / Water & Sanitation, including rainwater harvesting	0.15	0.13	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Papua New Guinea / Highlands Economic Development Programme	0.39	0.32	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Papua New Guinea / Sustainable Agriculture and Community Resilience	0.12	0.10	Disbursed	ODA	Grant	Adaptation	Agriculture
Samoa / Indigenous housing as a solution to climate change	0.12	0.09	Disbursed	ODA	Grant	Adaptation	Other social infrastructure and services
Solomon Islands / Mekem StrongFisheries (MSSIF)	0.30	0.25	Disbursed	ODA	Grant	Adaptation	Fishing

320 Bilateral activities with a moderated value of less than NZ$100,000 have been grouped together and are listed in the 'Other Activities' lines.

This list excludes support provided to Tokelau, which is detailed in chapter 2 of this *Seventh National Communication*. New Zealand's climate-related support for Tokelau was reported in chapter 5 of New Zealand's *Second Biennial Report*. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

Recipient country / programme or activity[320]	Total amount Climate-specific NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Solomon Islands / Munda Runway, Nusatupe Runway, Noro-Munda Rd	4.40	3.61	Disbursed	ODA	Grant	Adaptation	Transport
Tonga / Energy: Village Network Upgrade	0.45	0.36	Disbursed	ODA	Grant	Mitigation	Energy
Tonga / Energy: Village Network Upgrade Project S2&3	4.36	3.57	Disbursed	ODA	Grant	Mitigation	Energy
Tonga / Renewable Energy Solar Project	0.46	0.38	Disbursed	ODA	Grant	Mitigation	Energy
Tuvalu / Tuvalu renewable energy	0.12	0.10	Disbursed	ODA	Grant	Mitigation	Energy
Vanuatu / Central Vanuatu Community Economic Development	0.13	0.11	Disbursed	ODA	Grant	Adaptation	Business and other services
Vanuatu / Inter-Island Shipping Programme	0.11	0.09	Disbursed	ODA	Grant	Adaptation	Transport
Vanuatu / Tanna WaSH Project	0.17	0.14	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Pacific Regional / Alliance of Small Island States (AOSIS)	0.23	0.19	Disbursed	ODA	Grant	Cross-cutting	General environment
Pacific Regional / Fisheries: Tuna Science and Information	0.30	0.25	Disbursed	ODA	Grant	Adaptation	Fishing
Pacific Regional / Fisheries: Tuna Investment and Export Facilitation	0.25	0.20	Disbursed	ODA	Grant	Adaptation	Fishing
Pacific Regional / Pacific Disaster Risk Management	0.37	0.31	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Pacific Regional / Pacific Energy Summit	0.79	0.65	Disbursed	ODA	Grant	Mitigation	Energy
Pacific Regional / Pacific Region Infrastructure Facility**	0.30	0.25	Disbursed	ODA	Grant	Cross-cutting	Transport
Pacific Regional / University of the South Pacific**[321]	1.50	1.23	Disbursed	ODA	Grant	Cross-cutting	Education

[321] ** Contributions to these regional organisations were not included in New Zealand's *Second Biennial Report* for the corresponding years. As part of continuous improvements to New Zealand's tracking of climate-related support, these organisations were identified as having climate change components to their work programmes. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

Recipient country / programme or activity[320]	Total amount Climate-specific NZ$ million	 US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Afghanistan / Renewable Energy Programme	5.29	4.33	Disbursed	ODA	Grant	Mitigation	Energy
Indonesia / DRM: GNS – Reducing Risk from Disasters	0.19	0.15	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Indonesia / GNS Geothermal Capacity Training	0.22	0.18	Disbursed	ODA	Grant	Mitigation	Energy
Laos / Resilience through education[322]	0.26	0.21	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Philippines / Strengthening Red Cross	2.04	1.68	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Timor Leste / Bobonaro Food Security	0.13	0.11	Disbursed	ODA	Grant	Adaptation	Agriculture
Viet Nam / Ben Tre Disaster Risk Management and Climate Change	1.00	0.82	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Viet Nam / GNS Dam Safety Project	0.27	0.22	Disbursed	ODA	Grant	Adaptation	General environment
Viet Nam / New Premium Fruit Variety Development	0.12	0.10	Disbursed	ODA	Grant	Adaptation	Agriculture
Asia Regional / Strengthening Disaster Risk Reduction: ADPC	0.57	0.47	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Kenya / Building Resilience for Two Drought Affected Kenyan Communities	0.43	0.35	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Other activities - Mitigation	0.29	0.24	Disbursed	ODA	Grant	Mitigation	Cross-cutting
Other activities - Adaptation	0.64	0.52	Disbursed	ODA	Grant	Adaptation	Cross-cutting
TOTAL	**29.01**	**23.77**					

Note: ODA = official development assistance.

322 Contributions to this activity were not included in New Zealand's *Second Biennial Report* for the corresponding year. As part of continuous improvements to New Zealand's tracking of climate-related support, this activity was identified as having a climate change component. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

Table 7.5b: Provision of public financial support – contributions through bilateral, regional and other channels, 2014

	Total amount						
	Climate-specific						
Recipient country / programme or activity[323]	NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Cook Islands / Drought Response	0.23	0.19	Disbursed	ODA	Grant	Adaptation	Emergency response
Cook Islands / Renewable Energy (Airport West & Enabling)	3.75	3.11	Disbursed	ODA	Grant	Mitigation	Energy
Cook Islands / Renewable Energy (Northern Group)	12.17	10.09	Disbursed	ODA	Grant	Mitigation	Energy
Cook Islands / Wastewater Activity	0.15	0.12	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Cook Islands / Water Partnership (Te Mato Vai)	0.23	0.19	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Fiji / Rotahomes Koroipita Project (Phase 2)	0.25	0.21	Disbursed	ODA	Grant	Adaptation	Other social infrastructure and services
Kiribati / Water & Sanitation, including rainwater harvesting	0.39	0.32	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Papua New Guinea / Enga Hydro	0.20	0.17	Disbursed	ODA	Grant	Mitigation	Energy
Papua New Guinea / Geothermal kick-start activities	0.12	0.10	Disbursed	ODA	Grant	Mitigation	Energy
Papua New Guinea / Highlands Economic Development Programme	0.15	0.12	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Papua New Guinea / Increasing Access to Electricity for Rural Communities	0.46	0.38	Disbursed	ODA	Grant	Mitigation	Energy
Samoa / Renewable Energy Partnership (SED)	7.36	6.10	Disbursed	ODA	Grant	Mitigation	Energy
Solomon Islands / Domestic Maritime Support Project	0.86	0.72	Disbursed	ODA	Grant	Adaptation	Transport

323 Bilateral activities with a moderated value of less than NZ$100,000 have been grouped together and are listed as 'Other activities'.

This list excludes support provided to Tokelau, which is detailed in chapter 2 of this *Seventh National Communication*. New Zealand's climate-related support for Tokelau was reported in chapter 5 of New Zealand's *Second Biennial Report*. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

Recipient country / programme or activity[323]	Total amount Climate-specific NZ$ million	 US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Solomon Islands / Mekem StrongFisheries (MSSIF)	0.15	0.13	Disbursed	ODA	Grant	Adaptation	Fishing
Solomon Islands / Munda Runway, Nusatupe Runway, Noro-Munda Rd	0.31	0.25	Disbursed	ODA	Grant	Adaptation	Transport
Tonga / Energy: Village Network Upgrade Project S2&3	3.13	2.60	Disbursed	ODA	Grant	Mitigation	Energy
Tuvalu / Borrow Pits Remediation	0.61	0.50	Disbursed	ODA	Grant	Adaptation	General environment
Tuvalu / Renewable Energy Projects	8.68	7.20	Disbursed	ODA	Grant	Mitigation	Energy
Vanuatu / Central Vanuatu Community Economic Devel	0.21	0.17	Disbursed	ODA	Grant	Adaptation	Business and other services
Vanuatu / Inter-Island Shipping Programme	0.75	0.62	Disbursed	ODA	Grant	Adaptation	Transport
Vanuatu / Rural Electrification Project	0.90	0.75	Disbursed	ODA	Grant	Mitigation	Energy
Vanuatu / Tanna WaSH Project	0.14	0.12	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Vanuatu / Tourism Assistance Programme	0.16	0.13	Disbursed	ODA	Grant	Adaptation	Tourism
Vanuatu / Water and Sanitation on Tanna and Pentecost***	0.56	0.46	Disbursed	ODA	Grant	Mitigation	Water supply and sanitation
Vanuatu / Water supply systems and sector strengthening***[324]	0.59	0.49	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Pacific Regional / Fisheries: Tuna Science and Information	0.27	0.23	Disbursed	ODA	Grant	Adaptation	Fishing
Pacific Regional / Fisheries: Tuna Investment and Export Facilitation	0.25	0.21	Disbursed	ODA	Grant	Adaptation	Fishing

[324] *** Contributions to these activities were not included in New Zealand's *Second Biennial Report* for the corresponding year. As part of continuous improvements to New Zealand's tracking of climate-related support, these activities were identified as having a climate change component. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

Recipient country / programme or activity[323]	Total amount Climate-specific NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Pacific Regional / Pacific Disaster Risk Management	0.56	0.46	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Pacific Regional / Pacific Region Infrastructure Facility**	0.30	0.25	Disbursed	ODA	Grant	Cross-cutting	Transport
Pacific Regional / University of the South Pacific**[325]	1.50	1.24	Disbursed	ODA	Grant	Cross-cutting	Education
Afghanistan / Renewable Energy Programme	2.25	1.87	Disbursed	ODA	Grant	Mitigation	Energy
Cambodia / Development of Commercial Horticulture***	0.37	0.31	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Cambodia / Disaster Resilience through Improved Education	0.24	0.20	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Indonesia / CaRED: Research and Development Support Programme	0.10	0.08	Disbursed	ODA	Grant	Adaptation	Industry
Indonesia / DRM: GNS – Reducing Risk from Disasters	0.15	0.13	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Indonesia / DRM: Indonesia Disaster Fund	1.05	0.87	Disbursed	ODA	Grant	Adaptation	Reconstruction relief and rehabilitation
Indonesia / DRM: National Disaster Management Framework	0.12	0.10	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Indonesia / Geothermal Energy HRD	0.14	0.12	Disbursed	ODA	Grant	Mitigation	Energy
Indonesia / GNS Geothermal Capacity Training	0.17	0.14	Disbursed	ODA	Grant	Mitigation	Energy
Indonesia / Technical Assistance for Scale-up of Geothermal	3.22	2.67	Disbursed	ODA	Grant	Mitigation	Energy
Philippines / BRAVE – resilience and food security	0.35	0.29	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness

325 ** Contributions to these regional organisations were not included in New Zealand's *Second Biennial Report* for the corresponding years. As part of continuous improvements to New Zealand's tracking of climate-related support, these organisations were identified as having climate change components to their work programmes. This has resulted in differences in the reported totals when comparing the figures for New Zealand's *Second Biennial Report* and *Seventh National Communication*.

Recipient country / programme or activity[323]	Total amount Climate-specific NZ$ million	 US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Philippines / Strengthening Red Cross	2.52	2.09	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Timor Leste / Bobonaro Food Security & Economic Development	0.15	0.12	Disbursed	ODA	Grant	Adaptation	Agriculture
Viet Nam / Ben Tre Disaster Risk Management and Climate Change	1.05	0.87	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Viet Nam / Building strong and resilient communities	0.15	0.12	Disbursed	ODA	Grant	Adaptation	Agriculture
Viet Nam / GNS Dam Safety Project	0.44	0.37	Disbursed	ODA	Grant	Adaptation	General environment
Viet Nam / New Premium Fruit Variety Development	0.12	0.10	Disbursed	ODA	Grant	Adaptation	Agriculture
Asia Regional / ASEAN AHA Centre Training Canterbury University	0.10	0.08	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Asia Regional / Strengthening Disaster Risk Reduction: ADPC	0.25	0.21	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Uruguay / Family Farm Improvement Project	0.26	0.22	Disbursed	ODA	Grant	Adaptation	Agriculture
West Indies Regional / Caribbean Geothermal Energy Support	0.10	0.08	Disbursed	ODA	Grant	Mitigation	Energy
Other activities – Mitigation	0.48	0.40	Disbursed	ODA	Grant	Mitigation	Cross-cutting
Other activities – Adaptation	0.63	0.52	Disbursed	ODA	Grant	Adaptation	Cross-cutting
Other activities – Cross-cutting	0.10	0.09	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
TOTAL	**59.90**	**49.68**					

Note: ASEAN AHA Centre = Association of South East Asian Nations Humanitarian Assistance Centre; DRM = disaster risk management; GNS = Institute of Geological and Nuclear Sciences Limited; ODA = official development assistance.

Table 7.5c: Provision of public financial support – contributions through bilateral, regional and other channels, 2015

Recipient country / programme or activity[326]	Total amount Climate-specific NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Cook Islands / Renewable Energy (Airport West & Enabling)	0.21	0.15	Disbursed	ODA	Grant	Mitigation	Energy
Cook Islands / Renewable Energy (Northern Group)	7.49	5.22	Disbursed	ODA	Grant	Mitigation	Energy
Cook Islands / Tropic Twilight 2015	0.91	0.63	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Cook Islands / Wastewater Activity	0.79	0.55	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Cook Islands / Water Partnership (Te Mato Vai)	0.90	0.63	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Federated States of Micronesia / North Pacific Development Fund	0.14	0.10	Disbursed	ODA	Grant	Mitigation	General Environment
Fiji / Evacuation Centres Upgrade Project	0.30	0.21	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Fiji / Rotahomes Koroipita Project (Phase 2)	0.28	0.20	Disbursed	ODA	Grant	Adaptation	Other Social Infrastructure and Services
Kiribati / Kiritimati Island Energy Sector Programme	0.44	0.30	Disbursed	ODA	Grant	Mitigation	Energy
Kiribati / Water & Sanitation, including rainwater harvesting	0.53	0.37	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Niue / Energy Support	0.25	0.17	Disbursed	ODA	Grant	Mitigation	Energy
Papua New Guinea / Enga Hydro	0.35	0.24	Disbursed	ODA	Grant	Mitigation	Energy
Papua New Guinea / Increasing Access to Electricity for Rural Communities	2.10	1.46	Disbursed	ODA	Grant	Mitigation	Energy

[326] Bilateral activities with a moderated value of less than NZ$100,000 have been grouped together and are listed as 'Other activities'.

Recipient country / programme or activity[326]	Total amount Climate-specific NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Papua New Guinea / Oxfam El Nino Response in Simbu Province	0.29	0.20	Disbursed	ODA	Grant	Cross-cutting	Disaster prevention and preparedness
Papua New Guinea / Rural On Grid extension project	0.30	0.21	Disbursed	ODA	Grant	Mitigation	Energy
Papua New Guinea / SFML Drought Mitigation and Adaptation in Simbu	0.11	0.07	Disbursed	ODA	Grant	Cross-cutting	Disaster prevention and preparedness
Samoa / Renewable Energy Partnership (SED)	2.09	1.46	Disbursed	ODA	Grant	Mitigation	Energy
Samoa / Tourism Infrastructure - Apia Waterfront Development	0.15	0.10	Disbursed	ODA	Grant	Adaptation	Tourism
Solomon Islands / Domestic Maritime Support Project	0.12	0.09	Disbursed	ODA	Grant	Adaptation	Transport
Solomon Islands / Fisheries Development	1.91	1.33	Disbursed	ODA	Grant	Adaptation	Fishing
Solomon Islands / Photovoltaic Power generation	2.77	1.93	Disbursed	ODA	Grant	Mitigation	Energy
Tonga / Energy: Village Network Upgrade Project S2&3	1.78	1.24	Disbursed	ODA	Grant	Mitigation	Energy
Tonga / Energy: Wind and Biomass Feasibility	0.11	0.07	Disbursed	ODA	Grant	Mitigation	Energy
Tonga / Renewable Energy Solar Project	0.33	0.23	Disbursed	ODA	Grant	Mitigation	Energy
Tuvalu / Borrow Pits Remediation	9.28	6.47	Disbursed	ODA	Grant	Adaptation	General environment
Tuvalu / Renewable Energy Projects	7.24	5.05	Disbursed	ODA	Grant	Mitigation	Energy
Vanuatu / Inter-Island Shipping Programme	0.33	0.23	Disbursed	ODA	Grant	Adaptation	Transport
Vanuatu / Support to Wan Smolbag 2015–19	0.15	0.11	Disbursed	ODA	Grant	Adaptation	Government and civil society, general
Vanuatu / Vanuatu Tourism Infrastructure Project (VTIP)	1.46	1.01	Disbursed	ODA	Grant	Adaptation	Tourism
Vanuatu / Water Supply Systems and Sector Strengthening	0.74	0.52	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation

Recipient country / programme or activity[326]	Total amount Climate-specific NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Pacific Regional / Fisheries: Tuna Science and Information	0.17	0.12	Disbursed	ODA	Grant	Adaptation	Fishing
Pacific Regional / Fisheries: Tuna Investment and Export Facilitation	0.25	0.17	Disbursed	ODA	Grant	Adaptation	Fishing
Pacific Regional / Ocean Acidification	0.75	0.53	Disbursed	ODA	Grant	Adaptation	General environment
Pacific Regional / Pacific Region Infrastructure Facility (PRIF)	0.30	0.21	Disbursed	ODA	Grant	Cross-cutting	Transport
Pacific Regional / Strengthening Water Security in Vulnerable Island States	0.24	0.16	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Pacific Regional / Sustainable Development and Energy Advisor	0.13	0.09	Disbursed	ODA	Grant	Cross-cutting	Energy
Pacific Regional / University of the South Pacific	1.50	1.05	Disbursed	ODA	Grant	Cross-cutting	Education
Afghanistan / Renewable Energy Capability Building and Technical Support	0.44	0.31	Disbursed	ODA	Grant	Mitigation	Energy
Afghanistan / Renewable Energy Programme	0.56	0.39	Disbursed	ODA	Grant	Mitigation	Energy
Cambodia / Development of Commercial Horticulture	0.57	0.40	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Cambodia / Disaster Resilience through Improved Education	0.15	0.11	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Indonesia / CaRED: Research and Development Support Programme	0.28	0.19	Disbursed	ODA	Grant	Adaptation	Industry
Indonesia / DRM: GNS – Reducing Risk from Disasters	1.07	0.75	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Indonesia / Energy: Monitoring, Evaluation & Technical Advice	0.33	0.23	Disbursed	ODA	Grant	Mitigation	Energy

Recipient country / programme or activity[326]	Total amount Climate-specific NZ$ million	 US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Indonesia / Geothermal Energy HRD	0.26	0.18	Disbursed	ODA	Grant	Mitigation	Energy
Laos / Community Resilience through Education	0.70	0.49	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Myanmar / Rakhine Winter Cropping Activity	0.57	0.40	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Philippines / BRAVE – resilience and food security	0.18	0.13	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Philippines / Restoring Agricultural-based income in Cotabato	0.45	0.31	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Philippines / Strengthening Red Cross	0.21	0.15	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Viet Nam / Ben Tre Disaster Risk Management and Climate Change	1.14	0.80	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Viet Nam / New Premium Fruit Variety Development	0.10	0.07	Disbursed	ODA	Grant	Adaptation	Agriculture
Asia Regional / ASEAN AHA Centre Training Canterbury University	0.13	0.09	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Asia Regional / Strengthening Disaster Risk Reduction: ADPC	0.25	0.18	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Comoros / Support for realisation of geothermal potential	0.23	0.16	Disbursed	ODA	Grant	Mitigation	Energy
Kenya / Building Resilience for Two Drought Affected Kenyan Communities	0.22	0.16	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Colombia / Colombia Dairy Value Chain Project	0.39	0.27	Disbursed	ODA	Grant	Adaptation	Agriculture
Peru / Dairy Initiative	0.10	0.07	Disbursed	ODA	Grant	Mitigation	Agriculture
Uruguay / Family Farm Improvement Project	0.30	0.21	Disbursed	ODA	Grant	Adaptation	Agriculture

Recipient country / programme or activity[326]	Total amount						
	Climate-specific						
	NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
West Indies Regional / Caribbean Geothermal Energy Support	0.60	0.42	Disbursed	ODA	Grant	Mitigation	Energy
Other activities – mitigation	0.23	0.16	Disbursed	ODA	Grant	Mitigation	Cross-cutting
Other activities – adaptation	0.96	0.67	Disbursed	ODA	Grant	Adaptation	Cross-cutting
Other activities – cross-cutting	0.13	0.09	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
TOTAL	**57.74**	**40.26**					

Note: ASEAN AHA Centre = Association of South East Asian Nations Humanitarian Assistance Centre; DRM = disaster risk management; GNS = Institute of Geological and Nuclear Sciences Limited; ODA = official development assistance.

Table 7.5d: Provision of public financial support – contributions through bilateral, regional and other channels, 2016

Recipient country / programme or activity[327]	Total amount: Climate-specific NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Cook Islands / Renewable Energy (Northern Group)	0.10	0.07	Disbursed	ODA	Grant	Mitigation	Energy
Cook Islands / Water Partnership (Te Mato Vai)	0.91	0.63	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Fiji / Child-focused Disaster Risk Reduction	0.44	0.30	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Fiji / DRM Community Solar Lanterns Project	0.50	0.35	Disbursed	ODA	Grant	Cross-cutting	Energy
Fiji / Evacuation Centres Upgrade Project	0.16	0.11	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Kiribati / Kiritimati Island Energy Sector Programme	0.45	0.31	Disbursed	ODA	Grant	Mitigation	Energy
Kiribati / Water & Sanitation, including rainwater harvesting	0.33	0.23	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Kiribati / Water and Sanitation 2015–2020	0.10	0.07	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Papua New Guinea / Drought Adaptation Strategies in PNG Highlands	0.34	0.24	Disbursed	ODA	Grant	Cross-cutting	Disaster prevention and preparedness
Papua New Guinea / Enga Hydro	5.02	3.50	Disbursed	ODA	Grant	Mitigation	Energy
Papua New Guinea / Harvest - Improved livelihoods and well-being for women and their families	0.32	0.22	Disbursed	ODA	Grant	Adaptation	Agriculture
Papua New Guinea / Increasing access to renewable energy	0.49	0.34	Disbursed	ODA	Grant	Cross-cutting	Energy
Papua New Guinea / NGO Drought Funding Round	0.73	0.50	Disbursed	ODA	Grant	Cross-cutting	Disaster prevention and preparedness
Papua New Guinea / Rural On Grid extension project	2.99	2.08	Disbursed	ODA	Grant	Mitigation	Energy

327 Bilateral activities with a moderated value of less than NZ$100,000 have been grouped together and are listed as 'Other activities'.

Recipient country / programme or activity[327]	Total amount Climate-specific NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Papua New Guinea / SFML Drought Mitigation and Adaptation in Simbu	0.15	0.10	Disbursed	ODA	Grant	Cross-cutting	Disaster prevention and preparedness
Papua New Guinea / Support for Food Distribution for Drought	0.75	0.52	Disbursed	ODA	Grant	Mitigation	Disaster prevention and preparedness
Samoa / Renewable Energy Partnership (SED)	2.51	1.75	Disbursed	ODA	Grant	Mitigation	Energy
Solomon Islands / Fisheries Development	2.14	1.49	Disbursed	ODA	Grant	Adaptation	Fishing
Solomon Islands / Photovoltaic Power generation	0.28	0.19	Disbursed	ODA	Grant	Mitigation	Energy
Tonga / Energy: Village Network Upgrade Project S2&3	8.33	5.80	Disbursed	ODA	Grant	Mitigation	Energy
Tonga / Energy: Wind and Biomass Feasibility	0.11	0.08	Disbursed	ODA	Grant	Mitigation	Energy
Tonga / Renewable Energy Solar Project	0.33	0.23	Disbursed	ODA	Grant	Mitigation	Energy
Tuvalu / Borrow Pits Remediation	0.12	0.08	Disbursed	ODA	Grant	Adaptation	General environment
Tuvalu / Renewable Energy Projects	1.98	1.38	Disbursed	ODA	Grant	Mitigation	Energy
Vanuatu / Agricultural development for Tanna's economic growth	0.17	0.12	Disbursed	ODA	Grant	Adaptation	Agriculture
Vanuatu / Central Vanuatu Community Economic Development	0.17	0.12	Disbursed	ODA	Grant	Adaptation	Business and other services
Vanuatu / Cyclone Pam Recovery	0.96	0.67	Disbursed	ODA	Grant	Adaptation	Reconstruction relief and rehabilitation
Vanuatu / Inter-Island Shipping Programme	0.52	0.36	Disbursed	ODA	Grant	Adaptation	Transport
Vanuatu / Rural Electrification Project	0.48	0.33	Disbursed	ODA	Grant	Mitigation	Energy
Vanuatu / Support to Wan Smolbag 2015–2019	0.12	0.08	Disbursed	ODA	Grant	Adaptation	Government and civil society, general
Vanuatu / Tourism Assistance Programme	0.13	0.09	Disbursed	ODA	Grant	Adaptation	Tourism

Recipient country / programme or activity[327]	Total amount Climate-specific NZ$ million	 US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Vanuatu / Vanuatu Tourism Infrastructure Project (VTIP)	3.56	2.48	Disbursed	ODA	Grant	Adaptation	Tourism
Vanuatu / Water Supply Systems and Sector Strengthening	0.24	0.17	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Pacific Regional / Climate Change and Disaster Risk Reduction Research	0.16	0.11	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Pacific Regional / Effective Coastal Fisheries Management	0.47	0.32	Disbursed	ODA	Grant	Adaptation	Fishing
Pacific Regional / GCF Technical Assistance for Pacific Access programme	0.07	0.05	Disbursed	ODA	Grant	Cross-cutting	General environment
Pacific Regional / Ocean Acidification	0.31	0.22	Disbursed	ODA	Grant	Adaptation	General environment
Pacific Regional / Office of UNGA President Samoa Secondee	0.12	0.08	Disbursed	ODA	Grant	Cross-cutting	Multisector
Pacific Regional / Pacific Energy Conference 2016	0.74	0.51	Disbursed	ODA	Grant	Mitigation	Energy
Pacific Regional / Pacific Region Infrastructure Facility (PRIF)	0.30	0.21	Disbursed	ODA	Grant	Cross-cutting	Transport
Pacific Regional / PFTAC Phase 5	1.50	1.04	Disbursed	ODA	Grant	Mitigation	Government and civil society, general
Pacific Regional / Strengthening Water Security in Vulnerable Island States	0.42	0.29	Disbursed	ODA	Grant	Adaptation	Water supply and sanitation
Pacific Regional / Sustainable Aquaculture Development	0.25	0.17	Disbursed	ODA	Grant	Adaptation	Fishing
Pacific Regional / University of the South Pacific	1.50	1.04	Disbursed	ODA	Grant	Cross-cutting	Education
Afghanistan / Renewable Energy Capability Building and Technical Support	0.42	0.29	Disbursed	ODA	Grant	Mitigation	Energy

Recipient country / programme or activity[327]	Total amount Climate-specific NZ$ million	US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Asia Regional / ASEAN AHA Centre Training Canterbury University	0.15	0.10	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Cambodia / Development of Commercial Horticulture	0.40	0.28	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Cambodia / Disaster Resilience through Improved Education	0.14	0.10	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Colombia / Colombia Dairy Value Chain Project	0.30	0.21	Disbursed	ODA	Grant	Adaptation	Agriculture
Indonesia / CaRED: Research and Development Support Programme	0.29	0.20	Disbursed	ODA	Grant	Adaptation	Industry
Indonesia / DRM: GNS – Reducing Risk from Disasters	1.22	0.85	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Indonesia / DRM: National Disaster Management Framework	0.19	0.13	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Indonesia / Energy: Monitoring, Evaluation & Technical Advice	0.17	0.12	Disbursed	ODA	Grant	Mitigation	Energy
Indonesia / Massey Agribusiness Innovation in Eastern Indonesia	0.23	0.16	Disbursed	ODA	Grant	Adaptation	Agriculture
Myanmar / Rakhine Winter Cropping Activity	0.60	0.42	Disbursed	ODA	Grant	Cross-cutting	Agriculture
Viet Nam / Ben Tre Disaster Risk Management and Climate Change	0.61	0.42	Disbursed	ODA	Grant	Adaptation	Disaster prevention and preparedness
Viet Nam / Building Strong and Resilient Communities	0.24	0.16	Disbursed	ODA	Grant	Adaptation	Agriculture
Viet Nam / GNS Dam Safety Project	0.41	0.28	Disbursed	ODA	Grant	Adaptation	General environment
Viet Nam / New Premium Fruit Variety Development	0.11	0.07	Disbursed	ODA	Grant	Adaptation	Agriculture
Peru / Dairy Initiative	0.19	0.13	Disbursed	ODA	Grant	Mitigation	Agriculture

Recipient country / programme or activity[327]	Total amount Climate-specific NZ$ million	 US$ million	Status	Funding source	Financial instrument	Type of support	Sector
Uruguay / Family Farm Improvement Project	0.26	0.18	Disbursed	ODA	Grant	Adaptation	Agriculture
West Indies Regional / Caribbean Geothermal Energy Support	0.32	0.23	Disbursed	ODA	Grant	Mitigation	Energy
Other activities – mitigation	0.56	0.39	Disbursed	ODA	Grant	Mitigation	Cross-cutting
Other activities – adaptation	0.77	0.54	Disbursed	ODA	Grant	Adaptation	Cross-cutting
Other activities – cross-cutting	0.46	0.32	Disbursed	ODA	Grant	Cross-cutting	Cross-cutting
TOTAL	**49.78**	**34.65**					

Note: ASEAN AHA Centre = Association of South East Asian Nations Humanitarian Assistance Centre; DRM = disaster risk management; GNS = Institute of Geological and Nuclear Sciences Limited; ODA = official development assistance.

7.3 Technology transfer

The development and transfer of climate technologies is critical for achieving the goals of the Paris Agreement to reduce greenhouse gas emissions and adapt to the impacts of climate change. 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 is a win–win, helping 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 is therefore a priority for New Zealand. During the *Seventh National Communication* reporting period, New Zealand delivered on these commitments through the New Zealand Aid Programme and the Global Research Alliance on Agricultural Greenhouse Gases. This section reports on these commitments in text and tabular format while referencing other relevant sections of this chapter.

7.3.1 Technology transfer delivered through the New Zealand Aid Programme

As detailed in section 7.2.3, country partnerships are at the heart of New Zealand's climate-related support, with countries' identified priorities central to the development support New Zealand provides. The New Zealand Aid Programme is committed to supporting climate change action in developing countries, with particular areas of focus being the Pacific region, renewable energy and agriculture. These focus areas are reflected in the sectors most prevalent in table 7.6. In addition, New Zealand has supported a number of technology transfer activities in South-East Asia, Africa and South America, both through the aid programme and the Global Research Alliance on Agricultural Greenhouse Gases, as outlined in tables 7.6 and 7.7.

A priority for the New Zealand Aid Programme, detailed in section 7.2.3, has been supporting renewable energy initiatives to enable access to affordable, reliable and clean energy sources reducing carbon emissions, improving energy efficiency and creating low-carbon development pathways. Section 7.2.3 sets out a number of examples of renewable energy projects that have promoted, facilitated and financed technology transfer for the benefit of non-Annex 1 Parties. The majority of mitigation activities detailed in table 7.6 are also renewable energy activities.

Another priority in the aid 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 intense extreme weather events, increasing risk of drought, sea-level rise and changes in fisheries resource. Section 7.2.3 details a number of these projects, including those focused on water and sanitation, agriculture and disaster-resilient infrastructure.

Global Research Alliance on Agricultural Greenhouse Gases

In addition to technology transfer delivered through the New Zealand Aid Programme, under the framework of the Global Research Alliance on Agricultural Greenhouse Gases, New Zealand promotes and facilitates the development of endogenous and non-endogenous capacities and technologies of developing country Parties in agriculture. New Zealand support enables developing countries to implement their commitments, including in particular by: developing national agricultural inventories; developing, applying and diffusing – including transferring – technologies, practices and processes that control, reduce or prevent greenhouse gases in the agriculture sector; and conserving and enhancing sinks and reservoirs of all greenhouse gases 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 greenhouse gas inventories consistent with their national circumstances, priorities and capacities (see table 7.7)
- providing training in South East Asian countries to improve agricultural development strategies that aim for low greenhouse gas emissions and reduce vulnerability or increase resilience to climate change (see table 7.7).

Explanation of information provided in tables 7.6 and 7.7

During the reporting period New Zealand's support for technology transfer involved both 'hard' technology – tangible components – and 'soft' technology, which includes information and knowledge-sharing, training and research. Much of New Zealand's support is a combination of both hard and soft technology to help ensure that the climate-friendly technologies developed and managed are country-relevant, sustainable and long-lasting. Tables 7.6 and 7.7 include examples of both hard and soft technology transfer, with the majority of activities identified comprising a combination of both.

Similarly the majority of the activities identified in tables 7.6 and 7.7 combine 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, tables 7.6 and 7.7 generally do not differentiate between endogenous and non-endogenous technology transfer.

Section 7.2.3 has explained that New Zealand follows a number of development principles when providing climate-related support through the New Zealand Aid Programme. These principles include ownership, alignment, donor harmonisation, results focus and transparency. As 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 how they apply to each project. The Global Research Alliance on Agricultural Greenhouse Gases applies a different funding criterion. Where possible therefore, table 7.7 identifies factors that led to a project's success in a different way from table 7.6. Where these factors have not been recorded, the equivalent column in table 7.7 has been left blank.

As detailed in section 7.2.3, New Zealand recognises the importance of private sector investment in contributing to effective climate outcomes in developing countries. The aid programme's investment priority of renewable energy offers strong opportunities to increase private sector investment and trade in the Asia–Pacific region. Table 7.6 identifies, where possible, activities that encouraged private sector investment. Work is currently under way to identify how to incentivise greater private sector investment in the renewable energy sector for the benefit of developing countries. Aside from New Zealand's investments in renewable energy, activities that encourage private sector support are limited.

Table 7.6: Technology transfer delivered through the New Zealand Aid Programme

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
Afghanistan Renewable Energy Programme	To increase use of renewable energy in Bamyan province	Afghanistan	Energy	Mitigation	Installing 1.05 MWp of photovoltaic arrays, transmission and distribution lines and built local capacity to manage the installations	2013–15	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	1.05 MWp of photovoltaic arrays	Public	Refer to tables 7.5a–7.5d
Tonga Energy: Village Network Upgrade	To reduce high network losses, improve community access to the electricity network and prepare it for further renewable energy generation	Tonga	Energy	Mitigation	Replace and extend the existing electricity network to more villages on Tongatapu	2013	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Networks were rebuilt and extended using New Zealand standards to increase the efficiency of the network	Local lines-people were trained to install network assets to New Zealand standards by NorthPower Ltd	Refer to tables 7.5a–7.5d
Tonga Energy: Village Network Upgrade Project S2&3	To reduce high network losses, improve community access to the electricity network and prepare it for further renewable energy generation	Tonga	Energy	Mitigation	Replace and extend the existing electricity network to more villages on Tongatapu	2013–18	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, Transparency	Networks were rebuilt and extended using New Zealand standards to increase the efficiency of the network	Local lines-people were trained to install network assets to New Zealand standards by NorthPower Ltd	Refer to tables 7.5a–7.5d

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
Tonga Renewable Energy Solar Project	To reduce reliance on diesel fuel and increase use of renewable energy	Tonga	Energy	Mitigation	Building a 1.3 MWp solar photovoltaic power plant in Nuku'alofa, which is reducing reliance on diesel fuel supply, and reducing greenhouse gas emissions	2013–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, Transparency	1.3 MWp solar photovoltaic power plant	Partnered with Meridian Energy	Refer to tables 7.5a–7.5d
Cook Islands Renewable Energy (Airport West & Enabling)	To reduce diesel consumption, build energy resilience and provide over 5 per cent of Rarotonga's annual energy needs	Cook Islands	Energy	Mitigation	Installing photovoltaic panels	2013–16		961 kWp of photovoltaic panels connected to the main Rarotongan electricity network	Public	Refer to tables 7.5a–7.5d
Northern Group Renewable Energy	To switch from reliance on diesel fuel to 90 per cent renewable energy	Cook Islands	Energy	Mitigation	Installing eight solar-diesel-battery hybrid mini-grids on six islands of the Cooks Northern Group	2014–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Eight solar-diesel-battery hybrid mini-grids, including 850 kWp of photovoltaic modules	Public	Refer to tables 7.5a–7.5d

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
Rotahomes Koroipita Project (Phase 2)	To improve the infrastructure and resilience of marginalised communities	Fiji	Other	Adaptation	Constructing cyclone-proof housing and urban infrastructure, and installed solar street lights	2013–15	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Houses and buildings have been constructed in line with Fiji building codes to withstand cyclones and other natural hazards compounded by climate change. The Koroipita township serves as a model for low-cost, resilient infrastructure development for marginalised families	Public	Refer to tables 7.5a–7.5d
Building Resilience for Two Drought-Affected Kenyan Communities	To improve drought resilience for two drought-affected communities in Kenya	Kenya	Water supply and sanitation	Adaptation	Improving access to water through the provision of boreholes, water-pans and drip irrigation systems	2013–15	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Improved water infrastructure and better management systems for changing weather patterns	Public	Refer to tables 7.5a–7.5d

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
Water Partnership (Te Mato Vai)	To deliver a reliable source of potable water to the population of Rarotonga	Cook Islands	Water supply and sanitation	Adaptation	Ongoing activity that is upgrading Rarotonga's water reticulation system to increase storage capacity, building resilience to more frequent dry spells with climate change	2013–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Water storage tanks, filtration system, pipes	Public	Refer to tables 7.5a–7.5d
Tanna WaSH Project	To increase resilience to drought	Vanuatu	Water supply and sanitation	Mitigation	Providing water catchments and gravity-fed water systems, including the installation of improved spring boxes in the water catchments that are reducing water contamination during floods and cyclones	2013–14	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Construction of household latrines and water supply of solar powered piped water systems in two communities. Transfer of knowledge to ensure sustainability of water and sanitation systems	Public	Refer to tables 7.5a–7.5d
Kiribati Water & Sanitation, including rainwater harvesting	To increase Kiribati's resilience to drought events as a result of climate change	Kiribati	Water supply and sanitation	Adaptation	Providing rainwater harvesting systems in South Tarawa's community buildings and refurbishing water and sanitation systems in its two hospitals, as well as improved water	2013–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Rainwater harvesting systems, sanitation systems. Information and knowledge sharing on better water management	Public	Refer to tables 7.5a–7.5d

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
					resource management and water testing					
Papua New Guinea Sustainable Agriculture and Community Resilience	To increase use of drought-resistant farming methods and alternative climate-resistant crops	Papua New Guinea	Agriculture	Adaptation	Working with farmers to increase their understanding and using farming methods and alternative climate-resistant crop varieties	2013	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Training and information sharing about climate-resilient crops and farming methods	Public	Refer to tables 7.5a–7.5d
Samoa Indigenous housing as a solution to climate change	To build prototype traditional buildings that can withstand increasingly intense cyclones	Samoa	Other social infrastructure and services	Adaptation	Building a prototype building using indigenous and current building materials and techniques that can withstand increasingly strong cyclones	2013	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Endogenous technology transfer supporting the development of indigenous building practices and materials to better withstand cyclones	Public	Refer to tables 7.5a–7.5d
Tuvalu Renewable Energy Projects	Increasing use of renewable energy, reducing greenhouse gas emissions and reliance on diesel fuel	Tuvalu	Energy	Mitigation	Installing hybrid mini-grid systems on the Northern Outer Islands of Nanumaga (195 kW), Nanumea (195 kW), Niutao (232 kW) and Vaitupu (410 kW). New	2014–16	Country ownership, alignment with country strategies and priorities, donor harmonisation – project	Two 195 kW, one 232 kW and one 410 kW hybrid mini-grid photovoltaic systems. Rooftop grid-connected photovoltaic systems. Training on	Public	Refer to tables 7.5a–7.5d

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
					Zealand also funded the installation of grid-connected rooftop photo voltaic arrays on media and government public buildings in Funafuti		coordination with the European Union and the United Arab Emirates, results focused, transparency	the operation and maintenance of the systems		
Samoa Renewable Energy Partnership	To increase use of renewable energy in Samoa	Samoa	Energy	Mitigation	Installing three photovoltaic arrays and co-financing with the ADB three rehabilitated and three new hydro-power plants. Support to asset management and capacity building	2014–16	Country ownership, alignment with country strategies and priorities, donor harmonisation (partnering with the EU and the ADB), results focused, transparency	2.58 MWp photovoltaic arrays and contributing to ADB-led rehabilitation and new hydro-power plants	Public	Refer to tables 7.5a–7.5d
Vanuatu Rural Electrification Project	To support the distribution of solar home systems to off-grid households in rural areas to replace the use of petroleum for light and power	Vanuatu	Energy	Mitigation	New Zealand contributed to the World Bank to support the distribution of solar home systems to off-grid households in rural areas to replace the use of petroleum for light and power	2014–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Solar home systems	Model includes local private sector as vendor to distribute solar home systems in Vanuatu (World Bank led)	Refer to tables 7.5a–7.5d

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
Tuvalu Borrow Pits Remediation	To fill in pits on Tuvalu's most populated island, Funafuti, where soil was 'borrowed' for the airport runway, providing 6 per cent more useable land and increasing resilience to sea-level rise and significant weather events	Tuvalu	General environment	Adaptation	Dredging sand from the lagoon and transferring it into the pits. Shoreline strengthening was also undertaken where it had been eroded	2014–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	A complex project that required significant engineering, knowledge-sharing and technical support to build resilience to climate change	Public	Refer to tables 7.5a–7.5d
Vanuatu Water Supply Systems and Sector Strengthening	To increase resilience to drought	Vanuatu	Water and sanitation	Adaptation	Assisting with the recovery of the water, sanitation and hygiene in Vanuatu following Tropical Cyclone Pam	2014–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency Community ownership through Participatory Hygiene and Sanitation Training	Technical and strategic advice to assist with the design, management and maintenance of climate-resilient water projects	Public	Refer to tables 7.5a–7.5d

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
Vanuatu Water and Sanitation on Tanna and Pentecost	To increase resilience to drought	Vanuatu	Water and sanitation	Mitigation	Providing water catchments and gravity-fed water systems, including the installation of improved spring boxes in the water catchments that are reducing water contamination during floods and cyclones	2014	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Water reticulation systems	Public	Refer to tables 7.5a–7.5d
Papua New Guinea Enga Hydro	To extend electricity access to over 15,200 people	Papua New Guinea	Energy	Mitigation	Activity to install a 500 kW – 1 MW mini hydro-plant on the Tare River	2014–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	500 kW – 1 MW mini hydro-plant and local electricity distribution network	Public	Refer to tables 7.5a–7.5d

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
Caribbean Geothermal Energy Support	To expand access to geothermal energy	West Indies region	Energy	Mitigation	Providing technical assistance and project management support, implemented by an in-country geothermal advisor, to develop the geothermal resource. Technical assistance package laid the ground for larger donors and the private sector to invest further in geothermal energy generation	2014–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Enabling technology transfer through information and knowledge sharing and training to encourage public and private sector investment in the geothermal sector	Encouraging private sector investment	Refer to tables 7.5a–7.5d
Solomon Islands Photovoltaic Power Generation	To increase Solomon Islands uptake of renewable energy	Solomon Islands	Energy	Mitigation	Jointly funded project, in partnership with the United Arab Emirates, to install 1 MW of grid-connected solar photovoltaics to provide approximately 4 per cent of Honiara's electricity needs and	2015–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	1 MWp grid-connected photovoltaic plant	Public	Refer to tables 7.5a–7.5d

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
					save more than 450,000 litres of diesel					
Papua New Guinea Rural On Grid extension project	To extend the Port Moresby Grid and to connect more consumers who were previously without electricity access	Papua New Guinea	Energy	Mitigation	Ongoing activity extending the Port Moresby Grid by 36 kilometres to bring electricity from a hydro-plant to approximately 15,000 direct beneficiaries	2015–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Support for PNG Power Ltd to extend grid	Public	Refer to tables 7.5a–7.5d
Fiji Evacuation Centres Upgrade Project	To provide greater access to safe emergency evacuation centres during disasters	Fiji	Disaster prevention and preparedness	Adaptation	Strengthening disaster evacuation centres to withstand increased disaster events	2015–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Buildings have been constructed in line with Fiji building codes to withstand cyclones and other natural hazards compounded by climate change	Public	Refer to tables 7.5a–7.5d

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
Pacific Regional Strengthening Water Security in Vulnerable Island States	To strengthen water availability in five low-lying Pacific islands that are subject to drought and water shortages	Tuvalu, Tokelau, Kiribati, Cook Islands and the Republic of Marshall Islands	Water and sanitation	Adaptation	Funding the appointment, training and operation of five water security officers, who are placed in government departments to provide technical support for water security planning and implementation	2015–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Funding has enabled the purchase of equipment for groundwater monitoring and effective management of water supply to withstand more frequent drought events	Public	Refer to tables 7.5a–7.5d4
Comoros Support for Realisation of Geothermal Potential	Provide technical assistance to support the Comoros Government to develop its geothermal energy resource	Comoros	Energy	Mitigation	Providing technical assistance to support the development of its geothermal resource surface exploration, infrastructure assessments and fundraising for exploratory drilling	2015–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Enabling geothermal development through technical assistance	Public	Refer to tables 7.5a–7.5d
Papua New Guinea SFML Drought Mitigation and Adaptation in Simbu	To increase resilience to drought	Papua New Guinea	Disaster prevention and preparedness	Adaptation	Replacing and installing more communal water tanks and repairing piping to maximise rainwater harvesting	2015–16	Country ownership, alignment with country strategies and priorities, donor	Water tanks, pipes	Public	Refer to tables 7.5a–7.5d

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
							harmonisation, results focused, transparency			
Tonga Energy: Wind and Biomass Feasibility	To determine feasibility of wind generation	Tonga	Energy	Mitigation	Partnership with Japan to determine feasibility of a wind and biomass farm	2015–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Promoting technology transfer through technical assistance in assessment and design of a wind farm	Public	Refer to tables 7.5a–7.5d
Fiji DRM Community Solar Lanterns Project	To improve access to solar lighting for 3000 people in 700 homes across five informal settlements where there is no access to electricity	Fiji	Energy	Cross-cutting	Activity that is providing a reliable lighting source for 3000 people, reducing emissions and building community resilience	2016	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Solar-powered lanterns	Public	Refer to tables 7.5a–7.5d

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
Papua New Guinea Increasing access to renewable energy	To develop a pipeline of projects to increase access in remote areas	Papua New Guinea	Energy	Mitigation	Activity identifying and project-managing delivery of rural and/or remote renewable-diesel-battery hybrid mini-grids	2016	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Rural and/or remote renewable-diesel-battery hybrid mini-grids	Tranche 1 project may be a private sector owner-operator	Refer to tables 7.5a–7.5d
Kiritimati Island Energy Sector Programme	To upgrade the electricity network on Kiritimati Island and provide some renewable generation	Kiribati	Energy	Mitigation	Installing more fuel-efficient generators, improving the distribution network and installing photovoltaic system supplying 15 per cent of the electricity demand	2016	Country ownership, alignment with country strategies and priorities, donor harmonisation (joint project with the European Union), results focused, transparency	More fuel-efficient generators, photovoltaic system. Significant capability building to ensure local operators maintain the systems appropriately for long life	Public	Refer to tables 7.5a–7.5d

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
Kiribati Water and Sanitation 2015–20	To increase Kiribati’s resilience to drought events as a result of climate change	Kiribati	Water supply and sanitation	Adaptation	The second stage of this adaptation activity is providing more community rainwater harvesting systems, improving South Tarawa’s reticulated water supply and sewerage systems, and scoping possible investment in desalination	2016	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Rainwater harvesting systems, sanitation systems. Information and knowledge sharing on better water management	Public	Refer to tables 7.5a–7.5d
Solomon Island Domestic Maritime Support	To construct and rehabilitate 13 wharves and landing strips	Solomon Islands	Infrastructure	Adaptation	Constructing and rehabilitating 13 wharves and three landing strips, all of which have been designed to withstand sea-level rise	2014–15	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Engineering technical expertise to design climate resilient wharves and ramps	Public	Refer to tables 7.5a–7.5d

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
Vanuatu Tourism Infrastructure Project	To strengthen areas of the Port Vila Seafront Precinct to withstand storm surges and sea-level rise	Vanuatu	Infrastructure	Adaptation	Strengthening areas of the Port Vila Seafront Precinct to withstand storm surges and sea-level rise	2015–16	Country ownership, results focused, transparency	Engineering technical expertise to design climate resilient seafront able to withstand climate projections of cyclones, sea-level rise and rainfall	Public	Refer to tables 7.5a–7.5d
Vanuatu Inter-island Shipping Project	To promote economic development through strengthened transportation modes and agencies/public sector	Vanuatu	Transport	Adaptation	Building wharves and landing ramps to withstand projected sea-level rise and storm surges	2013–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Engineering technical expertise to design climate resilient wharves and ramps	Public	Refer to tables 7.5a–7.5d
Solar Power in Primary Schools (SDF 2-134)	To increase lighting in Solomon Islands primary schools	Solomon Islands	Energy	Mitigation	Installing solar power systems in 10 rural primary schools and providing training in solar power system operation and basic maintenance	2013-14	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Photovoltaic systems for 10 schools (average of two per school)	Public	Refer to tables 7.5a–7.5d

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
Vanuatu Geothermal Energy Support	To provide technical assistance to support the Government of Vanuatu to develop its geothermal energy resource	Vanuatu	Energy	Mitigation	Technical assistance to support the Government of Vanuatu to develop its geothermal energy resource	2014–15	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Promoting development of renewable geothermal energy	Public	Refer to tables 7.5a–7.5d
Fisheries: Tuna Science and Information	To improve management of the tuna fisheries resource and adapt to the effects of climate change	Pacific region	Other	Adaptation	Tagging and tracing fisheries resource in the Pacific region to better manage fish stocks in that region	2013–15	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Improving fisheries management by tagging and tracing fisheries resource with changing oceanic conditions, including those resulting from climate change	Public	Refer to tables 7.5a–7.5d
MMR Rakhine Winter Cropping Activity	To improve food security and generate more sustainable farming systems in Rakhine State, Myanmar	Myanmar	Agriculture	Cross-cutting	Activity to improve agriculture farm systems so they are more resilient to changing weather patterns through better water management and crop diversification	2014–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Selecting crops that are resilient to harsh weather conditions; improving soil management; better water harvesting, storage irrigation systems	Public	Refer to tables 7.5a–7.5d

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
Pacific Energy Initiatives	To enable private sector energy investment in the Pacific region	Pacific region	Energy	Mitigation	Technical assistance so that Pacific Island countries can encourage and enable independent power producer projects	2015–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Technical assistance and capability building to enable and encourage private sector renewable energy generation projects	Initiative was aimed at supporting private sector investment in the Pacific region	Refer to tables 7.5a–7.5d
Niue Renewable Energy Design	To increase renewable energy production	Niue	Energy	Mitigation	Increasing renewable energy production and reducing reliance on fossil fuels through solar modules	2015–16	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	600 kWp solar modules, 800 kW/1 MWh battery, 750 kW power control system, remediation of existing solar and grid, plus capacity building for local utility	Public	Refer to tables 7.5a–7.5d
Vanuatu Water Supply Systems and Sector Strengthening	To rehabilitate water and sanitation facilities	Vanuatu	Water and sanitation	Adaptation	Partnership with UNICEF to strengthen information systems and build water and sanitation infrastructure	2015–2016	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Water and sanitation infrastructure that enables more reliable access to water with changing weather patterns	Public	Refer to tables 7.5a–7.5d

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
Cook Island Invasive Species Biocontrols	To improve food security and build climate resilience by suppressing invasive weeds that inhibit crop growth in changing climatic conditions	Cook Islands	Other	Adaptation	Using imported biocontrol agents to sustainably control and supress invasive weeds	2016	Country ownership, alignment with country strategies and priorities, donor harmonisation, results focused, transparency	Using biocontrol agents and weed management techniques to reduce climate change-related invasive weed species	Public	Refer to tables 7.5a–7.5d

Note: ADB = Asian Development Bank; EU = European Union; kW = kilowatt; kWp = kilowatt peak; MWh = megawatt hour; MWp = megawatt peak.

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 (NZD)
High Tier Agriculture Inventories in South East Asia	To assist South East Asian countries to develop Higher Tier Agricultural inventories in SE Asia	Thailand, Indonesia, Malaysia, Philippines, Sri Lanka, Viet Nam, Papa New Guinea, Canada, Colombia, Japan	Agriculture	Mitigation	Developing Tier 2 inventories to measure the impacts of mitigation technologies and practices	2016		Identification of barriers and enabling factors for improving emissions inventories; sharing of country experiences and successful examples; and identified links with other regional projects	Public	83,059
Livestock Mitigation in South East Asia	To develop regional livestock mitigation project in Asia	Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, Viet Nam	Agriculture	Mitigation	A workshop to develop enteric methane (NH_4) projects based on country needs that supported specific development goals and focus areas	2016	Used lessons learned from similar projects implemented in other regions	Created enabling environment for climate-friendly agriculture methods and technologies by developing ways to consolidate and merge productivity, mitigation and inventory activities into a coherent regional network of countries	Public	69,885

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 (NZD)
Global Research Alliance – Sri Lanka engagement	A workshop on the Global Research Alliance on Agricultural Greenhouse Gases, and opportunities for engagement with Sri Lanka	Sri Lanka	Agriculture	Mitigation	A workshop to develop enteric NH_4 projects based on country needs that supported specific development goals and focus areas	2016	Included partners from the wider regional enteric NH_4 project (science, policy and industry) together with additional policy-makers from the inventory team and line ministries (agriculture, rural development and environment)	Developing a project to identify practices that improve efficiency and livelihoods while reducing greenhouse gas intensity and capturing these gains through the development of higher-tier inventories	Public	26,597
Malaysian Inventory Training	To incorporate livestock emissions into Malaysia's national inventory	Malaysia	Agriculture	Mitigation	A workshop that brought together researchers and policy-makers to include livestock emissions in Malaysia's inventory	2016		Created an enabling environment for the uptake of climate-friendly livestock management systems and technology by incorporating livestock emissions in Malaysia's inventory	Public	43,733

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 (NZD)
African Inventory Training	To improve agriculture greenhouse gas inventories of Ghana, Botswana and South Africa	Ghana, Botswana, South Africa	Agriculture	Mitigation	Improving and monitoring three African countries' agriculture greenhouse gas inventories	2015		Created an enabling environment for the uptake of climate-friendly agricultural practices and technologies through training to develop agricultural inventories, included overview of using IPCC methods, Agriculture Land Use and Tier 2 inventories	Public	62,901
South East Asia Inventory and Monitoring Training	To identify the steps needed for participating countries to improve their inventories consistent with their national circumstances, priorities and capacities	Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, Viet Nam	Agriculture	Mitigation and adaptation	This workshop identified the benefits of higher-tier greenhouse gas inventories for livestock systems and the steps needed for participating countries to improve their inventories consistent with their national circumstances, priorities and capacities	2015	Built on previously successful Asia–Pacific Economic Cooperation (APEC) project. Was consistent with participating countries' national circumstances, priorities and capacities	Created enabling environments for climate-friendly livestock management and technologies by building on outcomes from APEC activity Climate Change Adaptation Options in Livestock with Mitigation Potential, and the regional South East Asia Inventory project	Public	125,974

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 (NZD)
South East Asia Farm Systems	To improve agricultural development strategies that aim for low greenhouse gas emissions and reduce vulnerability or increase resilience to climate change in participating countries	Cambodia, China, Indonesia, Japan, Korea, Lao PDR, Malaysia, Myanmar, Philippines, Viet Nam, Thailand, Sri Lanka	Agriculture	Mitigation and adaptation	New Zealand support for a Netherlands-funded workshop with participants from science institutes and policy-makers	2015	High calibre of participants from science institutes and governments	Promoted climate-friendly agricultural development strategies that aim for low greenhouse gas emissions and increased resilience to climate change	Public	34,500
Livestock and Climate Change	To build regional leadership on livestock and climate change, and methods for measuring greenhouse gas emissions	Ethiopia, Kenya, Uganda, Tanzania, Rwanda, Burundi, Malawi, Zambia, Botswana, Namibia, Zimbabwe, South Africa	Agriculture	Mitigation	Training to undertake nitrous oxide (N_2O) measurements from manual or automatic chambers and CH_4 emission measurements from ruminants using the sulphur hexafluoride tracer technique and respiration chambers	2015		Promoting climate-friendly livestock management through training for N_2O and CH_4 measurements	Public	41,449

7.4 Capacity building

To mitigate and adapt to climate change, countries must have the capacity to do so. New Zealand recognises the important role that enhancing the capacity and ability of developing countries to take effective climate change action must play in responding to climate change. New Zealand provides capacity-building support that responds to the existing and emerging capacity-building needs identified by developing country Parties in the areas of mitigation, adaptation, and technology development and transfer. This occurs through a number of mechanisms including the New Zealand Aid Programme, the Global Research Alliance on Agricultural Greenhouse Gases, the UNFCCC and regional organisations such as the Secretariat of the Pacific Regional Environment Programme, the Asia-Pacific Network for Global Change Research and Asia–Pacific Economic Cooperation (APEC).

New Zealand's capacity-building activities are targeted to areas where it has expertise such as agriculture, renewable energy generation and disaster risk resilience building, and where countries have identified specific needs and capacity gaps. A large portion of New Zealand's capacity-building activities has been aimed at the Pacific region, aligning with the Ministry of Foreign Affairs and Trade's strategic objective of maximising the impact of New Zealand's engagement in improving the prosperity, stability and resilience of the Pacific Island region and its people.[328] This also means New Zealand's capacity-building support is focused on developing the needs of those with the least capacity – small island developing states, many of which are also those most vulnerable to climate change. Other capacity-building activities where New Zealand has expertise have been delivered to the benefit of developing country Parties in Africa, South East Asia and South America.

7.4.1 Capacity building supported through the New Zealand Aid Programme

Much of New Zealand's capacity-building support for climate change adaptation, mitigation and technology transfer during the reporting period occurred through activities managed by the New Zealand Aid Programme, as detailed in tables 7.5a–7.5d and sections 7.2.2 and 7.2.3. Examples in those sections and in table 7.8 include: disaster risk management and resilience building; renewable energy; ocean acidification; drought resilience; agriculture; and support to developing countries to better access the finance needed for climate action, such as the Technical Assistance for Pacific Access programme, which provides rapid deployment of technical support to develop project proposals from the Pacific region.

7.4.2 Other capacity-building support

New Zealand has also provided support to capacity-building initiatives from other government funding sources. Some of this has been channelled through the Global Research Alliance on Agricultural Greenhouse Gases, the UNFCCC and Pacific regional organisations such as SPREP, the Asia–Pacific Network for Global Change Research and APEC. As detailed in table 7.9, during the reporting period New Zealand funded the following.

- A $43,157 workshop in 2015 assisted officials from Pacific Island countries to prepare their country's Intended Nationally Determined Contribution. It responded to needs identified by Pacific Island countries to help ensure their Intended Nationally Determined

328 Ministry of Foreign Affairs and Trade. 2016. *Strategic Intentions 2016–2020.* Wellington: Ministry of Foreign Affairs and Trade. Retrieved from www.mfat.govt.nz/en/media-and-resources/news/mfat-strategic-intentions-2016-20.

Contributions reflected Pacific priorities and capabilities. Pacific Island countries had the opportunity to exchange ideas and experiences, including learning from New Zealand's experience of preparing an Intended Nationally Determined Contribution. The workshop looked at emissions reduction targets, data and policy processes and the importance of evidence-based information in annual greenhouse gas inventories, national communications and biennial reports.

- New Zealand provided SPREP with $20,000 to upskill Pacific Island country representatives in effective negotiating techniques ahead of the COP20 climate change negotiations in 2014.
- It provided $60,000 to the Asia–Pacific Network for Global Change Research for its CAPaBLE capacity-building programme to enhance the capacity of scientists, policy-makers and other relevant stakeholders in the Asia–Pacific region. This enabled them to identify and assess global change issues at local, national and regional levels, to further identify appropriate solutions and to achieve sustainability.
- As detailed in section 7.2.1, New Zealand provided $444,000 to the UNFCCC to support: the international consultation and analysis processes in developing countries; the implementation of national greenhouse gas inventories by developing country Parties, including training in the use of the 2006 IPCC inventory guidelines; and the implementation of the Cancun Adaptation Framework and the Nairobi work programme on impacts, vulnerability and adaptation to climate change. All of these activities had significant capacity-building elements.
- As detailed in section 7.2.1, New Zealand contributed $130,000 to the GEF's Capacity Building Initiative for Transparency. Established at COP21, the CBIT will support developing country Parties to meet enhanced transparency requirements under the Paris Agreement.
- Through the Global Research Alliance on Agricultural Greenhouse Gases, New Zealand provided $8331 in support to a Food and Agriculture Organization agriculture inventory workshop delivered in South East Asia. The workshop was designed to build capacity in how to implement the Enhanced Transparency Framework in agriculture and land-use sectors in Asia and the Pacific.
- New Zealand provided $10,213 for a workshop in which officials from a range of Asian countries learned about enteric fermentation in the agriculture sector. This workshop supports a Climate and Clean Air Coalition project, which aims to identify practices and technologies to reduce livestock emissions while improving productivity.
- With $661,521 for the Livestock Emissions Abatement Research Network (LEARN),[329] New Zealand supported technicians, PhD students, and postdoctoral fellows from developing countries to build international capability in livestock emissions research (for more information, see section 9.6.2).
- New Zealand provided $128,134 for the World Farmers' Organisation–GRA study tours (for more information, see section 9.6.2)
- $454,000 in capacity building and coordination support to Pacific Island Countries by MetService to help ensure their National Meteorological Services (NMSs) are able to manage, operate and sustain their own Global Climate Observation Systems Essential Climate Variables observation programmes (for more information see Annex D: New Zealand's report on the Global Climate Observing System).

[329] www.livestockemissions.net

Fossil fuel subsidy reform

Capacity building that encourages the removal of environmentally harmful subsidies is critical to establishing environments that enable effective climate-friendly technology development and transfer, such as renewable energy technologies. Policies that encourage the removal of harmful subsidies are critical to implementing successful and sustainable fossil fuel subsidy reform. In some cases building capacity to implement policies is thus necessary. As a founding member of the Friends of Fossil Fuel Subsidy Reform, New Zealand, alongside an informal group of 20 non-Group countries, is building international political consensus on the importance of fossil fuel subsidy reform. In addition, it is encouraging and building the capacity of the Group of 20 (G20) and APEC economies to meet their commitments to reform inefficient fossil fuel subsidies.

For example, in 2015 and 2016 New Zealand, with several other friends, supported the APEC capacity-building workshops on fossil fuel subsidy reform. These workshops built developing country capacity by sharing experiences with domestic reform and/or fossil fuel subsidy peer reviews among APEC, G20 and other economies. It included perspectives from international experts on the best strategies for phasing out fossil fuel subsidies and effective ways to pursue reform while providing essential energy services. Other examples of capacity support provided through the Friends of Fossil Fuel Subsidy Reform during the reporting period were the 2015 and 2016 side events, hosted jointly by New Zealand, the United States and the World Bank, in the margins of the World Bank–International Monetary Fund Spring Meetings. The events provided an opportunity to hear first-hand accounts from countries about their experiences with reform, and to understand the tools and initiatives available to support reform.

Table 7.8: Activities managed by the New Zealand Aid Programme that address capacity building

Recipient country or countries	Target area	Project title	Description
Papua New Guinea	Adaptation	Sustainable Agriculture and Community Resilience	Working with Caritas NZ to support sustainable agriculture- and fishery-based alternative livelihoods for rural Papua New Guineans
Vanuatu	Adaptation	Agricultural development for Tanna's economic growth	The goal of the activity is to strengthen household economic resilience through developing the sustainable agriculture sector in Tanna
Vanuatu	Adaptation	Tanna WaSH Project	World Vision-led project focused on water, sanitation, hygiene, health and nutrition issues through community-led interventions in five communities in southwest Tanna, Vanuatu
Pacific region	Cross-cutting	GCF Technical Assistance for Pacific Access programme	The overall goals of this activity are to: (1) build capacity and understanding of the Green Climate Fund; (2) identify current barriers preventing countries from readily accessing the Green Climate Fund; (3) identify potential projects (in concept stage or in development) that meet the criteria of Green Climate Fund financing; and (4) support governments (and other regional stakeholders) to successfully gain financing for selected projects through the capacity-building initiatives and the provision of specialist technical advice

Recipient country or countries	Target area	Project title	Description
Pacific region	Adaptation	Ocean Acidification	This activity aims to build community and environmental resilience to ocean acidification. It is being led by SPREP.
Afghanistan	Mitigation	Renewable Energy Capability Building and Technical Support	This project contributed to growing the economy in Bamyan province, Afghanistan by providing capability-building and technical assistance to ensure the successful long-term operation of the New Zealand-funded Renewable Energy Programme
Indonesia	Mitigation	Geothermal Energy Human Resource Development	The activity produced a Strategic Geothermal Energy Human Resource Development Plan for Indonesia's geothermal energy sector
Indonesia	Energy Generation and Supply	GNS Geothermal Capacity Training	GNS Science, in partnership with University of Gadjah Mada, is conducting basic and advance geothermal courses and developing training and course modules. Training-of-trainers is also being extended to lecturers of the University’s Faculty of Engineering
Laos	Adaptation	Resilience through education	Working with Save the Children to support local communities and institutions to prepare for, respond to and recover from disasters. Disaster risk reduction plans to be prepared and implemented in communities and schools. Communities will also be strengthened through improved disaster-resilient livelihoods
Philippines	Adaptation	BRAVE – resilience and food security	Building resilience and improving food through three key output areas: disaster risk reduction, education and food security
Timor Leste	Adaptation	Bobonaro Food Security & Economic Development	Working with World Vision to support farmers in Timor Leste to increase their yields of subsistence crops through the introduction of innovative, sustainable production, processing and storage techniques
Viet Nam	Adaptation	Building strong and resilient communities	Working with ChildFund NZ to implement an activity to build stronger and more resilient communities in six rural communes in Cao Bang Province, through improved agriculture, diversified livelihoods, and disaster risk management
Asia region	Adaptation	ASEAN Humanitarian Assistance Centre	Practical-level training and technical support to the ASEAN Humanitarian Assistance Centre in disaster risk management and risk identification
Asia region	Adaptation	ASEAN Humanitarian Assistance Centre Training, Canterbury University	The activity delivered three 2-week training courses in New Zealand for ASEAN officials working in disaster risk management

Recipient country or countries	Target area	Project title	Description
Asia region	Adaptation	Strengthening Disaster Risk Reduction: ADPC	The activity aims to improve disaster risk reduction capacity in Lao People's Democratic Republic (PDR), Myanmar, the Philippines and Viet Nam. It focuses on: (1) improving the use of risk information; and (2) enhancing preparedness for the recovery phase of disasters
Papua New Guinea	Cross-cutting	Drought Adaptation Strategies in PNG Highlands	Provides immediate support to affected communities in Enga Province, and potentially other areas affected by a prolonged drought as a result of the El Nino Weather conditions in Papua New Guinea, by delivering agriculture drought strategies
Tonga	Adaptation	SDF 3-201 Ama Takiloa Tonga Sustainable Development	The Ama Takiloa programme of the Tonga Community Development Trust worked with women's groups in villages on Tongatapu, 'Eua, Ha'apai, Vava'u and the Niuas to increase incomes, increase resilience to natural disasters and improve health
Vanuatu	Adaptation	Water supply systems and sector strengthening	In partnership with UNICEF, New Zealand is funding technical advice to the Government of Vanuatu, strengthen information systems, and the build of priority water and sanitation infrastructure
Pacific region	Adaptation	Pacific Disaster Risk Management	This activity aims to boost disaster readiness and response, principally in the Pacific
Pacific region	Adaptation	Meteorological Forecasting	This activity funds New Zealand Meteorological Service to provide expert meteorological advice (relating to the annual Pacific cyclone season)
Pacific region	Cross-cutting	SPREP Programme Support	Support to build the capacity of SPREP, which is the regional organisation charged with the protection and sustainable development of the region's environment
Indonesia	Adaptation	Disaster Risk Management: GNS – Reducing Risk from Disasters	Training and capability building provided to increase the disaster risk management skills of local governments, to provide specialist advice and technical support to local governments, and increase participation of the private sector, NGOs and community
Indonesia	Cross-cutting	Geo-INZ – Geothermal Technical Assistance	The provision of technical assistance embedded in the Indonesian Ministry of Energy and Mineral Resources at an operational level to support the newly established Ministry in its responsibilities, including by providing assistance in the tendering of geothermal concessions
Indonesia	Mitigation	Geothermal Training (NZSTIGS)	New Zealand support for training in the Indonesian geothermal sector
Laos	Adaptation	Community Resilience through Education	Improved risk and disaster recovery preparedness in seven districts in the Luang Prabang and Sayaboury Provinces in the Lao PDR

Recipient country or countries	Target area	Project title	Description
Asia region	Adaptation	ASEAN Humanitarian Assistance Centre	Practical training and technical support to the Humanitarian Assistance Centre in disaster risk management and risk identification
Comoros	Mitigation	Support to attend a geothermal conference	Support to Comoros to attend a geothermal conference: “Driving Geothermal Development: How to Realise Geothermal Potential”
Africa region	Mitigation	Renewable Energy Study Tour	Study tour to contribute to the development of the Africa Clean Energy Corridor, which will accelerate the use of renewable power in East Africa
Central America region	Mitigation	Energy Summit Caribbean Attendance	Support for Caribbean delegations to attend the Pacific Energy Summit
West Indies region	Mitigation	Caribbean Geothermal Workshop	A workshop on the development of geothermal energy in the Caribbean

Note: ADPC = Asia Disaster Preparedness Centre; ASEAN = Association of South East Asian Nations; GCF = Green Climate Fund; GNS Science = Institute of Geological and Nuclear Sciences Limited; SPREP = Secretariat of the Pacific Regional Environment Programme.

Table 7.9: Capacity-building activities funded from other sources

Recipient countries	Target area	Programme/ project title	Description
Indonesia, Philippines, Sri Lanka, Viet Nam, Thailand	Cross-cutting	Asian Inventory and Monitoring Workshop	This was a workshop organised by the Food and Agriculture Organization: “On the Road to Enhanced Transparency for NDC Implementation: Understanding Capacity Needs for the Paris Enhanced Transparency Framework in Agriculture and Land-Use Sectors in Asia and the Pacific”
India, Bangladesh, Japan, the Philippines, Indonesia, Thailand, Malaysia, Viet Nam	Mitigation	Enteric Methane project	An Asia region workshop on enteric fermentation – to support Climate and Clean Air Coalition project
Pacific Island countries	Cross-cutting	Preparing Nationally Determined Contributions workshop	A workshop to assist officials from Pacific Island countries to prepare their countries’ Intended Nationally Determined Contributions
Global	Cross-cutting	Support to the UNFCCC	Support to the UNFCCC to assist developing countries to implement national greenhouse gas inventories including training on the use of the 2006 IPCC inventory guidelines, and support the implementation of the Cancun Adaptation Framework and the Nairobi work programme on impacts, vulnerability and adaptation to climate change

Recipient countries	Target area	Programme/ project title	Description
Global	Cross-cutting	Support to the Global Environment Facility's Capacity Building Initiative for Transparency	Capacity building to support developing country Parties in meeting enhanced transparency arrangements under the Paris Agreement
APEC developing countries	Mitigation	APEC Fossil Fuel Subsidy Reform Capacity-building workshops	Workshops supporting APEC developing country members' capacity-building efforts to undertake fossil fuel subsidy reform
Pakistan, Viet Nam, China, Sri Lanka, Ethiopia, Colombia, Kenya, Uganda, Ghana	Mitigation	Livestock Emissions Abatement Research Network	Support for technicians, PhD students and postdoctoral fellows from developing countries to build international capability in livestock emissions research
Argentina, Paraguay, South Africa, Uruguay	Cross-cutting	World Farmers' Organisation-GRA study tours	Farmers' study tour 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 to be informed of, and inform, the global research agenda
Pacific Islands countries	Cross-cutting	SPREP Negotiating Capacity Building	Capacity-building event to upskill officials and high-level representatives from the Pacific Island region on climate change negotiations ahead of COP20
Pacific Islands countries	Adaptation	Global Climate Observation Systems Essential Climate Variables observation programme	Capacity building and coordination support to Pacific Island Countries by MetService to help ensure their National Meteorological Services (NMSs) are able to manage, operate and sustain their own Global Climate Observation Systems Essential Climate Variables observation programmes, as detailed in Annex D: New Zealand's report on the Global Climate Observing System
Asia-Pacific	Cross-cutting	CAPaBLE	Support for Asia–Pacific Network for Global Change Research and its capacity-building programme, CAPaBLE
Global	Mitigation	Fossil Fuel Subsidy Reform	Encourage and support the G20 and APEC economies to reform inefficient fossil fuel subsidies

Note: APEC = Asia–Pacific Economic Cooperation; COP20 = Conference of Parties 20; G20 = Group of 20; GRA = Global Research Alliance on Agricultural Greenhouse Gases; IPCC = Intergovernmental Panel on Climate Change; NDC = Nationally Determined Contribution; SPREP = Secretariat of the Pacific Regional Environment Programme; UNFCCC = United Nations Framework Convention on Climate Change.

8 Research and systematic observations

Key developments since the *Sixth National Communication*

- The New Zealand Government's investment in climate change research in the 2015/16 financial year was approximately NZ$48 million.
- Systematic weather and climate observations and information exchange were supported by a further NZ$16 million.
- The government departments supporting research have been reorganised, as has the system for allocating research funds to Crown research institutes, to promote research that contributes to the well-being and prosperity of New Zealand.
- Progress continues on the National Science Challenges, several of which include a significant component of climate change research.
- Research on projected regional climate changes and impacts is based on the most recent global climate model results.
- Agriculture sector research is focused on mitigation of greenhouse gas emissions.

8.1 Introduction

New Zealand's climate change research needs are dictated by its geographical situation, unique biophysical features, population distribution and economic activities. These are described in detail in chapter 2.

The country spans a wide range of latitudes, with climatic zones ranging from subtropical to subantarctic, and 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 sea ice, as well as producing regional climate change projections and determining the likely effects of climate change on diverse ecosystems.

Mitigation and adaptation research has to cover equally diverse issues. These include transport in a country with a low 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 export and international trade also means that mitigation options need to be compatible with the commercial requirements and technology standards of international markets.

Just under half of New Zealand's emissions come from agriculture, particularly pastoral agriculture, which also makes a significant contribution to the New Zealand economy. Consequently New Zealand faces a particular need to undertake research to mitigate agricultural emissions and understand the climate change impacts and adaptation options for agriculture. Research is a key Government measure to reduce greenhouse gas emissions from this sector. Domestically, this need for research is currently addressed by the Government-funded New Zealand Agricultural Greenhouse Gas Research Centre and by the Pastoral Greenhouse Gas Research Consortium, which is jointly funded by Government and industry. Internationally, it is addressed by leadership in and financial support for the Global Research

Alliance on Agricultural Greenhouse Gases (GRA). New Zealand contributes funding and support for experts to participate in research activities of the GRA. Much of the research it supports contributes to the Livestock Research Group of the GRA, which is co-chaired by the Director of the New Zealand Agricultural Greenhouse Gas Research Centre. This research should ultimately contribute to global emissions reductions far greater than New Zealand's 0.16 per cent total contribution to global emissions.

New Zealand has continued to support and promote collaboration in research and systematic observations on climate change, as required by Articles 4 and 5 of the United Nations Framework Convention on Climate Change (UNFCCC). Central government investment in research related to climate change for the 2015/16 financial year is estimated at NZ$50.3 million. This is complemented by substantial expenditure from the private sector, which matches government funding in some research consortia, and also from regional governments, particularly on climate impacts.

The National Institute of Water and Atmospheric Research (NIWA) receives funding for climate research and observations and for maintaining the National Climate Database as part of its core work. 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 Global Climate Observing System (GCOS) programme. MetService's observing network is supported in part through a contract with the Ministry of Transport for provision of New Zealand's national meteorological service.

Through the government's investment in research and observations, climate observations have been maintained and new knowledge has been generated about climate change and its impacts in New Zealand and the southwest Pacific. Using this knowledge, adaptation and mitigation options are being identified and developed.

New Zealand also addresses climate change research through its National Science Challenges. These 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 New Zealand. The impacts of climate change are being studied in several Challenges.

New Zealand continues to contribute personnel and funding to support the work of the Intergovernmental Panel on Climate Change (IPCC) and participates in the production of its reports and updating of climate reporting methodologies. New Zealand researchers participate in international research and observation programmes of the World Meteorological Organization; the World Climate Research Programme; the GCOS and its Pacific component (PI-GCOS); the Integrated Marine Observing System; the Southern Ocean Observing System; Future Earth; and the Asia–Pacific Network for Global Change Research.

Under a New Zealand government contract, MetService provides some assistance to a number of Pacific Island nations (the Cook Islands, Kiribati, Niue, Tonga, Tuvalu, Samoa and Tokelau) 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 coordinate the production and publication of the *Island Climate Update*, in collaboration with various scientific organisations in the Pacific Islands, Australia, the United States, the United Kingdom and France. The *Island Climate Update* provides updates of current climate conditions and outlooks for the coming season to help Pacific Island countries plan and adapt to climate variability and change. NIWA also works with Pacific Island and Australian partners on climate adaptation work in several Pacific Island countries, supported from a range of funding sources and bilateral arrangements.

8.2 Research and systematic observations: policy and funding

8.2.1 Strategy for research and systematic observations

The New Zealand Government supports a range of 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.

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 range of different funding mechanisms is explained in more detail below.

Much of the Government's research investment is made through the Science and Innovation group within the Ministry of Business, Innovation and Employment. The Ministry for Primary Industries 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 issues in 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.

Funding is allocated through non-contestable long-term funding to Crown research institutes (CRIs; see section 8.2.2), together with competitive bidding, which is open to all research providers including universities and other institutes as well as the CRIs. Collaborative research projects involving subcontracting to a mix of different organisations are common.

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 related to climate change annually. The Society facilitates interactions between scientists and stakeholders in New Zealand and maintains some international links on behalf of the New Zealand Government through a Catalyst: Influence fund, which supports New Zealand's participation in the World Climate Research Programme; the Scientific Committee on Antarctic Research; the Scientific Committee on Oceanic Research; and the International Council for Science, which supports the Future Earth research programme.

Research needs

The strategic directions and goals for research in New Zealand are set out by the Government in its *National Statement of Science Investment 2015–2025*.[330] This identifies climate change as

[330] www.mbie.govt.nz/info-services/science-innovation/national-statement-science-investment

one of a number of complex, long-term, national-scale issues to be addressed by National Science Challenges, and as a significant issue for the primary industries.

Specific statements of research priorities in the field of climate change can be found in the 20-year *Conservation and Environment Science Roadmap*,[331] 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
- 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 our marine and land carbon sinks.

Further specific climate change research priorities are stated in the *Primary Sector Science Roadmap – Te Ao Tūroa*[332] and the *New Zealand Antarctic and Southern Ocean Science Directions and Priorities 2010–2020*.[333]

Research programmes for agricultural greenhouse gases

A number of programmes and organisations carry out research on agricultural greenhouse gas emissions. The major research programmes are described below; research highlights are detailed in section 8.4.

The **New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC)** is a government-funded consortium of nine CRIs, universities and industry bodies, which is led by AgResearch (one of the CRIs) and based in Palmerston North. Its role is to find ways for New Zealand to meet its international greenhouse gas emissions obligations without reducing agricultural output. Its programmes address ruminant methane (CH_4), soil nitrous oxide (N_2O) emissions, soil carbon (C) and integrated farm systems. It is supported by an annual NZ$4.85 million grant through the Primary Growth Partnership[334] and is contracted for a 10-year period, finishing in 2019, with reviews every 2.5 years. The Centre also has an important role in supporting New Zealand's commitments to the GRA.

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331 Ministry for the Environment. 2017. *Conservation and Environment Science Roadmap*. Wellington: Ministry for the Environment.

332 Ministry for Primary Industries. 2017. *Primary Sector Science Roadmap – Te Ao Tūroa.* Wellington: Ministry for Primary Industries.

333 www.antarcticanz.govt.nz/science/new-zealands-antarctic-science-strategy

334 The Primary Growth Partnership aims to improve the future market success of New Zealand primary industries through long-term innovation programmes that are jointly funded by government and industry. A key goal is to encourage more private investment in research and development in New Zealand.

Much of the industry funding is channelled through the **Pastoral Greenhouse Gas Research Consortium (PGgRc)**,[335] in which the Government matches the investment of the pastoral industry in research on the reduction of greenhouse gases from pastoral production. The Consortium's research programme, which commenced in 2002, aims to provide New Zealand livestock farmers with the knowledge and tools to mitigate greenhouse gas emissions from the agriculture sector. The Consortium is a commitment by the pastoral sector to address pastoral emissions while ensuring that New Zealand's economic wealth is enhanced. The PGgRc works closely with the NZAGRC, particularly on ruminant CH_4 research.

The **Biological Emissions Reference Group**, a joint government and industry reference group, was set up in 2016 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 commissions independent third-party research in support of this evidence base and will publish a final synthesis report by mid-2018. This evidence will inform any future actions or policies to reduce biological emissions from agriculture.

The **Ministry for Primary Industries (MPI)** supports research to improve the accuracy of New Zealand's agricultural emissions reporting to the UNFCCC in the annual greenhouse gas inventory, and reporting of projections of future land use emissions in the *National Communication* and *Biennial Report*. The research improves knowledge of country-specific emission factors and activity data for agricultural greenhouse gas emissions reporting, and the key drivers for projections of future emissions from land use.

Internationally, New Zealand's leadership in establishing and hosting the **GRA Secretariat** and New Zealand's activities in support of the GRA (see chapters 4, 7 and 9) aim to foster collaborative international research projects, global data sets, and standard measurement and mitigation techniques and protocols between countries. New Zealand 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.

8.2.2 Funding policies

A significant amount of climate research and systematic observation in New Zealand is conducted by the Crown research institutes. In the past this work was supported by contestable funding and, from 2011–17, by CRI core funding via the Ministry of Business, Innovation and Employment, which provided stability to help CRIs engage in longer-term research programmes that contribute to the well-being and prosperity of New Zealand.

Central government has also made it clear that CRIs are expected to work to develop long-term strategic partnerships with government, their sectors and potential research collaborators. This is intended to help set the priorities for the CRIs, maximise private sector involvement in the research process (eg, by leveraging private investment in collaboration) and facilitate technology transfer and knowledge exchange. Ultimately, the aim is to promote wide engagement in research relating to describing, mitigating and adapting to climate change, and to help ensure the results are taken up as rapidly as possible.

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335 www.pggrc.co.nz

CRI core funding contracts expired in 2017 and the funding was transferred to the Strategic Science Investment Fund (SSIF). The SSIF provides longer-term funding for underpinning 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 2017/18, the SSIF is worth over NZ$260 million per year. Much climate change science is well aligned with the principles and intent of the SSIF.

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, national and regional predictions and projections, impacts and adaptation options
- AgResearch – agricultural greenhouse gas mitigation and climate change impacts and adaptation in agriculture
- Landcare Research – indigenous forest measurement and management, agricultural greenhouse gas mitigation, soil carbon, impacts of climate change on natural, productive and built environments, and assessing life-cycle greenhouse gas emissions profiles for various sectors
- Plant and Food – soil carbon particularly under cropping, N2O emissions, erosion tree species (eg, poplars and willows) and their adaptation to drought and insect pests, and breeding of forage crops
- Institute of Geological and Nuclear Sciences Limited (GNS Science) – palaeoclimate, natural hazards, geo-sequestration of carbon dioxide (CO2)
- Scion – planted forests, forest sinks modelling and projections of forest sink carbon, harvested wood products and indigenous forests, land-use modelling, soil carbon under forests and biofuels.

In mid-2013 the Ministry of Business, Innovation and Employment announced significant new research funding aligned to 11 National Science Challenges,[336] to be supported for 10 years. The funding includes NZ$55 million per annum 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 New Zealand. The impacts of climate change are being studied in several Challenges, including:

- understanding the role of the Antarctic and the Southern Ocean in determining our climate and our future environment (the Deep South)
- 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 our 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).

Further details on three of these challenges are outlined in the box below.

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336 www.mbie.govt.nz/info-services/science-innovation/national-science-challenges

The Deep South

The Deep South National Science Challenge is working to understand the role of the Antarctic and Southern Ocean in determining New Zealand's future climate and how this role impacts on key economic sectors, infrastructure and natural resources. This will enable New Zealanders to adapt to, manage the risk of and thrive in a changing climate. Through collaboration with communities and industry, the Challenge will guide planning and policy to enhance resilience and exploit opportunities. The Challenge framework of five linked programmes will connect society with scientists, and combine community engagement with a world-class earth systems model to better predict New Zealand's climate. For further information on the results of this research, see section 6.4.

Resilience to Nature's Challenges

The objective of the Resilience to Nature's Challenges National Science Challenge is to enhance New Zealand's resilience to natural disasters. Working closely with research users, the Challenge is developing technical resilience solutions and applying them in high-priority geographical and economic settings. This includes developing Māori-specific tools and business strategies to make communal assets more resilient and enhance kaitiakitanga (guardianship). In rural economies, work is aimed at strengthening value chains, and using future scenarios to identify effective interventions. In cities, the Challenge looks to build in resilience in growing populations, housing and transport systems. For our vulnerable coastlines, the Challenge will integrate community and governance views to design innovative pathways that balance our desire to live near the sea with resilience to the hazards brought about by sea-level rise and climate change.

Our Land and Water

The Our Land and Water National Science Challenge aims to enhance the production and productivity of New Zealand's primary sector, while maintaining and improving the quality of the country's land and water for future generations. The way New Zealand uses and manages its land and water will be transformed by Challenge research on gaining greater value from global markets, innovative resilient land and water use, and building collaborative capacity. These drivers, along with research to connect them, form the themes that focus the Challenge's multidisciplinary approach that includes research expertise from a wide range of organisations.

The Ministry for Primary Industries is also a significant funder of climate change research. To ensure New Zealand's primary sectors are resilient and can respond to the opportunities and challenges of climate change, MPI provides policy advice to Government, and information to industry, farmers, growers and foresters, as well as contributing internationally on agricultural and forestry climate change issues. It funds research to support these goals through a number of programmes, including the Sustainable Land Management and Climate Change Research Programme, the New Zealand Agricultural Greenhouse Gas Research Centre and the GRA. MPI also supports research programmes that address adaptation through sustainability (eg, the Sustainable Farming Fund) and projects on productivity enhancement that address emissions intensity (eg, reducing the emissions per unit of product). The major fund addressing this area is the Primary Growth Partnership.

The Ministry of Business, Innovation and Employment's Endeavour Fund also contributes funding to climate change research. More than NZ$190 million in funding is available through the Endeavour Fund, with up to NZ$48 million per year invested in Smart Ideas and Research Programmes. Four of the projects funded in 2016 specifically mention climate change in their briefs.

Some additional government support for research comes through:

- the Marsden Fund, which is administered by the Royal Society of New Zealand and is not subject to government research priorities
- funding for university research within Vote Education
- the Health Research Council through Vote Health
- the Pastoral Greenhouse Gas Research Consortium through Vote Research, Science and Technology.

There is also direct funding of research 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).

Systematic observations are part-funded through the Crown contract for New Zealand's National Weather Service administered by the Ministry of Transport and awarded to MetService, which cover routine upper air and surface weather observations that are also used for climate research. Further observations for climate research are supported by CRI core 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.

8.2.3 Funding levels

Table 8.1 summarises the estimated government-funded annual investment in research related to climate change. A further NZ$16 million is spent on systematic weather and climate observations.

Table 8.1: Estimated central government investment in climate change research, 2015/16 year

	Investment (NZ$ million)						
			Core CRI				
Area	MBIE	MPI (including GRA)	NIWA	Other	Government other	Marsden	Total
Underpinning science	12.8	3.5	7.1	2.0	3.2	2.6	**31.3**
Emissions reduction	2.2	9.1		1.5			**12.7**
Adaptation	1.8	0.8	0.5	3.0		0.1	**6.2**
Technology transfer		0.1					**0.1**
Total	**16.8**	**13.6**	**7.6**	**6.4**	**3.2**	**2.7**	**50.3**

Note: CRI = Crown research institute; GRA = Global Research Alliance on Agricultural Greenhouse Gases; MBIE = Ministry of Business, Innovation and Employment; MPI = Ministry for Primary Industries; NIWA = National Institute of Water and Atmospheric Research. 'Other' includes GNS Science.

8.3 Information exchange and dissemination of knowledge

The Ministry for the Environment and the Ministry for Primary Industries work in conjunction with science providers to disseminate research findings on climate change, mitigation options and adaptation processes to the appropriate audiences. MPI provides publications and online information for farmers and businesses in the primary sector, particularly through the Climate Cloud website.[337] It also publishes an annual update on the status of the ocean though the MPI Aquatic Environment, Biodiversity and Annual Review on its website. The Ministry for the Environment publishes online information on climate projections and impacts for all New Zealanders, and guidelines for planning for climate change, both in a popular format for local governments and residents and as larger technical documents for engineers and planners. High-resolution climate projections for the whole country, downscaled from the Coupled Model Intercomparison Project 5 (CMIP5) results, were published in 2016.

Outside of central government, NIWA provides public access to the National Climate Database via the internet, and also produces monthly updates of recent climate data and the seasonal outlook. Other CRIs provide information on their specific subject area on climate change on their websites and through papers, conferences and peer-reviewed publications. Until it was disestablished in 2016, the New Zealand Climate Change Centre facilitated knowledge dissemination through conferences, workshops, round tables and climate briefs. The Centre produced a summary of the IPCC *Fifth Assessment Report*'s New Zealand findings in 2014.[338] The document synthesises the key findings from the Australia and New Zealand chapter included in the Working Group II report.

The New Zealand Agricultural Greenhouse Gas Research Centre provides information via its website on mitigation of agricultural greenhouse gases. It also publishes a range of factsheets and reports on issues related to agricultural greenhouse gases. The NZAGRC has developed a strong media profile through regular appearances in print, radio and TV, issuing several press releases and initiating a social media presence. Work undertaken in support of the GRA serves to extend the domestic research programme, develop internationally relevant solutions and increase the capability of other countries to engage with agricultural greenhouse gases. The NZAGRC continues to work closely with the PGgRc, which is a key funding partner. The PGgRc also provides an important pathway for the NZAGRC to interact with industry stakeholders, assist MPI to manage intellectual property and enable knowledge transfer through commercialisation of new tools, technologies and practices.

Since the *Sixth National Communication*, the NZAGRC has published over 40 journal articles and around 100 conference papers. It has progressed its goal of enhancing awareness among stakeholders by getting greater alignment with industry via the PGgRc, supporting a range of knowledge transfer activities and having a Māori-specific greenhouse gas research programme.[339] The NZAGRC has contributed to domestic policy goals through providing ongoing input into IPCC processes and domestic policy, having a leadership role in the GRA and having national and international advisory roles.

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337 www.climatecloud.co.nz

338 New Zealand Climate Change Centre. 2014. *Climate Change: IPCC Fifth Assessment Report – New Zealand findings*. New Zealand Climate Change Centre. Retrieved from www.niwa.co.nz/sites/niwa.co.nz/files/NZCCC%20Summary_IPCC%20AR5%20NZ%20Findings_April%202014%20WEB.pdf.

339 Māori are the indigenous people of New Zealand.

The Deep South National Science Challenge also has an engagement programme. The programme aims to help New Zealanders to make decisions informed by climate science, and to inform Deep South Challenge research. It has a focus on working with Māori, communities, industry sectors and central and local government in order to facilitate collaboration between New Zealand society and scientists.

The Royal Society of New Zealand has developed a review summary of current evidence around the impacts of climate change on health in New Zealand. The review outlines the evidence for potential health impacts in New Zealand as a result of climate change.

8.3.1 International exchange of data and information

New Zealand exchanges data and information with other countries in line with the policies of the World Meteorological Organization (WMO). Appropriate weather observations useful for climate modelling are disseminated in real time through standard WMO channels, 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).

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 above in section 8.1), and NIWA also produces a similar monthly publication for New Zealand, the *New Zealand Climate Update*. 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 (EFDB). A New Zealand scientist serves on the Editorial Board and a number of emission factors based on New Zealand agricultural research have been submitted to the EFDB. New Zealand data are contributing to the development of new emission factors for the agriculture sector in the refinement of the IPCC 2006 Guidelines.

8.3.2 Partnerships

Multilateral partnerships

Global Research Alliance on Agricultural Greenhouse Gases

New Zealand provides funding to support GRA research to reduce agricultural greenhouse gases primarily from pastoral-based livestock farming systems. This includes mitigation of enteric CH_4, reduction of N_2O from grazed pastures and soil carbon sequestration. New Zealand supports international research collaborations through multi-partner funds, such as the New Zealand Fund for Global Partnerships in Livestock Emissions Research. This is a contestable, international research fund managed by MPI to accelerate global research in mitigating greenhouse gas emissions from pastoral livestock farming by seeking solutions to research challenges in the areas of: manipulating rumen function, reducing N_2O 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 one of 14 partner countries in the European Commission's Joint Programming Initiative on Agriculture, Food Security and Climate Change multi-partner call on agricultural greenhouse gas research. It is also a participant in the European Union Multi-Country Research Call 'ERA-GAS' to fund research into monitoring and mitigating greenhouse gas emissions from farming and forestry.

The Global Research Alliance Senior Scientist (GRASS) awards provide 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, seven exchanges have been supported between New Zealand and Australia, Canada, Denmark, Finland, Spain and the United States.

Other partnerships

In support of the GRA, New Zealand has contributed to a joint project between the GRA, Climate and Clean Air Coalition (CCAC) and Food and Agriculture Organization of the United Nations (FAO), using the FAO Global Livestock Environment Assessment Model (GLEAM) to assess mitigation options for livestock in 13 developing countries. The project Reducing Enteric Methane for Improving Food-Security and Livelihoods reviews mitigation practices and their potential for reducing emissions in the livestock sector on regional to global scales and builds capacity of practitioners to develop mitigation practices that are appropriate for a representative range of production contexts (eg, farming system, agro-ecological zone, species, region) on regional to global scales. The NZAGRC leads the domestic input into this project.

New Zealand is a member of CCAC, which focuses on reducing short-lived climate pollutants, including CH_4. New Zealand is a Lead Partner in its Agriculture Initiative.

In addition, New Zealand is a member of the International Energy Agency and the International Partnership for the Hydrogen Economy, and is a member of the Carbon Sequestration Leadership Forum.

Bilateral partnerships

As part of its Carbon Farming Futures programme, Australia established a new research investment scheme called Filling the Research Gap, aimed at reducing agricultural greenhouse gas emissions. The second round of this scheme included a priority of international collaboration with member countries of the Global Research Alliance. New Zealand allocated funding to support researchers involved in successful bids to this programme that also meet New Zealand's priority areas for research. New Zealand has also co-funded projects with the Inter-American Development Bank's Regional Fund for Agricultural Technology (FONTAGRO) on greenhouse gas mitigation in South and Central America (see section 7.2.2).

International organisations

New Zealand is an active member of the World Meteorological Organization 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 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, as well as participating in plenary meetings, task groups, workshops and expert meetings, and contributing to the IPCC's assessment reports. Since 2015 New Zealand has been one of the co-chairs of the IPCC's Financial Task Team. The Government also provides some financial support for New Zealand lead authors involved in the three Special Reports and the refinement of inventory methodologies being produced in the sixth assessment cycle. Draft reports and outlines receive wide government review. In early 2018 New Zealand will host the second lead author meeting for the Special Report on Climate Change and Land.

8.4 Research highlights

This section presents some of the highlights, innovations and significant projects over a range of topics in climate change research in New Zealand since the *Sixth National Communication*. For more details about the research projects funded by the Ministry of Business, Innovation and Employment, search its database of abstracts and project reports, using the search term "climate change".[340]

Climate change research in New Zealand seeks to develop information and knowledge on a wide variety of 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 impacts 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
- reducing the emissions of greenhouse gases, particularly those resulting from pastoral agriculture
- enhancing sinks, particularly forest sinks and soil carbon
- community resilience and human health
- oceanic and atmospheric chemistry
- greenhouse gas measurement and national greenhouse gas inventory development and support.

8.4.1 Climate processes and climate system studies

Climate variability and trends

Work to identify regional climate trends and variability has continued, largely through core-funded research at NIWA. 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. There is substantial international collaboration, including analysing data from Argo floats to provide

[340] www.mbie.govt.nz/info-services/science-innovation/investment-funding/who-got-funded

improved knowledge of physical ocean conditions in the region, and contributions to the Atmospheric Circulation Reanalysis 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. A set of regional climatology publications providing information of interest to councils, farmers and other regional stakeholders is currently being updated.

The Deep South National Science Challenge also includes observational studies as part of its Processes and Observations programme. For example, the sea-ice project recently deployed buoys that will be used to understand the impacts of ocean waves on sea ice in the marginal ice zone. Other studies that are under way as part of the Deep South Challenge include a study on measuring sea ice in Antarctica and another on the impact of Southern Ocean clouds and aerosols on climate.

Climate processes, phenomena and causes of variability and change

The goal of this research, also carried out mainly through core funding at NIWA, is to understand how the dynamics of the climate system influence atmosphere, ocean, ice and hydrospheric conditions in the New Zealand region, and to identify the causes of changes. This includes research on particular climate phenomena of regional relevance, including the El Niño / Southern Oscillation, the Inter-decadal 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 impact 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.

Two of the five programmes of the Deep South National Science Challenge – Processes and Observations; and Earth System Modelling and Prediction – conduct new research on climate processes in the Deep South to inform better projections of future climate through the development of a world-class Earth System Model. Extensive observational campaigns in Antarctica and the Southern Ocean have taken place during the 2016/17 year.

Palaeoclimate

The past climates of the 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 geological 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 14 million years, and other changes in ice, vegetation and sea level during climates warmer than the present. This project is a multinational collaboration comprising more than 200 scientists, students and educators from eight nations (Brazil, Germany, Japan, Italy, New Zealand, Republic of Korea, the United Kingdom and the United States). More recently, New Zealand has developed the capability for drilling long ice cores, and recovered a 750-metre-deep ice core from Roosevelt Island in Antarctica to investigate the past 20,000 years, and the stability of the Ross Ice Shelf and the West Antarctic Ice Sheet in a warming world.

A research project recently concluded is *Antarctic New Zealand Interglacial Climatic Extremes – a window into a warmer world*. This work reports new observations and develops new models to improve projections of future change in the region between New Zealand and Antarctica, part of a vast southern region that is a major influence on the world's climate and ocean. The response of the ice, ocean and atmosphere to these previous warm phases will provide insights into how the planet is likely to behave in the future.

Atmospheric chemistry

NIWA is 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 World Meteorological Organization'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.

Ocean–atmosphere gas exchange

The ocean–atmosphere gas exchange programme at NIWA provides information on the transfer of CO_2, key trace gas species and aerosols between the ocean and atmosphere, 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. Long-term regional monitoring and modelling provide critical inputs into national policy and strategy – and international commitments – on climate change, ocean acidification and geo-engineering.

In particular, knowledge of carbon sinks in the New Zealand region is a key requirement of regional budgets and models that inform national policy. The Southern Ocean is the largest regional sink for anthropogenic CO_2, and so understanding the controls and rate of marine CO_2 uptake is critical for global carbon budgets. Knowledge from these studies could also inform assessment of possible future oceanic geo-engineering techniques to combat climate change.

8.4.2 Modelling and prediction, including general circulation models

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 updated projections based on CMIP5 global climate model runs, assessed in the *Fifth Assessment Report*, were completed in 2016. This involved both statistical downscaling and dynamical downscaling using a climate model installed in NIWA's supercomputer, and also assisted in assessing likely changes in climatic extremes. Outputs from the dynamical modelling are also being 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 strong links to the United Kingdom Met Office, the Commonwealth Scientific and Industrial Research Organisation (Australia's national science agency), the Australian Bureau of Meteorology and Melbourne University. This international collaboration on climate modelling helps underpin the research and development within the programme.

The projections based on both the downscaling and the regional climate modelling provide data that are used extensively in other research, such as that 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.

8.4.3 Research on the impacts of climate change

Research studies on the projected impacts of climate change have been commissioned for all regions of New Zealand, as well as for several specific economic sectors. It should be noted that most of the impact studies conducted in recent years are based on the global climate projections produced by the CMIP5 results, which were assessed in the IPCC's *Fifth Assessment Repo*rt in 2013/14.

A major research study involving multiple providers and funded by the Ministry for Primary Industries covered primary sector impacts and adaptation options. Separate reports were produced for the dairy, sheep and beef, broad acre cropping, horticulture and forestry sectors. In addition, a stakeholder report[341] summarised key material for each sector and presented material on drought and water resources. The main focus was on the period up to the middle of the 21st century.

Another impact study carried out with funding from the Ministry for Primary Industries[342] addressed the question of what New Zealand might look like in 2100 – and the possible consequences for the country's primary producers – should New Zealand experience global warming of around 4°C compared with pre-industrial times. This report did not expressly predict 4°C of warming by the end of the 21st century: the aim was to explore the possible impacts for New Zealand if temperatures were to rise by this much, to complement previous New Zealand studies that focused on low- to medium-temperature change scenarios.

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[341] AJ Clark, RAC Nottage, L Wilcocks, JM Lee, C Burke, et al. 2012. *Impacts of Climate Change on Land-based Sectors and Adaptation Options*. Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/dmsdocument/32-impacts-of-climate-change-on-land-based-sectors-and-adaptation-options-stakeholder-report.

[342] NIWA. 2013. *Four Degrees of Global Warming: Effects on the New Zealand Primary Sector.* Wellington: Ministry for Primary Industries. Retrieved from www.mpi.govt.nz/dmsdocument/6241-four-degrees-of-global-warming.

Expertise in numerical modelling of the Antarctic ice sheet, developed at Victoria University of Wellington, has been used to investigate the response of the ice sheet under different future climate scenarios. The results suggest that under a greenhouse gas emissions scenario in which no mitigation takes place, nearly all floating ice in Antarctica is lost by the end of the 21st century. Without these ice shelves to hold back the grounded ice on the rest of the continent, Antarctica could contribute 40 centimetres to global sea-level rise by 2100, and ultimately lead to increases in global sea level of up to 3 metres by 2300. Significantly, the simulations showed that the only way to avoid a substantial contribution to sea level from Antarctica is to limit global warming to less than 1.5–2°C above present temperatures, which is the level agreed by governments at the 2015 UNFCCC Conference of Parties in Paris.

An important research study on climate change impacts and urban infrastructure led to the development of an Urban Impacts Toolbox, which can also be used to develop adaptation options.

A project completed in 2016 is the wide-ranging, multi-year project, Climate Change Impacts and Implications. Led by NIWA and Landcare Research and involving researchers from a number of CRIs, universities and other institutions, the project undertook targeted research on climatic conditions, impacts and implications for New Zealand up to 2100, through five inter-related research aims:

- improving climate projections
- identifying pressure points, critical steps and potential responses
- identifying feedbacks, understanding cumulative impacts and recognising limits
- enhancing capacity and increasing coordination to support decision-making
- exploring options for New Zealand under different global climates.

The Deep South National Science Challenge is now continuing this work through its Impacts and Implications research programme (see section 8.4.4).

Wind

Information on the patterns and extremes of New Zealand’s future wind environment is important for understanding New Zealand’s wind energy resources, infrastructure design constraints, and the wind-throw and fire risk impacts on New Zealand’s planted forests. Regional projections of the future wind environment, including changes to extremes, based on both the downscaled data and the regional climate modelling projections, were completed in 2016. The research found that daily extreme winds are expected to increase in eastern regions.

Hydrology

Agriculture is a significant part of 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 a range of IPCC scenarios and climate models has suggested that drought 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 also 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 the potential implications for flooding in some locations. Initial results suggest that some areas could 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

Research is under way to build the capacity of New Zealand coastal communities to effectively adapt to climate change. This will be achieved by providing resources, decision-support tools and future policy and implementation options that can be used as the basis for adaptation to coastal hazards and climate-change impacts. The development of a suite of resources and decision-support tools will help both communities and decision-makers to work towards sustainable and appropriate adaptation measures.

The Government supports a number of 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.

Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand[343] is a technical guidance manual on planning for climate change in the coastal margins. During the reporting period, work has begun on updating this guidance. The updated guidance takes into account the latest 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*.

Research at the University of Auckland[344] has addressed the future of low-lying reef islands in conditions of rising sea level. This has been the subject of growing international concern, scientific debate and media interest, and is of great importance to New Zealand's Pacific neighbour countries. Historical studies of Pacific atolls show little evidence of increased erosion during the recent rapid sea-level rise. Instead, island shores have adjusted size and shape in response to human impacts such as seawall construction and to variations in climate–ocean processes. The research has implications for ways that atoll island governments, communities and international agencies can reduce risk and adapt to climate change, perhaps allowing the islands to persist and avoid external migration.

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[343] Ministry for the Environment. 2008. *Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand* Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate/coastal-hazards-climate-change-guidance-manual.

[344] For example, R McLean, P Kench. 2015. Destruction or persistence of coral atoll islands in the face of 20th and 21st century sea-level rise? *Wiley Interdisciplinary Reviews: Climate Change* 6(5): 445–463. DOI: 10.1002/wcc.350.

Marine environment

The Ministry for Primary Industries has funded a number of research projects to progress the development of a national Marine Environmental Monitoring Programme and to examine the impacts of climate change on New Zealand's living marine resources. This includes impacts on commercial fish stocks and shellfish behaviour and life history development. The research commissioned by the Ministry for Primary Industries 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.

Currently a major piece of research to look at climate change effects and the risks and opportunities for the seafood sector is under way.

A government-funded research programme, *Climate Changes, Impacts and Implications for New Zealand*, included a marine case study.[345] This case study looked at the impacts of climate change on the ocean food chain and the implications for native biodiversity, seafood and tourism. Research has shown that the north Tasman Sea is expected to experience greater warming than the rest of our surrounding ocean. This could drive regional change in marine ecosystems in the form of reducing the number of temperate species, and increasing the number of sub-tropical species and nutrient-poor conditions.[346] Some species that presently live in lower-latitude regions may migrate into New Zealand waters in response to rising temperatures and changing ecological community structures.[347] Work is also under way to characterise impacts on fish in the New Zealand region. The clearest example of a link between coastal sea-surface temperature and fish recruitment and growth comes from northern stocks of snapper (*Pagras auratus*), where relatively high recruitment and faster growth rates have been correlated with warmer conditions.[348] Other species where fisheries indices appear to be linked to sea-surface temperature include elephantfish, southern gemfish, hoki, red cod, red gurnard, school shark, snapper, stargazer and tarakihi.[349] The causal mechanisms for these species are not well understood.

New Zealand's subantarctic waters have become more acidic since measurements were first taken in 1998. The pH of surface water is expected to decline by 0.33 under the highest-emissions scenario by 2100, a rate of change that is unprecedented in the last 25 million years. Marine and coastal species with carbonate shells, such as pāua, mussels and oysters, and the

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345 CS Law, GJ Rickard, SE Mikaloff-Fletcher, MH Pinkerton, R Gorman, et al. 2016. T*he New Zealand EEZ and South West Pacific. Synthesis Report RA2, Marine Case Study. Climate Changes, Impacts and Implications (CCII) for New Zealand to 2100*. MBIE contract C01X1225. Retrieved from http://ccii.org.nz/research-aims/ra2/marine.

346 Ibid.

347 GJ Molinos, BS Halpern, DS Schoeman, CJ Brown, W Kiessling, et al. 2015. Climate velocity and the future global redistribution of marine biodiversity. *Nature Climate Change* 6: 83–88. DOI: 10.1038/nclimate2769.

348 From the Leigh Sea Surface Temperature series. See: MP Francis. 1993. Does water temperature determine year class strength in New Zealand snapper (*Pagrus auratus*, Sparidae)? *Fisheries Oceanography* 2(2): 65–72; MP Francis. 1994. Growth of juvenile snapper, *Pagrus auratus* (Sparidae). *New Zealand Journal of Marine and Freshwater Research* 28: 201–218.

349 RJ Hurst, JA Renwick, PJH Sutton, MJ Uddstrom, SC Kennan, CS Law, et al. 2012. Climate and oceanographic trends of potential relevance to fisheries in New Zealand region. *New Zealand Aquatic Environment and Biodiversity Report* No. 90. Wellington: Ministry for Primary Industries.

plankton that support all life in the oceans are particularly vulnerable to climate change because increased acidity interferes with the formation of shells.[350]

An additional project is the Coastal Acidification – Rate, Impact and Management Project (2016–19),[351] which will provide new knowledge on coastal acidification to enhance the protection and management of coastal ecosystems. The NIWA-led project focuses on two main areas:

- establishing pH at critical locations – pH is monitored at three sites around New Zealand, in order to determine experimental conditions in impact studies and to underpin development of models and algorithms of the main drivers of acidification in the Firth of Thames. The aim is to provide tools for coastal management
- ecosystem impacts of acidification – the project will examine the ecosystem effects of acidification on primary production, food quality and habitat availability. It has a particular focus on the sensitivity of the different stages of life of iconic New Zealand species. It will also assess the sensitivity to low pH of different shellfish families, in order to identify those with the greatest potential resilience to acidification. The experimental information will be combined in population forecast models to project the future success of these species.

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 CO_2 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. With the release of the newer CMIP5 climate projections, this cycle is likely to repeat as the important questions are addressed using updated information. Limited research has been carried out on many second- and third-order impacts and the interactions between impact drivers.

Research is been carried out to understand the effects of elevated atmospheric CO_2 on pasture over time. The Free Air Carbon Dioxide Enrichment (NZ FACE) experiment has been operating for 20 years and the experiment is still in progress. The NZ FACE is providing data on grazed grassland – the only experiment in the world that includes grazing animals – making the results relevant to both New Zealand and 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 CO_2 on grasslands. Under elevated CO_2, 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 that the increase in legumes is limited by an increased preference for legumes by grazing sheep. This has implications for the potential growth rate that could be expected from additional CO_2–the 'CO_2-fertilisation' effect. Further research is looking at potential plant adaptations that might ameliorate this response to CO_2.

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350 CS Law, GJ Rickard, SE Mikaloff-Fletcher, MH Pinkerton, R Gorman, et al. 2016. *The New Zealand EEZ and South West Pacific. Synthesis Report RA2, Marine Case Study. Climate Changes, Impacts and Implications (CCII) for New Zealand to 2100*. MBIE contract C01X1225. Retrieved from http://ccii.org.nz/research-aims/ra2/marine.

351 www.niwa.co.nz/coasts-and-oceans/research-projects/carim-coastal-acidification-rate-impacts-management

Results from the study are also showing that responses to CO_2 change over time; this is expected given the different timeframes of feedbacks through the plants and soil. In the last three years there has been no CO_2 stimulation of pasture growth; if this is confirmed as the long-term outcome of CO_2 enrichment this would be a major change in currently assumed inputs to impact studies for the pastoral sector.

New Zealand has also commissioned research into other impacts on agriculture. For example, research has looked at microbial function and adaptation in response to drought driven by climate change and the resulting effects on plant production and nutrient cycling. The impacts of climate change on irrigation water supply and demand and on soil carbon are also being considered, as are the impacts on river flow and agriculture.

Biosecurity impacts

Climate change will create new biosecurity challenges by allowing establishment of new exotic pests, weeds and diseases that are currently prevented from doing so by New Zealand's climate. The potential establishment of subtropical pests and current seasonal immigrants is of greatest concern, along with taxa that are 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.

Climate change will create opportunities for new crop types to be grown commercially in some sectors, and necessitate the use of new species in others (eg, C4 grasses in Northland pastures, drought-resistant forage plants in eastern areas).

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.

Species distribution models based on climatic requirements (eg, CLIMEX) may be useful for projecting future ranges of pests, weeds and diseases. A preliminary examination of 24 arthropod species (12 already present in New Zealand, 12 currently absent) suggested that the range of most of them could potentially increase and that lower temperature limits may be useful as a general indicator of the likelihood of establishment in New Zealand.

Forestry

Initial research into plantation forestry addressed carbon sequestration rates in New Zealand's most common plantation forest species, *Pinus radiata*, to inform the inclusion of carbon forestry in New Zealand's Emissions Trading Scheme (NZ ETS). More recent projects have investigated additional planted and indigenous species and forestry systems for different regions and terrains. 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 some of the potential major pests under a changing climate.

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, as well as 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.

Health

A project addressed the relationship between climate change and public health risk in New Zealand due to communicable diseases, heat stress and a wide range of issues affecting social infrastructure, such as housing, income and livelihoods. Work carried out in this programme has started specific monitoring of heat exposure in outdoor workers, developed empirical models for relating communicable disease to social and climatic factors, assessed the effect of rainfall variability on households and others relying on rainwater tanks, and assessed vulnerability for those who use prepayment electricity meters.

A 2014 paper on the health and equity impacts of climate change in New Zealand[352] covers the expected impacts of climate change on the health of New Zealanders. The main issues discussed include:

- food security and nutrition
- mental health and suicide
- housing and health
- injury and illness from extreme weather events
- heat-related deaths and illnesses
- vector-borne and zoonotic disease
- food- and water-borne disease
- ultraviolet radiation
- physical activity
- cardio-respiratory disease from air pollution
- allergic diseases
- indoor environment.

The paper also notes that climate change will impact on the broader socio-economic determinants of health in New Zealand.

Environmental Health Indicators New Zealand is a research, training and consultancy group specialising in environmental health information. It monitors New Zealand's health through a set of environmental health indicators, and has identified environmental health indicators relating to climate change. These include extremes of temperature and rainfall and changing occurrence of certain diseases. It has also identified population groups more at risk from the health impacts of climate change.

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.

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352 H Bennett, R Jones, G Keating, A Woodward, S Hales, S Metcalfe. 2014. Health and equity impacts of climate change in Aotearoa-New Zealand, and health gains from climate action. *New Zealand Medical Journal* 127(1406). Retrieved from www.nzma.org.nz/journal/read-the-journal/all-issues/2010-2019/2014/vol-127-no-1406/6366.

The New Zealand Government recently established a Climate Change Adaptation Technical Working Group to provide advice on options for building New Zealand's resilience to the effects of climate change while sustainably growing the economy. Its advice will be based on sound evidence, starting with a stocktake of existing adaptation work across central and local government and the private sector. The second report will contain options and recommendations for how New Zealand can adapt to the effects of climate change, and will address the gaps in the current approach identified by the stocktake report.

The adaptation-related research and information funded by central government includes the following.

- **The Deep South Challenge** (2015–19)[353] has three research programmes: Processes and Observations, Earth System Modelling and Prediction, and Impacts and Implications; as well as two cross-cutting programmes: Engagement and Vision Mātauranga.[354] The Impacts and Implications programme is the current provider of most adaptation-relevant research in New Zealand, along with NIWA's SSIF-funded programmes on the impacts and implications of climate change and the Resilience Science Challenge.
- A number of **other National Science Challenges**[355] are also relevant to adaptation, including Resilience to Nature's Challenges (2014–19), 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 (SLMACC) research programme**, launched in 2007 by the Ministry for Primary Industries and ongoing, aims to help the agriculture and forestry sectors address the challenges arising from climate change. Much of the output of the programme has been compiled into a web-based adaptation resource, the Climate Cloud.[356]
- The **Coastal Acidification – Rate, Impact and Management Project** (2016–19)[357] will provide new knowledge on coastal acidification to enhance the protection and management of coastal ecosystems.

The Ministry for the Environment has supported research to produce guidance manuals for local government on the expected impacts of climate change, which 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 6.

Research is also being conducted into the social aspects of successful adaptation. One example is a project studying Coastal Adaptation to Climate Change. The goal of this research was to build the capacity of New Zealand coastal communities to effectively adapt to climate change

[353] www.deepsouthchallenge.co.nz

[354] The Vision Mātauranga programme of research is strengthening connections between Māori and the science system to increase knowledge transfer between these groups, and increase iwi- and hapū-led research and development strategies (Deep South Challenge).

[355] www.mbie.govt.nz/info-services/science-innovation/national-science-challenges

[356] www.climatecloud.co.nz

[357] www.niwa.co.nz/coasts-and-oceans/research-projects/carim-coastal-acidification-rate-impacts-management

by providing resources, decision-support tools and future policy and implementation options that can be used as the basis for adaptation to coastal hazards and climate change impacts. Achieving this goal has three main strands: building a national coastal vulnerability profile, engaging and informing communities, and encouraging best practice planning. More information on this project can be found online at NIWA's National Centre for Coasts.[358]

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 an Urban Impacts Toolbox,[359] which 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 used to perform an assessment of 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:

- studying the impacts from, and adaptation of pasture plants to, future climate scenarios
- assessing the impacts and movement of C4 plants, which photosynthesise more efficiently in high-temperature and drought conditions
- selecting drought-tolerant varieties of Pinus radiata and conservation trees (such as poplar and willow)
- assessing the growth of maize and other crops under future climate scenarios.

8.4.5 Socio-economic analysis, including impacts and response options

Economic modelling work has identified impacts from climate variations on New Zealand's gross domestic product (GDP) through changes in pastoral production. This work uses the projected impacts – particularly the impacts on the occurrence of droughts – to estimate the changes in production, both in average years and in drought years.

Integrated socio-economic and natural-science models have been developed for use in policy design and analysis for land-use and climate change issues. These models can investigate the likely influence of various possible policies on changes in land use for forestry, including the effects of different levels of carbon pricing. A further research project has examined greenhouse gas emissions paths in connection with different New Zealand economic development scenarios. A global trade model has been developed to support policy and address how global climate change impacts may affect the New Zealand economy.

A four-year project addressed diverse aspects of community vulnerability, resilience and adaptation to climate change.[360] It aimed to develop integrative and consistent frameworks for assessing multiple socio-economic and physical hazard effects on community vulnerability to climate change, which could be used by local and central government agencies as well as

358 www.niwa.co.nz/our-science/coasts/research-projects/all/coastal-adaption-to-climate-change

359 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.

360 www.victoria.ac.nz/sgees/research-centres/ccri/research/community-vulnerability,-resilience-and-adaptation-to-climate-change,-2008-2013

Māori authorities. The impact of climate change on Māori land has been assessed at the national level and at an individual farm-scale level.

New Zealand's vulnerability to climate change has been investigated, and potentially vulnerable groups highlighted. These groups include babies and young children, the elderly, indigenous populations and those living in poverty.

The Deep South Challenge, in partnership with Motu Economic and Public Policy Research, is running a series of dialogues in order to develop a shared understanding of key issues, come up with creative ideas to address them, and then pose research questions. Two of the dialogues addressed issues involving socio-economic analysis. These dialogues were on insurance, coastal housing and climate adaptation, and on vulnerable communities and sea-level rise. Future dialogues are planned for drought and transport.

A report has been released[361] following the dialogues on insurance, coastal housing and climate adaptation. It proposes six research questions.

1. Where do sea-level rise risks currently fall across the different parties (homeowners, government, and private insurers)? How should this exposure to risk be allocated to contribute to a fair and sustainable adaptation to sea-level rise?
2. What policy options are available to local, regional and national government when a tipping point of uninsurability is reached?
3. What would those tipping points be? What would be the economic implications of a maximum probable weather event in Auckland?
4. What is the relationship between house prices, climate change related hazards, and insurability?
5. What financial instruments or institutional arrangements can be developed to mitigate climate change risk and insure the functioning of housing markets?
6. How can we better inform coastal property owners' decision-making with respect to climate change?

A similar report is being produced for the dialogue on vulnerable communities and sea-level rise.

The Deep South Challenge's Vision Mātauranga 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. Its four research themes are:

1. understanding climate change – linkages, pressure points and potential responses
2. exploring adaptation options for Māori communities
3. assistance to Māori businesses to aid decision-making and long-term sustainability
4. products, services and systems derived from mātauranga Māori.

Te Kūwaha, NIWA's Māori Environmental Research Group,[362] assists Māori communities throughout New Zealand by providing the latest scientific knowledge, tools and resources to assist in their management of natural resources.

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361 www.deepsouthchallenge.co.nz/sites/default/files/2017-05/Insurance-Housing-Climate.pdf

362 www.niwa.co.nz/te-k%C5%ABwaha

8.4.6 Research and development on emissions and mitigation

Mitigation of agricultural greenhouse gas emissions

Because almost half of New Zealand's greenhouse gas emissions come from the agriculture sector, significant research is focused on reducing emissions from agriculture.

Agricultural mitigation research is undertaken through a range of programmes and organisations, including the New Zealand Agricultural Greenhouse Gas Research Centre, the Pastoral Greenhouse Gas Research Consortium, the Biological Emissions Reference Group, the Sustainable Land Management and Climate Change 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

New Zealand has a comprehensive research programme to address CH_4 from enteric fermentation. Areas of research include breeding low greenhouse gas animals, identifying low-CH_4 feeds, developing vaccines to inhibit enteric CH_4 and discovering inhibitory compounds that reduce enteric CH_4 emissions. Progress since the last national communication includes:

- identifying and developing the ability to breed low-CH_4-emitting sheep
- confirming that selected low CH_4 in sheep is genetic and heritable with differences maintained under grazing conditions
- showing that prototype vaccines can produce high levels of methanogen-specific antibody in the saliva entering the rumen
- identifying five classes of compounds that have been shown to reduce CH_4 emissions in animals trials.

Through the Global Research Alliance, New Zealand scientists led a global project to compare rumen samples from around the world. They received over 700 contributions from 35 countries, including not only goats, sheep and cattle, but also species such as reindeer, giraffes and camels. They found that despite some differences related to feed and species, methanogens are surprisingly similar everywhere. This means that strategies to inhibit dominant methanogens, such as the CH_4 inhibitors being developed by the PGgRc and NZAGRC, are likely to be effective in all ruminant systems globally.

Nitrous oxide from livestock excreta

Research on mitigating N_2O emissions covers identifying and testing plant species effects on N_2O emissions, manipulating denitrification processes, feed management options, management effects on emission factors, urine patch detector development, and identifying and testing inhibitory compounds that reduce N_2O emissions. Progress since the last national communication includes:

- identifying naturally occurring compounds that can reduce nitrification and lower N2O emissions in pastures
- field-testing 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 aids in understanding water quality
- improving understanding of the emissions of N_2O from dung and urine on New Zealand hill country pastures.

Soil carbon

New Zealand's soils have relatively high soil carbon stocks. 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, tools to quantify soil carbon content and the stability of stored carbon, and modelling management greenhouse gas manipulations. Progress since the last national communication includes:

- demonstrating via improved carbon modelling that carbon stocks in New Zealand's agricultural soils are currently below their theoretical carbon saturation level
- a comprehensive review of all research on changes in soil carbon stocks in New Zealand's grazed grasslands, summarising the effects of land management practices on carbon stocks
- ongoing development of a framework by which to make a national estimate of soil carbon stock changes within and between land use classes
- researching the impacts of deep ploughing, normal cultivation and direct drilling, mixed-species swards, irrigation and maize on soil carbon content changes
- developing 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-infrared scanning methods for cost-effective estimation of soil carbon in soil cores.

Farm systems

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 assist the Māori pastoral sector to improve its capacity to increase resource efficiency and farm productivity while lowering greenhouse gases. Progress since the last national communication includes:

- identifying and evaluating mitigation options and practices on farms, using farm systems models and farm trials, on dairy, beef and sheep farms
- demonstrating a range of options for dairy farmers to decrease N, phosphorus (P) and sediment losses to water, which can be successfully implemented with commercial-scale herds
- a literature review and analysis of farmers' decision-making with regard to climate change and biological greenhouse gas emissions
- a review of the suitability of the OVERSEER nutrient budget model for farm-scale greenhouse gas reporting
- a Māori agriculture project to identify mitigation options via modelling, which found that:
  - many of the changes in farm systems resulted in relatively marginal changes in emissions and profitability

- some systems changes resulted in a win–win, in that emissions decreased and profitability increased. These included: (1) lowering stocking rates on dairy farms; (2) increasing sheep:cattle ratios; (3) increasing farm efficiency; and (4) planting marginal areas in forestry.

Cross-cutting issues

Progress on cross-cutting issues since the *Sixth National Communication* includes assessments of:

- the mitigation potential for on-farm N2O and CH4 greenhouse gas emissions using a range of current and potential future mitigation practices
- the costs and barriers of implementing various scenarios to mitigate biological greenhouse emissions from agriculture
- land-use change as a mitigation for climate change
- the nationwide economic impacts of farm-level biological options for mitigating greenhouse gas emissions.

The Greenhouse Gas Inventory Research Fund continues to support research to ensure New Zealand's reporting of agricultural emissions is robust and enables the development of effective policy. Achievements since the *Sixth National Communication* are: research to improve the method for estimating CH_4 emissions from sheep; inclusion of mitigation of N_2O emissions by urease inhibitors; a new emission factor for urea fertiliser; and ongoing research assessing the different emission factors for animal nitrogen waste inputs on sloping hill lands.

Land use, land-use change and forestry: inventories and sequestration research

Significant research efforts are also being made on the role of vegetation and soil in the carbon cycle. The 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 aim of the programme is to improve New Zealand's ability to estimate carbon fluxes in vegetation and soil in a transparent, robust and defensible manner.

The research builds on earlier work. The methodologies for data collection are undergoing refinements, as are the analysis methods. This includes improving our understanding of allometric relationships in the case of natural forests and improving models and parameters (eg, carbon fractions) in the case of planted forests. Detailed studies have been carried out to improve wood density and dead wood decay rate estimates. Dead wood decay models have been further developed. Research has also been focused on the effects of forest management activities and harvest residues on carbon stocks of biomass and soils to improve the estimates in planted forests. Improvements to methods for collecting and analysing natural and planted forest plot data are ongoing.

New Zealand-specific emission factors have been developed in the woody subcategories of the grassland and cropland land-use classes. Improvements to the soil Carbon Monitoring System model for estimating changes in the mineral soil carbon stock have also been an ongoing focus of the research programme.

There has also been research into the impacts of natural disturbance on forest carbon and, since 2013, an ongoing focus on improving estimates of harvested wood products. Research has been conducted on improving models of non-traditional species such as Douglas fir and eucalypts as well as of the natural establishment and growth of indigenous species under various environmental conditions and cover species. The strategies for establishment, growth, management and harvesting on difficult slopes have been researched because much of New Zealand's forests are planted on steep hillslopes.

Other research has been carried out to understand the future role of New Zealand's planted production forests in reducing greenhouse gas emissions. This has included work to understand harvesting intentions of forest owners, and possible afforestation and deforestation rates of planted forests. Research has also investigated the potential role that New Zealand's natural/indigenous forest estate could have in sequestering carbon in the future.

Research is continuing into the role of forests in particular in the mitigation of climate change. This programme focuses on the effects of climate change on forests and using this knowledge to support the development of climate mitigation and adaptation responses, both by government and by the forestry sector. Objectives include the development of spatial and temporal models that will allow better prediction of how forests may respond to climate change, which will enable the development of adaptation and mitigation approaches. Research into improving estimates for the current tree carbon look-up tables and the field measurement approach for forestry in the NZ ETS is also being conducted.

Energy efficiency, renewables and mitigation of industrial emissions

Massey University hosts the New Zealand Biochar Research Centre, which aims to advance the understanding of biochar (a stable form of carbon) to mitigate global climate change and to enable its use in New Zealand, particularly by the agriculture and forestry sectors. This technology could provide an opportunity to permanently remove CO_2 from the atmosphere and store it as inert carbon in soils. Biochar can also be used to make a bioenergy product that can then be used to produce heat and generate electricity, and for other applications. The Centre supports two professorships: one in biochar use and the other in biochar production.

The Crown research institute GNS Science is investigating the potential of sites for the geo-sequestration of CO_2. Scientists are engaged in assessing how much CO_2 can be stored in a particular region or reservoir, what chemical reactions might occur with the rocks, what risks there are and their magnitudes, monitoring for potential leakage, and community concerns and perceptions associated with carbon capture and storage. New Zealand also collaborates in an Australian cooperative research centre programme on CO_2 geo-sequestration.

The Royal Society of New Zealand released a report in 2016 entitled *Transition to a Low-carbon Economy for New Zealand*.[363] The report includes a section on mitigation options for the energy (heat and power supply) sector.

Transport

Public and private research into biofuels is facilitated by the Advanced Biofuels Research Network, which aims to accelerate the development of biofuel technology for the benefit of New Zealand by encouraging a coordinated approach to biofuels research. The purpose of this Network is to improve communication across the New Zealand biofuels research community,

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363 Royal Society of New Zealand. 2016. *Transition to a Low-carbon Economy for New Zealand.* Wellington: Royal Society of New Zealand. Retrieved from https://royalsociety.org.nz/assets/documents/Report-Transition-to-Low-Carbon-Economy-for-NZ.pdf.

establish collaborations within the New Zealand biofuels research community, and build interactions between New Zealand biofuels researchers and industry, government and international research organisations.

The Royal Society of New Zealand's 2016 report also includes a section on mitigation options for the transport sector.[364] These actions are grouped into the following categories: avoid (avoiding unnecessary travel), shift (changing modes of transport), and improve (improving emissions performance). The report provides options for reducing greenhouse gas emissions in the sector, which are based mainly on improving energy efficiency and include measures such as switching from fossil fuels to renewable energy and modifying consumer behaviour to reduce demand.

8.5 Systematic observations

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* (included after the annexes in this report) and are presented in accordance with the revised UNFCCC reporting guidelines on global climate change observing systems (Decision 11/CP.13).

[364] Ibid.

9 Education, training and public awareness

Key points

Independent research in 2016 found ENERGYWISE™ to be the most influential government brand, the best brand for encouraging New Zealanders to make smarter choices and the 11th most influential brand overall.

Mātauranga Whakauka Taio – Environment Education for Sustainability Strategy and Action Plan, launched on 27 July 2017, has a focus on Māori knowledge and values in environmental education.

The New Zealand public have been consulted about the Intended Nationally Determined Contribution and the review of New Zealand Emissions Trading Scheme.

The New Zealand Government has engaged internationally on climate change issues through initiatives such as The Asia–Pacific Carbon Markets Roundtable and Global Research Alliance on Agricultural Greenhouse Gases.

The Climate Cloud is a digital library with over 1800 peer-reviewed resources on the risks, impacts and adaptation solutions related to climate change and adverse events.

9.1 Introduction

The New Zealand Government actively supports initiatives that increase public awareness of climate change and promote behaviour change, including by providing information to the public, local government and different 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 with the public, businesses, Māori[365] and young people has taken place over the past four years. The New Zealand Government also engages with other countries on climate change issues.

This chapter provides information about initiatives in these areas 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

This section outlines campaigns the New Zealand Government has initiated over the past four years to provide the public with information to help them to make informed consumer decisions to reduce greenhouse gas emissions and encourage long-term behavioural change.

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[365] Māori are the indigenous people of New Zealand.

Public awareness campaigns have focused on household and vehicle energy efficiency, certification schemes, tools for measuring emissions, and environmental awards.

9.2.1 Energy efficiency campaigns

ENERGYWISE™

The ENERGYWISE™ programme is a New Zealand Government public awareness initiative to promote energy efficiency, energy conservation and the uptake of renewable energy in New Zealand households. The programme is run by the Energy Efficiency and Conservation Authority (EECA). Information is provided on the ENERGYWISE™ website and social media channels, as well as regular marketing and communication campaigns. ENERGYWISE™ provides authoritative advice to consumers via media, including television, radio, digital advertising and social media. For more information on the effects of this programme, see section 4.3.2.

The Energy Spot™ television advertising campaign has run for seven years. These advertisements are a high-profile way of raising public awareness and consumer interest in energy efficiency. The Energy Spot™ advertisements screen during prime-time television – usually at the end of the evening news on a number of television channels – and offer tips and advice on energy savings to households and businesses. Topics covered include hot-water wastage, energy-efficient renovation, holiday driving tips and choosing efficient lighting. The campaign has more recently moved from 60-second advertisements to shorter, more action-oriented advertisements that focus specifically on thermal performance and "three essentials for a warm, healthy home".

Over 30 Energy Spot™ television advertisements are available to be viewed online.[366] These advertisements have been well received in New Zealand, and a number of countries have asked for information about the campaign.

In 2017, independent research found ENERGYWISE™ to be New Zealand's 11th most influential brand after global brands such as Google, Facebook, Microsoft and Apple.

The results also ranked ENERGYWISE™ first for encouraging New Zealanders to make smarter or better choices. It was found to be the most influential of the government brands as well, with the research highlighting that its influence comes from strengths in trustworthiness and corporate responsibility.

Transport

EECA provides information and tools on the ENERGYWISE™ website to influence consumer behaviour in vehicle choice, efficient driving and using alternative fuels. The FuelSaver website[367] enables consumers to compare the fuel efficiency of vehicles.

The Vehicle Fuel Economy Labelling Programme requires the display of mandatory fuel economy labels on new and used vehicles for sale through registered motor vehicle traders and on internet listings. The labels help consumers make informed decisions about environmental impacts when purchasing a car. The scheme is unique in that 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 section 4.3.3.)

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366 www.energywise.govt.nz/resource-centre/videos

367 www.fuelsaver.govt.nz

In 2016 the Government announced a cross-agency Electric Vehicles Programme to accelerate the uptake of electric vehicles in New Zealand. The Government's goal, with industry support and involvement, is to double the number of registered electric vehicles in New Zealand every year to reach 64,000 by the end of 2021. New Zealand exceeded its 2016 target for electric vehicles.

One aspect of the Programme is an information campaign that aims to increase awareness and understanding of, and favourability towards, electric vehicles. This five-year Programme (funded with NZ$1 million per annum) will evolve as the market matures. Key campaign milestones to date have included the launch of the electric vehicle web portal[368] as the comprehensive source of electric vehicle information for consumers; the completion of an extensive market research project to inform messaging and targeting for electric vehicles; the launch of a television commercial to promote electric vehicles; a series of videos and articles on electric vehicles; and the development of an ongoing community outreach programme to provide the New Zealand public with "see/ride/drive" experiences.

9.2.2 Carbon reduction and neutrality certification

Enviro-Mark Solutions Limited (a wholly owned subsidiary of Landcare Research, a Crown research institute) runs programmes that provide tools and support for individuals and organisations to measure and reduce greenhouse gas emissions. Enviro-Mark Solutions offers two internationally accredited greenhouse gas certification programmes:

- **CEMARS** (Certified Emissions Management and Reduction Scheme) certification – for carbon measurement and reduction claims
- **carboNZero** certification – for carbon neutrality claims.

Members that are ready to meet the programme's requirements are verified by a programme-approved auditor. Once approved, members are issued with a certificate, and can display the CEMARS or carboNZero certification mark or logo. Case studies featuring the emissions reduction achievements of member companies are available on the Enviro-Mark Solutions website.[369] Energy efficiency is recognised as an important part of the actions that companies need to take to reduce their greenhouse gas emissions.

Enviro-Mark Solutions operates CEMARS and the carboNZero programme in five countries (Australia, Chile, New Zealand, United Kingdom and United Arab Emirates). The two programmes are accredited by the Joint Accreditation System of Australia and New Zealand, and recognised by both the United Kingdom's Environment Agency and the Carbon Disclosure Project.

9.2.3 Other environmental certification schemes

In addition to the CEMARS and carboNZero certification schemes, the New Zealand Government supports three other environmental certification schemes: the Energy-Mark certification programme, the Enviro-Mark certification programme and the Environmental Choice New Zealand ecolabel.

368 www.electricvehicles.govt.nz

369 www.enviro-mark.com

The Energy-Mark certification programme is an energy management system programme operated by Enviro-Mark Solutions Limited. It is a three-step process to developing an energy management system, with a focus on continuous improvement, as companies work from 'Bronze' upwards to a 'Gold' level of certification. Energy-Mark Gold (the final step) is equivalent to the ISO 50001 International Standard. Achieving this level of certification shows that the organisation understands its energy use, has policies and strategies in place to reduce energy use, and is monitoring progress and continually improving.

The Enviro-Mark programme is an environmental certification programme established in 2001 by Landcare Research and is now operated by Enviro-Mark Solutions Limited. It is a five-step environmental management system, with a focus on continuous improvement, as companies work from 'Bronze' upwards to a 'Diamond' level of certification. Enviro-Mark 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.[370]

The Environmental Choice New Zealand[371] ecolabel is a life-cycle impact ecolabel. It is managed for the New Zealand Government by the independent New Zealand Ecolabelling Trust. Companies must meet published specifications before they can use the ecolabel. These specifications include (among other life-cycle impact areas) the sourcing of raw materials, having energy and waste management plans and product stewardship solutions.

To gain the ecolabel, organisations undergo rigorous multiple-criteria, third-party verification of their products and/or services against environmental standards through the life cycle of the product or service. Environmental Choice New Zealand has more than 50 licensees, covering around 1500 products and services. Around two-thirds of those products and services are building-related, while most of the balance comprises consumer products and commercial cleaning products.

Users of the Environmental Choice New Zealand ecolabel include purchasers from:

- corporate and small businesses (business-to-business procurement)
- the public sector (central and local government, schools, Crown entities)
- the building industry
- household consumers.

Through the Global Ecolabelling Network,[372] New Zealand has mutual recognition agreements with Japan, Taiwan, Thailand, South Korea, China, the Czech Republic, the United States, Canada, Hong Kong, Ukraine and Scandinavian countries.

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370 Online resources are provided by Enviro-Mark Solutions Limited (a wholly owned subsidiary of Landcare Research).

371 Type I (ISO International Standard 14024).

372 The Global Ecolabelling Network is a non-profit association of third-party environmental performance recognition, certification and labelling organisations founded in 1994 to improve, promote and develop the 'ecolabelling' of products and services. See https://globalecolabelling.net.

9.2.4 Green Ribbon Awards

The Green Ribbon Awards,[373] established in 1990, have become the Ministry for the Environment's annual flagship event to recognise outstanding contributions of individuals, organisations, businesses and communities to protecting and enhancing New Zealand's environment. Since 2010 the Green Ribbon Awards event, which is run in association with the Department of Conservation, has included an award category for reducing greenhouse gas emissions. The awards are presented by the Minister for the Environment and the Minister of Conservation and provide an opportunity to raise public awareness of people making a difference for the environment.

9.3 Public access to information

A key part of the New Zealand Government's response to climate change is providing climate change information to 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 website is the key source of climate change information provided by the Government.[374] It has information on the causes of, the evidence for and the impacts of climate change. It describes the key Government policies to reduce emissions and the work being done to help people prepare for and adapt to climate change. It also has links to climate change resources on other government and non-government websites.

The Ministry for the Environment website also describes the roles and responsibilities of other government ministries and departments with important climate change programmes.[375]

The summary document on New Zealand's action on climate change, published in 2016, is available online.[376]

Our Atmosphere and Climate 2017 is the first report produced under the Environmental Reporting Act 2015 to focus on New Zealand's climate.[377] The report uses a pressure-state-impact model to present an overview of what we know 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 general audience, but is backed up by technical web pages and rigorous analysis.

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373 www.mfe.govt.nz/withyou/awards/green-ribbon.html

374 www.mfe.govt.nz/climate-change

375 www.mfe.govt.nz/climate-change/overview-climate-change/roles-and-responsibilities

376 Ministry for the Environment. 2016. *New Zealand's Action on Climate Change.* Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate-change/new-zealands-action-climate-change.

377 Ministry for the Environment. 2017. *Our Atmosphere and Climate 2017.* Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/environmental-reporting/our-atmosphere-and-climate-2017.

New Zealand Emissions Trading Scheme

The Ministry for the Environment provides general information about the New Zealand Emissions Trading Scheme (NZ ETS). It describes how the NZ ETS works and how it links with New Zealand's international climate change commitments.[378]

The Environmental Protection Authority, which is responsible for the administration of the NZ ETS, also provides some information on its website.[379] For more on the Authority's role, see section 9.3.2.

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 a table format are available to the public on the Ministry for the Environment's website.

Every year in conjunction with the inventory's release, the New Zealand Government publishes the *New Zealand's Greenhouse Gas Inventory Snapshot* on the Ministry for the Environment's website.[380] The Snapshot summarises the inventory, and how it is used to monitor progress towards 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 progress towards our 2020 emissions reduction target).[381]

In addition to the Snapshot, the Ministry for the Environment maintains a visual online tool (New Zealand's Interactive Emissions Tracker), developed in 2016.[382] The aim of the tool is 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.

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378 www.mfe.govt.nz/climate-change/reducing-greenhouse-gas-emissions/new-zealand-emissions-trading-scheme

379 www.epa.govt.nz/e-m-t/Pages/About-ets.aspx

380 At the time of the publication of the *Seventh National Communication*, the most recent Snapshot release is: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015*. Wellington: Ministry for the Environment. Retrieved from www.mfe.govt.nz/publications/climate-change/new-zealands-greenhouse-gas-inventory-1990%E2%80%932015-snapshot.

381 www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/latest-2020-net-position

382 https://emissionstracker.mfe.govt.nz/

9.3.2 Information for businesses

New Zealand Emissions Trading Scheme

Ongoing communication about participants' obligations and the development of the New Zealand Emissions Trading Scheme (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. This includes sector-specific information links on the Authority's website.[383] Participants also receive updates and notifications from the New Zealand Emissions Trading Register.[384]

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.[385] Proactive outreach is undertaken for significant legislative obligations. For example, in the second half of 2017 all registered forestry participants received a notification of their upcoming obligations to undertake a mandatory emissions return in early 2018.

As the NZ ETS has developed, the Government has carried out consultation with the public and affected businesses on a multitude of issues and proposals (consultation with the public is discussed further in section 9.5.1). When changes are made, newsletters or factsheets are 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.[386]

Voluntary greenhouse gas reporting

The guidance for voluntary greenhouse gas reporting was first introduced in 2008 and has been reviewed on an annual basis. It has been prepared in response to increasing demand from organisations for guidance on how to compile a corporate greenhouse gas inventory.

The guide is written primarily for commercial and industrial organisations that wish to understand how to report their greenhouse gas emissions. However, it is also applicable to other types of organisations with operations that give rise to greenhouse gas emissions (eg, non-government organisations, government agencies and universities).

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383 www.epa.govt.nz/e-m-t/Pages/default.aspx

384 https://emissionsregister.govt.nz

385 https://mpi.govt.nz/growing-and-producing/forestry/forestry-in-the-emissions-trading-scheme

386 www.mfe.govt.nz/climate-change/reducing-greenhouse-gas-emissions/new-zealand-emissions-trading-scheme/legislative-8

The guidance encourages best practice in greenhouse gas reporting and supports voluntary reporting initiatives. The guidance is available on the Ministry for the Environment's website.[387]

9.3.3 Information for local government

The Ministry for the Environment has published technical manuals to provide local government with information about the predicted impacts of climate change.[388] These are:

- *Climate Change Projections for New Zealand* (June 2016)[389]
- *Tools for Estimating the Effects of Climate Change on Flood Flow: A Guidance Manual for Local Government in New Zealand* (May 2010)[390]
- *Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand* (July 2008)[391] (currently being updated)
- *Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand* (2nd edition, May 2008).[392]

The technical manuals contain a large amount of detailed information, so summary reports[393] have also been developed that present the key information in a more accessible format:

- *Climate Change Projections for New Zealand Snapshot* (June 2016)[394]
- *Preparing for Future Flooding: A Guide for Local Government in New Zealand* (May 2010)[395]
- *Preparing for Coastal Change: A Guide for Local Government in New Zealand* (March 2009)[396]
- *Preparing for Climate Change: A Guide for Local Government in New Zealand* (July 2008).[397]

For more information about the technical manuals and the summary publications can be found in see section 6.4.1.

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387 www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/voluntary-corporate-greenhouse-gas-reporting

388 The technical manuals were produced by science provider teams (led primarily by NIWA), under contract to the Ministry for the Environment.

389 www.mfe.govt.nz/publications/climate-change/climate-change-projections-new-zealand

390 www.mfe.govt.nz/publications/climate/climate-change-effects-on-flood-flow

391 www.mfe.govt.nz/publications/climate/coastal-hazards-climate-change-guidance-manual

392 www.mfe.govt.nz/publications/climate/climate-change-effect-impacts-assessments-may08

393 Summary reports were produced by the Ministry for the Environment, with assistance from science provider teams at NIWA.

394 www.mfe.govt.nz/publications/climate-change/climate-change-projections-new-zealand-snapshot

395 www.mfe.govt.nz/publications/climate/preparing-for-future-flooding-guide-for-local-govt

396 www.mfe.govt.nz/publications/climate/preparing-for-coastal-change-guide-for-local-govt

397 www.mfe.govt.nz/publications/climate/preparing-for-climate-change-guide-for-local-govt

9.3.4 Information for the land-based sector

The Ministry for Primary Industries website explains what climate change means for the rural sector, and has information about forestry and agriculture in the NZ ETS, sustainable forestry and sustainable land management, international climate change, and legislation and regulation.[398]

Climate Cloud

The Ministry for Primary Industries has developed a digital library, called the Climate Cloud, which has resources related to climate change in New Zealand for land managers, rural professionals and land-based businesses.[399] The digital library is designed to help land managers obtain information about the effects of climate change in order to make successful adaptation and mitigation decisions. It holds over 1800 peer-reviewed resources. The library contains resources on the risks, impacts and adaptation solutions from climate change and adverse events. It has physical copies and links to reports, factsheets and video, sourced largely from New Zealand organisations. Each resource is classified using sector and subject keywords and is also searchable by any word within the resource.

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.

The 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 New Zealand schools. There are opportunities to learn about climate change and sustainability issues across many areas and year levels of the curriculum. Te Kete Ipurangi[400] is the Ministry of Education's bilingual (te reo Māori and English) education portal. It provides schools and students with information, resources and curriculum materials (including about climate change and sustainability) to enhance teaching and learning for the education sector.[401]

Mātauranga Whakauka Taio – Environment Education for Sustainability Strategy and Action Plan was launched on 27 July 2017. Developed on behalf of the Government by the Department of Conservation, the Ministry for the Environment and the Ministry of Education,

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398 www.mpi.govt.nz/protection-and-response/environment-and-natural-resources/climate-change-and-the-primary-industries/

399 www.climatecloud.co.nz

400 www.tki.org.nz

401 http://esolonline.tki.org.nz/ESOL-Online/Teacher-needs/Reviewed-resources/Cross-curricular/Focus-on-English/Conservation/Climate-change

the strategy refreshes the Environmental Education strategy released in 1998 to reflect the changes in priorities and approaches in the last 20 years. The Strategy has a focus on Māori knowledge and values in environmental education.[402]

The Ministry of Education has developed a series of Achievement Standards for education on sustainability at levels 2 and 3 on the National Qualifications Framework, aligned with the New Zealand Curriculum. They may be used within dedicated year-long sustainability courses or be incorporated into other senior subjects such as geography, science, economics and horticulture as well as within learning areas such as technology and the arts. Credits gained at level 3 will contribute to University Entrance.[403]

Enviroschools and Te Aho Tū Roa

The Toimata Foundation (the Foundation) is a non-government 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.

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 immersion settings. Both programmes are designed to work in conjunction with the national curriculum (outlined above) and produce a range of 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. A range of projects across the 1105 schools,[404] kura[405] and centres involved in the Enviroschools and Te Aho Tū Roa programmes has relevance to climate change, including projects on waste minimisation, ecological restoration, school landscape projects, local food production, active transport to schools and energy efficiency.

9.4.2 Institutes and research centres

The New Zealand Government provides support for the institutions and research centres that educate professionals and 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 also investigates changes in New Zealand's

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402 For further information, see www.doc.govt.nz/eefs.

403 www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/subjects/education-for-sustainability/levels

404 www.enviroschools.org.nz

405 Kura refers to schools operating under Māori custom and using te reo Māori as the medium of instruction.

glaciers in response to climate. A key element in the scientific success of the ARC has been the development of expertise in Antarctic geological drilling and ice coring, integrated with numerical modelling of ice sheets and glaciers, to study past climates that are relevant to future projections. For more information about this area of research, see section 8.4.1.

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.

The Deep South National Science Challenge

The Deep South National Science Challenge (the Challenge) was launched in August 2014. The Challenge is funded by the Ministry of Business, Innovation and Employment and hosted by NIWA. The Mission of the Challenge is to "to enable New Zealanders to adapt, manage risk, and thrive in a changing climate". 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 key sectors that will be affected by climate change – ensuring key decision-making groups are informing, and are informed by, Deep South research. Key partners hail from central and local government, the Iwi Chairs' Forum[406] and key climate-affected sectors such 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 impacts and implications of climate change, with a specific focus on adaptation. Examples include partnership with a major visual exhibition (ANTARCTICA – While You Were Sleeping) at Auckland Museum as part of the Auckland Arts Festival (20,000 visitors), regular participation in an international Climathon[407] and exhibitions in regional art galleries (20,000–30,000 visitors each). The Challenge also supported Kiwi social media star Jamie Curry to make five videos about Antarctica, specifically targeted at young women aged 13–25 years, which garnered a staggering 2.5 million views. In addition, the Challenge has pursued innovative approaches in journalism: news and media releases are widely disseminated through a close relationship with the Science Media Centre; an agreement with the *New Zealand Geographic* magazine has led to a series of high-impact feature articles and an online hub with quality stories about climate change; and co-sponsorship of a new Science Journalism Fund has led to more stories about climate change impacts, implications and adaptation in mainstream media.

The Challenge also has a user-friendly website, a regular e-newsletter (1170 subscribers) and an active Twitter account as well as running a series of online seminars 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'.

[406] The Forum is a platform for sharing knowledge and information between the tangata whenua (people of the land – the indigenous people) of Aotearoa. See http://iwichairs.maori.nz.

[407] https://climathon.climate-kic.org

The Challenge prioritises 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 that culture plays in engagement about climate change. For more information on the Deep South National Science Challenge, see chapters 6 and 8.

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. 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 a range of activities with respect to climate change mitigation and adaptation since 2006. This has included hosting numerous conferences, forums, workshops and public seminars. In particular, it has hosted an invitation-only roundtable process from 2006–17. This brought together a wide range of stakeholders (including representatives from business and civil society organisations, policy advisors from within the public sector, parliamentarians and researchers) to address major global and domestic climate change issues. In recent years the roundtable process has been led by Dr Adrian Macey, a former New Zealand climate change ambassador. The IGPS has also published many articles and working papers on climate change, including special issues of its journal, *Policy Quarterly*, on climate-related topics. Collectively, these activities provide a useful contribution to public policy, as well as an opportunity for informal engagement among and with stakeholders.

Motu Economic and Public Policy Research

Motu Economic and Public Policy Research is a non-profit economic and public policy research institute. 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 New Zealand and other countries
- vulnerability and adaptation to climate change impacts.

Over the period 2013–17 Motu has run a series of innovative stakeholder dialogue groups designed to advance understanding of climate change issues and policy solutions. Participants have been drawn from the government, business, non-government organisation and research sectors. The outcomes have been documented and disseminated through Motu reports.

- The Low-Emission Future Dialogue (2013–16) focused on transformational low-emissions pathway options in New Zealand's stationary energy, transport and agriculture sectors.
- The Emissions Trading Scheme Dialogue (2016–17) discussed options for reforming unit supply, price management and linking in the NZ ETS.
- The Impacts and Implications Programme of the Deep South National Science Challenge aims to enable New Zealanders to adapt, manage risk, and thrive in a changing climate. In relation to that, Motu launched a series of dialogues in 2017 to develop shared understanding of key issues, map current knowledge about them, identify creative ideas

to address them, and pose well-formulated research questions. For more information, see chapters 6 and 8.

Motu releases many publications on its research and findings, all of which are freely available to the public.[408] Motu also shares its research and engagement outcomes by participating in other climate change initiatives in New Zealand and internationally.

Motu also provides education information to the public through the New Zealand's Low-Emission Future blog. The blog, which is co-run with the New Zealand Climate Change Research Institute, creates a forum for sharing information and perspectives about the mitigation challenge that New Zealand faces. It aims to help identify actions that government, businesses and civil society can take to prepare New Zealand to thrive in a future of global greenhouse gas constraints.

NIWA National Climate Centre

The NIWA National Climate Centre produces climate summaries, models, forecasts and general information about the New Zealand climate. For more information about the services and information that NIWA provides through the National Climate Database, see chapter 8.

NIWA is committed to making information available to the public. The NIWA website[409] 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.

The 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 team of researchers and policy thinkers work at the interface between climate change science and the decisions people have to make about climate change. There is a particular emphasis on work that spans the natural and social sciences.

The Institute collaborates internationally and within New Zealand with other researchers at New Zealand's Crown research institutes and universities, and with private institutes and researchers. It contributes to public debates 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 section 4.3.5 for details) produces regular publications, newsletters and reports.[410] Factsheets recently produced by the NZAGRC (in 2016 and 2017) include:

- Reducing NZ's agricultural GHGs: Methane inhibitors
- The structure of agricultural greenhouse gas research funding in New Zealand
- Reducing New Zealand's agricultural emissions: Mapping soil organic carbon stocks.

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408 https://motu.nz/find-publications/

409 www.niwa.co.nz/climate/information-and-resources

410 www.nzagrc.org.nz/

Since the *Sixth National Communication*, the NZAGRC has published over 40 journal articles and around 100 conference papers. 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 via the Pastoral Greenhouse Gas Research Consortium, 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. They ensure NZAGRC researchers are connected with each other, with relevant international researchers and with the agricultural industry and extension services. 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. This includes a comprehensive awards programme to build the capacity of technicians, doctoral and postdoctoral students from developing countries, and to facilitate exchanges of senior scientists between New Zealand and other Alliance member countries. It routinely hosts visiting scientific and policy delegations from other countries.

The Royal Society of New Zealand Te Apārangi

Royal Society of New Zealand Te Apārangi (the Society) is responsible for advancing and promoting research and scholarly activity. It is an independent statutory organisation and New Zealand's national academy of science, technology and the humanities. While the Royal Society of New Zealand Act 1997 talks about science, technology and humanities, over the years this scope has been expanded to include engineering, applied science and social sciences; and effectively the pursuit of knowledge in general. 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.

Recently the Society has released expert advice on climate change implications for New Zealand (2016); climate change mitigation options for New Zealand (2016); and human health impacts for climate change for New Zealand (2017). During 2016 the Society ran an information campaign on climate change, which included: a series called "10 things you didn't know about climate change" (in 13 centres); a talk by the co-Chair of the Intergovernmental Panel for Climate Change (IPCC) Working Group III (mitigation), Professor Jim Skea; a talk by IPCC Working Group II Editor, Professor Jean Palutikof; social media activity providing information about climate change; and resources for schools and teachers.

9.4.3 Science Media Centre

The Science Media Centre (SMC)[411] is an independent centre established by the Royal Society of New Zealand 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 Centre facilitates links between the media and science so that the media have 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 ultimate aim of a better-informed public.

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 workshops – designed to help researchers gain the confidence and skills to engage effectively with media and communicate their science in public
- SMC Expert Encounters – the SMC hosts regular events in Auckland and Wellington to help engage media with science and support more in-depth coverage of science-related topics. These free-ranging Q&A sessions invite journalists to meet dynamic local experts and visiting international scientists.

9.4.4 Industry training

Heavy Vehicle Fuel Efficiency training

EECA launched a Heavy Vehicle Fuel Efficiency programme in September 2012. The programme's aim was to improve the fuel efficiency of large fleets (those that used more than 1 million litres of fuel per annum) through expert advice and funding assistance.

Under the programme, EECA trained independent and in-company fuel advisors and trainers, and provided grants for fleet audits, information about how to save fuel, and training for fuel-efficient and safe driving. The programme was extended in 2014 to assist small to medium-sized fleet operators to improve their fuel efficiency in a way that was both cost-effective and able to be delivered to many fleets in a short timeframe. As reported in section 4.5.4, the programme has now ended, but an information component of the programme remains.[412]

[411] www.sciencemediacentre.co.nz

[412] www.eecabusiness.govt.nz/content/transport-heavy-vehicles

9.5 Public engagement

The preparation of the *Seventh National Communication* is a cross-governmental effort with contributions from a wide range of government agencies, along with organisations that receive funding or other support from the New Zealand Government. Although the public and non-government organisations are not consulted directly on the content of the *Seventh National Communication*, the Government actively engages with the public on climate change issues and has continued to do so since the last reporting period.

This section contains information about the Government's engagement with the public during the reporting period. This includes consultation on the 2030 emissions reduction target and the review of the NZ ETS, ongoing consultation with Māori, engagement with youth, and financial support for a variety of community groups with objectives related to climate change. It also covers engagement with the land-based sector.

9.5.1 Engaging with the public

Consulting the public on the Intended Nationally Determined Contribution

In 2015 a public consultation was held on what international emissions reduction target the Government would contribute as part of its Intended Nationally Determined Contribution. Fifteen public meetings and hui with iwi and hapū[413] were held in 11 locations across the country, which were together attended by approximately 1700 people. The Ministry for the Environment received over 17,000 submissions in total from approximately 15,600 submitters.

The following are some of key themes that came out of the consultation.

- Climate change is an important issue the Government should address urgently to protect New Zealanders, future generations and neighbouring Pacific Island countries.
- There was a strong call for an ambitious target and leadership from the Government (the most common target suggested by stakeholders was 40 per cent below 1990 levels or a target of zero carbon by 2050). Many related taking ambitious action to protecting our international reputation.
- Businesses and other stakeholders want to be more involved and engaged in climate change.
- A large majority of stakeholders highlighted that a target needs to be underpinned by a domestic plan.
- There were frequent requests for cross-party consensus and an independent commission on climate change.
- Strong concern was expressed that New Zealand is currently not doing enough to reduce emissions.
- Strong concern was expressed that the costs described in the discussion document were misleading and did not consider possible benefits of acting, or the costs of inaction.

[413] A hui refers to a gathering or meeting. It can involve individuals, a hapū (a grouping of related families) or several hapū, an entire iwi (a larger Māori grouping, sometimes called a tribe) or several iwi.

Public consultation for the New Zealand Emissions Trading Scheme review

The 2015/16 review of the NZ ETS was completed in July 2017. The review assessed how the NZ ETS should evolve to support New Zealand in meeting future emissions reduction targets and in its ongoing transition to a low emissions economy.

Consultation on the NZ ETS review was held between 24 November 2015 and 30 April 2016. During this period the Ministry for the Environment hosted 20 stakeholder sessions and co-hosted six hui with the Climate Change Iwi Leaders Group. There were around 600 attendees in total at these sessions.

Consultation was supported by a written discussion document and five technical notes. These set out the issues that the Government consulted on, as well as the objective and drivers for the review. In total, written submissions were received from 345 individuals and organisations.

Key themes of the submissions from the consultation were:

- the need for regulatory or policy certainty – this was the strongest theme and it was expressed across all sectors
- the need for a long-term plan for how the NZ ETS will help New Zealand meet its international obligations
- the importance of strongly connecting New Zealand's main policy tool for reducing emissions with the Government's other polices for climate change, including adaptation.

In February and March 2017 a series of seven stakeholder meetings and two teleconferences were held to discuss the progress on the NZ ETS review.

The feedback received was incorporated into advice on the outcomes of the review.[414]

Pou Taiao Iwi Leaders Group

The Treaty of Waitangi (Te Tiriti o Waitangi) is at the foundation of the relationship between the New Zealand Government and Māori. There is a shared desire for tenable and long-term solutions for environmental issues, including climate change.

The Ministry for the Environment has a Strategic Relationship Agreement with the Pou Taiao Iwi Leaders Group (Pou Taiao ILG). The Agreement facilitates an open dialogue between Ministers and the Pou Taiao ILG in relation to climate change policies and issues. Meetings between members of the Pou Taiao ILG and the Minister for Climate Change Issues are held at least three times a year to allow frank, informed and open dialogue to improve mutual understanding of interests and issues. The Pou Taiao ILG and the Ministry for the Environment have a joint work programme under the Agreement.

The Pou Taiao ILG is a subset of the wider Iwi Chairs Forum, which meets four times a year, with each hui hosted at different marae[415] throughout the country. Collectively the forum represents more than 400,000 Māori, over two-thirds of the Māori population.

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414 For more information about the 2015/16 NZ ETS review, see www.mfe.govt.nz/climate-change/reducing-greenhouse-gas-emissions/new-zealand-emissions-trading-scheme/reviews-of-nz.

415 Marae are Māori community facilities that usually consist of a carved meeting house, a dining hall and cooking area and the marae ātea (sacred space in front of the meeting house). See www.korero.maori.nz/forlearners/protocols/marae.html.

Sir Peter Blake Youth Enviroleaders Forum

The annual Youth Enviroleaders Forum (YELF) was established in 2004. It provides an opportunity for 50 young people aged between 15 and 18 years to take part in practical environmental projects, voice their opinion on environmental issues and learn first-hand about environmental management. YELF is hosted by the Ministry for the Environment in partnership with the Sir Peter Blake Trust.[416]

Previous forum themes have covered environmentally responsible business, urban water management, sustainable tourism, marine conservation, freshwater management and resource management practice. The 2017 YELF was held in Auckland, and focused on environmental issues facing New Zealand, particularly marine pollution, marine protected areas and ocean health.

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 key 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 there are 12 environment centres around New Zealand. The Ministry for the Environment funds environment centres through the Community Environment Fund.[417]

Waste Minimisation Fund

The Waste Minimisation Fund, administered by the Ministry for the Environment, funds projects that promote or achieve waste minimisation. 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.

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. Currently there are 182 Para Kore marae in New Zealand, which together have diverted 184.63 tonnes of waste from landfills.

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[416] The Sir Peter Blake Trust is a private charitable trust established with the support of the Blake family in December 2003 “to help New Zealanders make a positive difference for the planet through activities that encourage environmental awareness and action, and leadership development”. See https://sirpeterblaketrust.org/home.

[417] For a list of environment centres that received funding from the Community Environment Fund from 1 July 2012 to June 2018, see www.mfe.govt.nz/more/funding/community-environment-fund/cef-projects-funded-date/cef-environment-centre-funding-%E2%80%93.

9.5.2 Engaging with the land-based sector

In September 2007 the Government outlined an integrated package for the land-based sector called the Sustainable Land Management and Climate Change (SLMACC) Plan of Action. By 2014 many of the SLMACC strands of action had been completed. Those remaining include the technology transfer programme. For more information on the SLMACC programme, see chapters 4, 6 and 8.

The technology transfer programme has developed the Climate Cloud website, as described in section 9.3.4. Another resource developed from this programme is the 'Over the Fence' Extension Handbook. This handbook was developed to assist people to develop and deliver a successful extension programme that will help participants in understanding new or changed practices, accessing information or resources and changing their practice or behaviour if required. The technology transfer programme has also helped to deliver resources and demonstration programmes to rural professionals, encouraging climate change mitigation and adaptation.

Seven climate change extension programmes for the sector have been delivered through a variety of activities. The aim of these programmes was to inform and upskill farmers, foresters, land managers and rural consultants about climate change and the implications it may have.

Recognising the link between improved land management to reduce climate change and climate change impacts on waterways, the Plan of Action has funded the development of Overseer®, an on-farm nutrient budgeting tool to identify greenhouse gas emissions levels at the farm level. This tool provides farmers with information about nitrogen-use efficiency and nitrate leaching and includes a module for estimating greenhouse gas emissions on-farm. It is currently being rolled out to over 10,500 dairy farmers in New Zealand as a tool to more effectively manage nitrogen and reduce nitrate leaching on-farm. This roll-out has been implemented by Fonterra, the largest dairy-processing company in New Zealand, as part of its environmental management programme. Regional councils are also using the tool to set limits on the amount of nitrogen that can flow into waterways from farms in certain catchments.

Over the past few decades, significant improvements in efficiency and productivity have been made across the agriculture sector, attributed in part to technology transfer. Since 1990 these improvements have led to decreases in emissions from dairy cattle per kilogram of milk solids, and reductions in sheep and beef emissions per kilogram of lamb and mutton or beef.

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 last four years.

As detailed in chapter 7, the Government co-hosted the Second Pacific Energy Conference with the European Union in Auckland in June 2016. The conference built on the success of the Pacific Energy Summit in 2013, which kick-started wide-scale international investment in energy in the Pacific Island region, and has resulted in over $900 million of energy projects being developed across the region. The Conference was attended by heads of government and high-level officials from 23 Pacific Island countries, as well as by international and regional representatives and private sector stakeholders.[418] The conference focused on investment opportunities to increase renewable energy, energy efficiency and energy access for Pacific Island countries.

The Government has also promoted the sharing of technical-level expertise. The Asia–Pacific Carbon Markets Roundtable was initiated by New Zealand in 2011 to promote regional cooperation and information exchange on carbon markets. The initiative brings together senior officials from countries and jurisdictions around the region to discuss and progress the potential development of a regional carbon market. It has now met nine times, with the most recent Roundtable held in Seoul over 20–22 June 2017. The Roundtable was attended by nine countries, including Mexico for the first time.

The Government provides funding to support the technical contribution of New Zealand-based scientists at international scientific unions, such as the International Council for Science and a number of its global research programmes actively involved in coordinating research into climate change. The funding ensures the Government is well supported technically and that the scientific and policy advice provided by New Zealand is valued for its excellence, relevance and strategic awareness.

9.6.1 Contribution to the IPCC

The New Zealand Government provides a financial contribution to support New Zealand scientists selected to be part of the author teams of IPCC reports. As the sixth assessment cycle gathers pace, a number of New Zealand experts are involved in the Special Reports and the refinement of inventory methodologies. During the reporting period, the authors also received funding from the Government to travel to attend to IPCC meetings.

9.6.2 Global Research Alliance on Agricultural Greenhouse Gases

Education (LEARN and GRASS awards)

The Livestock Emissions Abatement Research Network (LEARN)[419] is New Zealand's competitive fellowship programme under the Global Research Alliance on Agricultural Greenhouse Gases (GRA; for more information on the GRA's aims and members, see section 4.3.5). LEARN provides opportunities for technicians, doctoral students and postdoctoral Fellows from developing countries in the area of livestock greenhouse gas research. The Global Research Alliance Senior Scientist (GRASS)[420] awards provide short-term exchange opportunities for senior scientists from both New Zealand and GRA member countries to encourage global research collaboration. During this reporting period, New Zealand has supported LEARN awards to five postdoctoral students from Pakistan, Viet Nam, China,

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[418] Heads of government attended from the Cook Islands, the Federated States of Micronesia, French Polynesia, the Republic of Kiribati, New Caledonia, Niue, Samoa, Tokelau and Tonga, along with representatives from American Samoa, the Republic of Nauru, Fiji, Guam, Papua New Guinea, the Republic of the Marshall Islands, the Republic of Palau, Northern Marianas, Pitcairn, Solomon Islands, Tuvalu, Vanuatu, and Wallis and Futuna. Other international and regional representatives attending included the Association of Small Island States, the Caribbean Community, the European Investment Bank, the International Energy Agency, the International Renewable Energy Agency, Japan, the Pacific Islands Forum Secretariat, the Pacific Community, the Secretariat of the Pacific Regional Environment Programme, the United Arab Emirates and the United Nations.

[419] https://livestockemissions.net/awards/learn-technical-training-award/

[420] https://livestockemissions.net/awards/grass-award/

Sri Lanka; three doctoral students from China; six technicians from Ethiopia, Colombia, Kenya, Uganda, Ghana and Viet Nam; and seven GRASS awards to support collaboration with the United States, Denmark, Spain, Australia, Canada and Finland.

Public awareness

New Zealand has partnered with the World Farmers' Organisation in the delivery of an annual farmer study tour. The tour's purposes are: 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 to 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: the first (2014) in New Zealand with the participation of farmers from Argentina, Canada and Poland; the second (2015) in Argentina with the participation of farmers from New Zealand, Paraguay, South Africa and Uruguay; and the third (2016) in New Zealand with the participation of farmers from Argentina, France, Germany, Japan, Portugal, Switzerland, Uganda and Uruguay.

Training

To support the GRA, 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 a number of countries in a particular region, or by countries sharing specific training needs.

Table 9.1 summarises the training that New Zealand has provided support for since the *Sixth National Communication*.

Table 9.1: GRA-related training New Zealand has supported, 2014–17

Workshop/course	Countries attending
Developing higher-tier agricultural inventories in South East Asia	Thailand, Indonesia, Malaysia, Philippines, Sri Lanka, Viet Nam, Papa New Guinea, Canada, Colombia and Japan
Workshop to develop regional livestock mitigation project in South and South East Asian countries	Indonesia, Malaysia, Philippines, Sri Lanka, Thailand and Viet Nam
Workshop on the GRA, and opportunities for engagement with Sri Lanka	Sri Lanka
Asian Inventory and Monitoring workshop on Nationally Determined Contribution implementation with the Food and Agriculture Organization of the United Nations	Indonesia, Philippines, Sri Lanka, Viet Nam and Thailand
Malaysian Inventory training workshop	Malaysia
African Inventory and Monitoring workshop	Ghana, Botswana and South Africa
South East Asia Inventory and Monitoring workshop	Indonesia, Malaysia, Philippines, Sri Lanka, Thailand and Viet Nam
Technical training course on livestock and climate change, and methods for measuring greenhouse gas emissions	Technicians chosen from Ethiopia, Kenya, Uganda, Tanzania, Rwanda, Burundi, Malawi, Zambia, Botswana, Namibia, Zimbabwe and South Africa
'AnimalChange' workshop to explore science of livestock greenhouse gases and science-policy forum	Botswana, Namibia, Nigeria, Ethiopia, Uganda, Kenya, Ghana and South Africa

Workshop/course	Countries attending
Asian regional workshop on enteric fermentation – to support the Climate and Clean Air Coalition project	India, Bangladesh, Japan, Philippines, Indonesia, Thailand, Malaysia and Viet Nam
Training on methods of measurement of methane emissions from forage-fed ruminants	Indonesia, Malaysia, Thailand, Viet Nam, Argentina, Chile, Colombia and Uruguay

Asia and Pacific activities

In this reporting period, the New Zealand Government has supported outreach events in the Asia–Pacific region through the Climate Change Development Fund (CCDF). These outreach events have shared information from the contribution of IPPC Working Group II and Working Group III to the IPCC's *Fifth Assessment Report*, for the purpose of enhancing the accessibility of the information. CCDF-funded outreach activities aim to assist stakeholders in countries vulnerable to the impacts of climate change in their planning for adaptation, risk management and future development. Targeted outreach events were held in Fiji (Suva) on 15–16 May 2014 and Samoa (Apia) on 19 May 2014, and in Manila and Jakarta in July 2014. Audiences at these events included government policymakers, non-government organisation representatives, and scientists. Media briefings held in conjunction with these events led to coverage in local television and newspapers. As well as presentations from IPCC representatives about the three Working Group Reports, there were presentations and discussions about relevant in-country work.

New Zealand holds one of the World Meteorological Organization Region V (southwest Pacific) seats on the IPCC Bureau. In 2015 the Canadian Government provided funding, via the World Meteorological Organization, for Meteorological Service of New Zealand Limited to deliver in-country training for the Severe Weather Forecasting and Disaster Risk Reduction Demonstration Project (SWFDDP) for six Pacific Island countries and territories. SWFDDP's purpose is to strengthen the capacity of national meteorological and hydrological services in developing countries, including least developed countries and small island developing states, to deliver improved forecasts and warnings of severe weather to save lives and livelihoods, and protect property and infrastructure. Participating countries are the Cook Islands, Kiribati, Fiji, Niue, Samoa, Solomon Islands, Tuvalu, Tonga, Tokelau and Vanuatu.

For more detailed descriptions of New Zealand's engagement with Pacific Island countries, see chapter 7.

Other activities

The Government provides funding to support the Organisation for Economic Co-operation and Development – International Energy Agency Global Forum on climate change, which is aimed at promoting dialogue and enhanced understanding between countries on technical issues in the international climate change negotiations. New Zealand also supported the Centre for Climate and Energy Solutions, which aims to advance strong policy and action to reduce greenhouse gas emissions, promote clean energy, and strengthen resilience to climate impacts by working with policy-makers and stakeholders to meet our climate and energy challenge.

Annex A: Summary of emissions and removals from New Zealand's 2017 *Greenhouse Gas Inventory*

Common Reporting Format for the provision of inventory information by Annex I Parties to the United Nations Framework Convention on Climate Change in May 2017

Table A.1: Emissions trends (CO_2 – three parts)

Table A.1: Emissions trends (CO_2 – part 1 of 3)

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
1. Energy	22,491.81	22,998.88	24,864.09	24,317.58	24,555.78	24,641.75	25,903.73	27,943.23	26,376.11	27,711.94
A. Fuel combustion (sectoral approach)	22,032.08	22,443.94	24,323.73	23,799.01	24,014.94	24,141.39	25,237.12	27,213.59	25,668.39	27,095.78
1. Energy industries	5,983.74	6,097.05	7,585.40	6,648.46	5,534.96	4,805.39	5,554.56	7,160.68	5,576.06	6,795.16
2. Manufacturing industries and construction	4,678.70	5,161.47	5,013.26	5,282.43	5,599.97	5,701.84	6,048.60	6,137.15	5,876.40	5,732.16
3. Transport	8,581.99	8,575.87	8,946.43	9,406.45	10,074.13	10,745.86	10,889.98	11,120.77	11,339.49	11,633.64
4. Other sectors	2,787.64	2,609.55	2,778.65	2,461.67	2,805.88	2,888.30	2,743.99	2,795.00	2,876.43	2,934.82
5. Other										
B. Fugitive emissions from fuels	459.73	554.94	540.36	518.57	540.84	500.37	666.61	729.64	707.73	616.16
1. Solid fuels	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE
2. Oil and natural gas and other emissions from energy production	459.73	554.94	540.36	518.57	540.84	500.37	666.61	729.64	707.73	616.16
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
2. Industrial processes	2,524.39	2,663.99	2,762.17	2,852.21	2,730.55	2,818.91	2,831.21	2,737.46	2,797.51	2,949.65
A. Mineral industry	561.87	572.41	648.54	646.71	625.40	674.60	646.19	695.08	650.96	728.35
B. Chemical industry	175.40	189.82	181.80	179.40	196.23	171.54	190.79	190.39	195.43	196.71
C. Metal industry	1,757.51	1,872.16	1901.17	1,994.16	1,874.88	1,936.83	1,957.86	1,814.77	1,913.27	1,985.89
D. Non-energy products from fuels and solvent use	29.61	29.61	30.67	31.93	34.05	35.95	36.37	37.22	37.85	38.70
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
H. Other										
3. Agriculture	399.26	440.54	468.46	522.45	588.09	677.93	627.06	662.41	747.90	855.03
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	360.06	388.70	417.33	451.95	496.55	541.15	485.22	534.62	584.01	633.41
H. Urea application	39.19	51.84	51.13	70.49	91.54	136.78	141.84	127.79	163.89	221.62
I. Other carbon-containing fertilisers	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
J. Other										

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
4. Land use, land-use change and forestry[2]	−30,392.73	−32,385.06	−31,886.49	−32,550.78	−32,614.53	−31,160.37	−30,745.91	−31,750.69	−32,185.85	−33,759.36
A. Forest land	−29,954.39	−31,056.57	−30,465.78	−30,881.86	−30,551.32	−28,871.58	−28,601.32	−29,257.96	−31,054.43	−31,382.66
B. Cropland	469.34	471.72	474.09	476.47	478.84	481.21	483.59	487.59	490.09	492.60
C. Grassland	762.32	832.81	897.58	1,013.81	1,130.91	1,237.18	1,337.69	1,456.79	1,552.50	1,651.62
D. Wetlands	−20.35	−19.26	−18.18	−17.09	−16.01	−14.93	−13.84	−12.69	−11.61	−10.53
E. Settlements	67.71	69.27	70.84	72.70	75.23	78.46	80.74	83.17	85.39	86.71
F. Other land	10.87	11.63	12.39	13.15	13.91	14.67	15.43	16.81	17.72	18.63
G. Harvested wood products	−1,728.24	−2,694.65	−2,857.44	−3,227.94	−3,746.09	−4,085.39	−4,048.20	−4,524.41	−3,265.50	−4,615.73
H. Other										
5. Waste	13.18	13.18	13.18	13.17	13.05	13.05	12.88	12.51	12.51	12.31
A. Solid waste disposal	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	13.18	13.18	13.18	13.17	13.05	13.05	12.88	12.51	12.51	12.31
D. Wastewater treatment and discharge										
E. Other										
6. Other *(as specified in summary 1.A)*										
Total CO_2-equivalent emissions without LULUCF	25,428.64	26,116.59	28,107.90	27,705.40	27,887.47	28,151.65	29,374.88	31,355.60	29,934.03	31,528.93
Total CO_2-equivalent emissions with LULUCF	−4,964.09	−6,268.47	−3,778.59	−4,845.38	−4,727.06	−3,008.72	−1,371.03	−395.09	−2,251.82	−2,230.43

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
Memo items:										
International bunkers	2,364.07	2,222.17	2,134.61	2,210.24	2,660.07	2,748.56	2,718.80	2,759.39	2,857.03	2,762.58
Aviation	1,321.65	1,282.16	1,258.35	1,284.21	1,281.41	1,601.89	1,627.38	1,628.90	1,770.22	1,836.55
Navigation	1,042.42	940.01	876.27	926.03	1,378.66	1,146.66	1,091.43	1,130.49	1,086.82	926.03
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	3,516.11	3,592.45	3,592.72	3,785.48	3,973.81	4,089.94	3,925.05	4,122.61	4,376.71	4,856.44
CO_2 captured	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Long-term storage of C in waste disposal sites	3,725.86	3,926.42	4,126.97	4,358.04	4,594.29	4,830.55	5,073.45	5,307.41	5,527.91	5,748.42
Indirect N_2O										
Indirect CO_2 [3]	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
Total CO_2-equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total CO_2-equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A.1: Emissions trends (CO_2 – part 2 of 3)

Greenhouse gas source and sink categories	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	28,507.69	30,552.52	30,599.97	32,207.16	31,792.36	33,228.27	33,286.05	32,147.74	33,448.87	30,668.86
A. Fuel combustion (sectoral approach)	27,914.43	29,931.00	30,005.82	31,595.91	30,929.04	32,313.02	32,325.65	31,126.31	32,206.60	29,300.57
1. Energy industries	6,452.73	7,956.21	7,179.51	8,514.75	8,131.78	10,195.40	10,091.44	8,459.30	9,636.25	7,421.93
2. Manufacturing industries and construction	6,252.16	6,630.39	6,891.14	6,337.81	5,809.03	4,993.36	5,046.24	5,484.09	5,489.67	5,226.54
3. Transport	12,187.48	12,259.39	12,722.73	13,267.28	13,569.78	13,656.23	13,795.12	13,915.74	13,949.47	13,774.21
4. Other sectors	3,022.05	3,085.02	3,212.44	3,476.07	3,418.45	3,468.04	3,392.85	3,267.19	3,131.21	2,877.89
5. Other										
B. Fugitive emissions from fuels	593.26	621.53	594.15	611.25	863.32	915.25	960.40	1,021.42	1,242.26	1,368.29
1. Solid fuels	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE
2. Oil and natural gas and other emissions from energy production	593.26	621.53	594.15	611.25	863.32	915.25	960.40	1,021.42	1,242.26	1,368.29
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Industrial processes	2,927.92	2,992.48	2,990.45	3,158.91	3,137.67	3,214.79	3,187.07	3,383.17	3,165.02	3,027.99
A. Mineral industry	718.54	716.89	706.97	697.26	666.68	756.18	719.14	861.50	807.03	752.17
B. Chemical industry	198.26	206.31	213.07	201.42	194.29	229.12	243.05	249.96	265.66	261.66
C. Metal industry	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	40.18	40.60	41.87	43.56	44.61	44.82	45.25	45.67	45.67	45.04
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
H. Other										

Greenhouse gas source and sink categories	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)
3. Agriculture	911.35	1,031.04	1,171.91	1,123.45	1,125.25	1,194.38	1,038.67	1,111.52	1,051.17	1,093.61
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	682.80	732.20	781.59	689.34	670.21	737.78	616.41	655.22	610.84	719.70
H. Urea application	228.54	298.84	390.32	434.11	455.04	456.60	422.26	456.29	440.33	373.91
I. Other carbon-containing fertilisers	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
J. Other										
4. Land use, land-use change and forestry[(2)]	–32,655.75	–32,032.85	–29,618.15	–30,738.79	–30,727.33	–29,130.37	–27,488.35	–25,390.28	–33,898.04	–30,557.95
A. Forest land	–31,882.61	–30,773.53	–27,275.67	–30,243.53	–34,084.51	–37,747.60	–38,306.62	–41,107.89	–33,165.76	–33,133.37
B. Cropland	509.89	511.80	509.75	526.68	555.46	607.80	634.51	682.94	495.12	475.98
C. Grassland	3,565.26	3,601.76	3,387.16	5,031.15	7,854.86	12,834.98	15,361.70	20,323.47	4,264.46	7,593.74
D. Wetlands	–8.77	–7.71	–6.85	–5.08	–2.74	0.74	2.90	6.22	9.43	15.54
E. Settlements	100.21	100.89	99.51	113.94	137.84	181.56	203.79	245.12	76.67	99.65
F. Other land	37.82	38.66	37.05	49.91	71.62	103.46	123.48	161.53	47.86	117.22
G. Harvested wood products	–4,977.56	–5,504.72	–6,369.10	–6,211.86	–5,259.85	–5111.31	–5,508.11	–5,701.68	–5,625.82	–5,726.70
H. Other										
5. Waste	11.68	11.03	6.17	5.58	5.04	4.98	3.91	2.69	1.21	1.21
A. Solid waste disposal	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										

Greenhouse gas source and sink categories	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)
C. Incineration and open burning of waste	11.68	11.03	6.17	5.58	5.04	4.98	3.91	2.69	1.21	1.21
D. Wastewater treatment and discharge										
E. Other										
6. Other ***(as specified in summary 1.A)***										
Total CO_2-equivalent emissions without LULUCF	32,358.64	34,587.07	34,768.50	36,495.10	36,060.32	37,642.41	37,515.69	36,645.12	37,666.27	34,791.66
Total CO_2-equivalent emissions with LULUCF	–297.12	2,554.22	5,150.35	5,756.31	5,333.00	8,512.04	10,027.34	11,254.84	3,768.23	4,233.72
Memo items:										
International bunkers	2,555.31	2,762.57	2,832.51	2,865.86	2,964.04	3,200.74	3,146.78	3,276.34	3,418.70	3,325.51
Aviation	1,800.08	1,943.22	1,933.98	2,002.37	2,228.09	2,210.89	2,180.08	2,287.52	2,304.12	2,308.01
Navigation	755.24	819.35	898.53	863.49	735.95	989.85	966.70	988.82	1,114.58	1,017.50
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	5,302.66	5,250.10	5,645.96	5,689.47	6,113.37	6,083.84	6,048.76	5,798.31	5,403.89	5,012.63
CO_2 captured	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Long-term storage of C in waste disposal sites	5,968.92	6,209.48	6,449.47	6,677.22	6,911.93	7,175.29	7,498.05	7,800.28	8,093.91	8,381.14
Indirect N_2O										
Indirect CO_2 (3)	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
Total CO_2-equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total CO_2-equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A.1: Emissions trends (CO_2 – part 3 of 3)

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
1. Energy	30,622.47	29,900.44	31,216.45	30,701.37	31,080.86	31,252.79	38.95
A. Fuel combustion (sectoral approach)	29,116.77	28,443.40	29,944.28	29,630.67	29,846.37	29,813.50	35.32
1. Energy industries	6,804.58	6304.36	7,693.47	6,396.23	5,418.90	5,279.86	–11.76
2. Manufacturing industries and construction	5,482.30	5,155.42	5,256.98	6,157.48	7,132.79	6,701.82	43.24
3. Transport	13,945.98	13,954.87	13,723.37	13,940.35	14,008.15	14,593.57	70.05
4. Other sectors	2,883.92	3,028.74	3,270.45	3,136.61	3,286.53	3,238.25	16.16
5. Other							
B. Fugitive emissions from fuels	1,505.70	1,457.04	1,272.17	1,070.70	1,234.49	1,439.29	213.07
1. Solid fuels	NO,NA,NE	NO,NA,NE	NO,NA,NE	NO,NA,NE	NE,NA,NO	NE,NA,NO	0.00
2. Oil and natural gas and other emissions from energy production	1,505.70	1,457.04	1,272.17	1,070.70	1,234.49	1,439.29	213.07
C. CO_2 transport and storage	NO	NO	NO	NO	NO	NO	0.00
2. Industrial processes	3,324.23	3,299.07	3,260.06	3,324.11	3,400.22	3,512.93	39.16
A. Mineral industry	740.23	713.26	751.88	774.42	830.50	876.33	55.97
B. Chemical industry	265.10	281.55	275.21	260.53	253.57	282.35	60.97
C. Metal industry	2,273.23	2,258.88	2,187.58	2,243.77	2,270.77	2,307.74	31.31
D. Non-energy products from fuels and solvent use	45.67	45.39	45.39	45.39	45.39	46.51	57.07
E. Electronic industry							
F. Product uses as ODS substitutes							
G. Other product manufacture and use	NA	NA	NA	NA	NA	NA	0.00
H. Other							

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
3. Agriculture	1,069.83	1,131.49	1,176.95	1,060.25	1,102.69	1,144.50	186.66
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	620.47	634.49	682.71	540.07	591.98	536.27	48.94
H. Urea application	449.36	497.00	494.24	520.18	510.71	608.23	1,451.81
I. Other carbon-containing fertilisers	NE	NE	NE	NE	NE	NE	0.00
J. Other							
4. Land use, land-use change and forestry[(2)]	–30,875.42	–26,385.50	–25,709.02	–24,362.89	–23,990.21	–23,964.01	–21.15
A. Forest land	–2,762.45	–26,373.04	–25,805.42	–23,732.57	–24,320.59	–23,466.61	–21.66
B. Cropland	475.92	466.57	483.08	544.80	466.72	444.36	–5.32
C. Grassland	7,858.13	6,362.18	7,139.91	7,378.38	7,368.00	4,595.69	502.85
D. Wetlands	3.26	1.16	0.61	1.03	10.42	1.85	–109.08
E. Settlements	87.89	99.12	91.74	80.94	78.92	85.76	26.66
F. Other land	124.08	194.18	189.67	132.00	130.18	144.68	1,231.01
G. Harvested wood products	–6,662.24	–7,135.67	–7,808.61	–8,767.47	–7,723.86	–5,769.73	233.85
H. Other							
5. Waste	1.21	1.21	1.21	1.21	1.21	1.21	–90.82
A. Solid waste disposal	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.00
B. Biological treatment of solid waste							

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
C. Incineration and open burning of waste	1.21	1.21	1.21	1.21	1.21	1.21	–90.82
D. Wastewater treatment and discharge							
E. Other							
6. Other *(as specified in summary 1.A)*							
Total CO_2-equivalent emissions without LULUCF	35,017.74	34,332.22	35,654.67	35,086.94	35,584.98	35,911.43	41.22
Total CO_2-equivalent emissions with LULUCF	4,142.31	7,946.72	9,945.64	10,724.05	11,594.78	11,947.43	–340.68
Memo items:							
International bunkers	3,384.94	3,435.60	3,474.44	3,461.36	3,502.90	3,792.92	60.44
Aviation	2,317.90	2,417.85	2,504.37	2,500.95	2,575.42	2,765.83	109.27
Navigation	1,067.03	1,017.75	970.07	960.40	927.48	1,027.09	–1.47
Multilateral operations	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass	5,615.00	5,691.12	5,659.37	5,374.65	5,404.27	5,443.38	54.81
CO_2 captured	NO	NO	NO	NO	NO	NO	0.00
Long-term storage of C in waste disposal sites	8,681.67	8,991.99	9,312.09	9,642.35	9,972.60	10,302.80	176.52
Indirect N_2O							
Indirect CO_2[(3)]	NO,NE	NO,NE	NO,NE	NO,NE	NE,NO	NE,NO	0.00
Total CO_2-equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	0.00
Total CO_2-equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	NA	NA	NA	NA	NA	NA	0.00

Note: C = carbon; CO_2 = carbon dioxide; kt CO_2-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land, land-use change and forestry; N_2O = nitrous oxide; NA = not applicable; NE = not estimated; NO = not occurring; ODS = ozone-depleting substance.

Table A.2: Emissions trends (CH_4 – three parts)

Table A.2: Emissions trends (CH_4 – part 1 of 3)

Greenhouse gas source and sink categories	Base year (1990)(1) (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)	1999 (kt CO_2-equivalent)
1. Energy	42.55	37.82	38.66	37.72	39.00	39.59	48.80	44.31	45.44	48.70
A. Fuel combustion (sectoral approach)	7.47	7.06	6.77	6.60	6.79	6.80	6.63	6.65	6.59	6.54
1. Energy industries	0.10	0.10	0.13	0.11	0.09	0.08	0.09	0.12	0.09	0.11
2. Manufacturing industries and construction	1.06	1.08	1.10	1.15	1.19	1.20	1.17	1.21	1.25	1.35
3. Transport	2.88	2.80	2.75	2.69	2.65	2.63	2.52	2.47	2.38	2.30
4. Other sectors	3.44	3.08	2.79	2.65	2.85	2.89	2.85	2.86	2.86	2.77
5. Other										
B. Fugitive emissions from fuels	35.08	30.76	31.89	31.12	32.21	32.78	42.16	37.66	38.86	42.16
1. Solid fuels	13.13	8.80	8.99	8.72	10.27	12.97	19.17	13.52	15.58	17.16
2. Oil and natural gas and other emissions from energy production	21.95	21.95	22.90	22.40	21.94	19.81	23.00	24.14	23.27	25.00
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	4.74
A. Mineral industry										
B. Chemical industry	1.10	1.89	1.60	1.79	2.25	3.16	4.25	4.38	4.12	4.74
C. Metal industry	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
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
H. Other										

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
3. Agriculture	1,096.97	1,105.66	1,089.63	1,088.41	1,117.85	1,130.51	1,142.29	1,169.85	1,139.76	1,146.73
A. Enteric fermentation	1,068.62	1,076.80	1,060.62	1,058.75	1,086.82	1,098.57	1,109.16	1,135.55	1,106.07	1,113.04
B. Manure management	27.44	28.06	28.25	28.79	30.10	31.14	32.21	33.25	32.75	32.75
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	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
F. Field burning of agricultural residues	0.90	0.80	0.76	0.87	0.92	0.80	0.92	1.05	0.94	0.94
G. Liming										
H. Urea application										
I. Other carbon-containing fertilisers										
J. Other										
4. Land use, land-use change and forestry[2]	3.73	3.18	3.55	4.15	4.17	4.47	4.92	4.43	5.49	3.66
A. Forest land	0.94	0.82	1.15	1.13	1.35	2.01	2.05	1.95	1.45	1.07
B. Cropland	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE
C. Grassland	2.79	2.36	2.40	3.01	2.82	2.46	2.87	2.48	4.04	2.60
D. Wetlands	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
F. Other land	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										

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
5. Waste	160.27	164.03	167.45	170.85	168.21	170.63	173.05	174.87	175.88	177.32
A. Solid waste disposal	150.74	154.19	157.61	160.86	158.06	160.21	162.53	164.24	165.48	167.19
B. Biological treatment of solid waste	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
C. Incineration and open burning of waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Wastewater treatment and discharge	9.53	9.84	9.84	9.99	10.14	10.42	10.52	10.63	10.40	10.12
E. Other										
6. Other *(as specified in summary 1.A)*										
Total CH_4 emissions without CH_4 from LULUCF	1,300.89	1,309.40	1,297.34	1,298.77	1,327.30	1,343.89	1,368.38	1,393.42	1,365.21	1,377.49
Total CH_4 emissions with CH_4 from LULUCF	1,304.62	1,312.58	1,300.89	1,302.92	1,331.47	1,348.36	1,373.30	1,397.85	1,370.69	1,381.15
Memo items:										
International bunkers	0.09	0.08	0.08	0.08	0.12	0.10	0.10	0.10	0.10	0.09
Aviation	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Navigation	0.08	0.07	0.07	0.07	0.11	0.09	0.09	0.09	0.09	0.08
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass										
CO_2 captured										
Long-term storage of C in waste disposal sites										
Indirect N_2O										
Indirect CO_2[3]										

Table A.2: Emissions trends (CH_4 – part 2 of 3)

Greenhouse gas source and sink categories	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	48.54	49.67	48.24	42.71	40.14	40.48	45.03	39.73	44.16	46.48
A. Fuel combustion (sectoral approach)	6.61	6.57	6.60	6.63	6.59	6.66	6.66	6.34	6.14	5.73
1. Energy industries	0.11	0.13	0.12	0.13	0.12	0.15	0.14	0.13	0.14	0.11
2. Manufacturing industries and construction	1.49	1.52	1.63	1.66	1.72	1.68	1.68	1.64	1.55	1.39
3. Transport	2.20	2.18	2.12	2.04	1.95	1.84	1.71	1.63	1.52	1.44
4. Other sectors	2.81	2.74	2.73	2.79	2.80	2.98	3.12	2.93	2.93	2.79
5. Other										
B. Fugitive emissions from fuels	41.92	43.10	41.64	36.08	33.54	33.82	38.37	33.39	38.03	40.75
1. Solid fuels	16.86	17.08	16.98	15.98	15.00	15.87	20.19	12.93	16.29	19.34
2. Oil and natural gas and other emissions from energy production	25.06	26.03	24.66	20.10	18.54	17.95	18.18	20.46	21.74	21.41
C. CO_2 transport and storage										
2. Industrial processes	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	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
D. Non-energy products from fuels and solvent use	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
H. Other										

Greenhouse gas source and sink categories	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)
3. Agriculture	1,178.24	1,183.50	1,180.52	1,200.03	1,199.06	1,210.68	1,215.03	1,170.66	1,126.15	1,140.68
A. Enteric fermentation	1,142.67	1,146.45	1,142.69	1,160.91	1,159.70	1,171.04	1,174.92	1,130.75	1,086.34	1,099.30
B. Manure management	34.63	36.01	36.80	38.14	38.63	38.75	39.29	38.88	38.92	40.46
C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural soils	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
F. Field burning of agricultural residues	0.94	1.04	1.03	0.98	0.73	0.88	0.82	1.02	0.90	0.92
G. Liming										
H. Urea application										
I. Other carbon-containing fertilisers										
J. Other										
4. Land use, land-use change and forestry(2)	3.47	3.44	3.40	3.69	3.58	5.54	5.93	7.84	3.48	4.47
A. Forest land	1.07	0.91	0.81	0.68	0.60	0.57	0.61	0.88	0.74	0.98
B. Cropland	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE
C. Grassland	2.40	2.53	2.60	3.01	2.98	4.97	5.32	6.96	2.75	3.49
D. Wetlands	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
F. Other land	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										
5. Waste	179.56	181.64	183.46	181.40	182.03	182.80	179.71	179.00	176.33	174.30
A. Solid waste disposal	169.44	171.60	173.53	171.36	172.10	172.94	170.26	169.57	166.73	164.95
B. Biological treatment of solid waste	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE

Greenhouse gas source and sink categories	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)
C. Incineration and open burning of waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Wastewater treatment and discharge	10.12	10.03	9.93	10.04	9.93	9.85	9.45	9.43	9.60	9.34
E. Other										
6. Other *(as specified in summary 1.A)*										
Total CH_4 emissions without CH_4 from LULUCF	1,411.88	1,419.71	1,417.46	1,426.36	1,423.73	1,434.74	1,440.70	1,390.39	1,347.96	1,363.35
Total CH_4 emissions with CH_4 from LULUCF	1,415.35	1,423.15	1,420.87	1,430.05	1,427.30	1,440.28	1,446.62	1,398.23	1,351.44	1,367.82
Memo items:										
International bunkers	0.08	0.08	0.09	0.09	0.08	0.10	0.10	0.10	0.11	0.10
Aviation	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Navigation	0.06	0.07	0.08	0.07	0.06	0.09	0.08	0.09	0.10	0.09
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass										
CO_2 captured										
Long-term storage of C in waste disposal sites										
Indirect N_2O										
Indirect CO_2[(3)]										

Table A.2: Emissions trends (CH_4 – part 3 of 3)

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
1. Energy	51.43	44.01	39.13	37.74	37.25	38.13	–10.39
A. Fuel combustion (sectoral approach)	6.02	6.20	6.32	6.04	5.64	5.66	–24.20
1. Energy industries	0.11	0.10	0.12	0.10	0.09	0.08	–15.15
2. Manufacturing industries and construction	1.56	1.56	1.55	1.52	1.56	1.56	48.19
3. Transport	1.37	1.29	1.22	1.19	1.15	1.08	–62.40
4. Other sectors	2.97	3.26	3.43	3.23	2.85	2.93	–14.69
5. Other							
B. Fugitive emissions from fuels	45.41	37.81	32.82	31.70	31.61	32.47	–7.45
1. Solid fuels	23.44	16.58	11.52	10.83	9.01	7.59	–42.18
2. Oil and natural gas and other emissions from energy production	21.97	21.23	21.29	20.87	22.60	24.87	13.33
C. CO_2 transport and storage							
2. Industrial processes	1.91	1.92	2.55	3.27	5.06	4.27	286.60
A. Mineral industry							
B. Chemical industry	1.91	1.92	2.55	3.27	5.06	4.27	286.60
C. Metal industry	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.00
D. Non-energy products from fuels and solvent use	NA	NA	NA	NA	NA	NA	0.00
E. Electronic industry							
F. Product uses as ODS substitutes							
G. Other product manufacture and use	NA	NA	NA	NA	NA	NA	0.00
H. Other							

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
3. Agriculture	1,138.48	1,155.21	1,180.74	1,183.80	1,191.48	1,170.51	6.70
A. Enteric fermentation	1,095.93	1,111.28	1,135.15	1,137.38	1,143.95	1,123.63	5.15
B. Manure management	41.54	43.17	44.47	45.30	46.57	46.14	68.13
C. Rice cultivation	NO	NO	NO	NO	NO	NO	0.00
D. Agricultural soils	NE	NE	NE	NE	NE	NE	0.00
E. Prescribed burning of savannas	IE	IE	IE	IE	IE	IE	0.00
F. Field burning of agricultural residues	1.01	0.75	1.12	1.12	0.96	0.75	–17.61
G. Liming							
H. Urea application							
I. Other carbon-containing fertilisers							
J. Other							
4. Land use, land-use change and forestry[(2)]	4.41	3.18	3.38	3.11	3.19	3.17	–14.87
A. Forest land	0.83	0.84	0.73	0.61	0.69	1.42	50.52
B. Cropland	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	NE,IE	0.00
C. Grassland	3.58	2.33	2.65	2.49	2.50	1.76	–36.95
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0.00
E. Settlements	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	0.00
F. Other land	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	0.00
G. Harvested wood products							
H. Other							
5. Waste	170.06	165.49	162.64	159.53	158.22	154.77	–3.43
A. Solid waste disposal	160.73	156.15	152.81	150.13	148.65	145.03	–3.78
B. Biological treatment of solid waste	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	0.00

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
C. Incineration and open burning of waste	0.00	0.00	0.00	0.00	0.00	0.00	–87.32
D. Wastewater treatment and discharge	9.33	9.34	9.83	9.41	9.57	9.73	2.13
E. Other							
6. Other *(as specified in summary 1.A)*							
Total CH_4 emissions without CH_4 from LULUCF	1,361.87	1,366.63	1,385.05	1,384.33	1,392.01	1,367.68	5.13
Total CH_4 emissions with CH_4 from LULUCF	1,366.28	1,369.81	1,388.44	1,387.44	1,395.20	1,370.85	5.08
Memo items:							
International bunkers	0.11	0.11	0.10	0.10	0.10	0.11	21.38
Aviation	0.02	0.02	0.02	0.02	0.02	0.02	107.46
Navigation	0.09	0.09	0.08	0.08	0.08	0.09	11.38
Multilateral operations	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass							
CO_2 captured							
Long-term storage of C in waste disposal sites							
Indirect N_2O							
Indirect CO_2[(3)]							

Note: C = carbon; CO_2 = carbon dioxide; CH_4 = methane; IE = included elsewhere, kt CO_2-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land, land-use change and forestry; N_2O = nitrous oxide; NA = not applicable; NE = not estimated; NO = not occurring; ODS = ozone-depleting substance.

Table A.3: Emissions trends (N_2O – three parts)

Table A.3: Emissions trends (N_2O – part 1 of 3)

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
1. Energy	0.65	0.66	0.71	0.72	0.78	0.80	0.79	0.83	0.84	0.89
A. Fuel combustion (sectoral approach)	0.65	0.65	0.71	0.72	0.78	0.80	0.79	0.83	0.84	0.88
1. Energy industries	0.02	0.01	0.03	0.02	0.01	0.02	0.02	0.03	0.02	0.03
2. Manufacturing industries and construction	0.16	0.16	0.17	0.17	0.18	0.18	0.18	0.18	0.18	0.20
3. Transport	0.37	0.39	0.41	0.44	0.47	0.50	0.50	0.53	0.54	0.56
4. Other sectors	0.10	0.09	0.10	0.09	0.11	0.11	0.09	0.10	0.09	0.10
5. Other										
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
1. Solid fuels	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	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	0.34	0.33	0.31	0.29	0.28	0.27	0.25	0.24	0.23	0.22
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
C. Metal industry										
D. Non-energy products from fuels and solvent use	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	0.34	0.33	0.31	0.29	0.28	0.27	0.25	0.24	0.23	0.22
H. Other										

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
3. Agriculture	17.78	18.08	18.25	18.90	19.48	20.28	20.72	21.22	20.91	21.14
A. Enteric fermentation										
B. Manure management	0.18	0.19	0.19	0.19	0.20	0.22	0.22	0.23	0.23	0.22
C. Rice cultivation										
D. Agricultural soils	17.59	17.88	18.05	18.69	19.26	20.05	20.48	20.98	20.67	20.90
E. Prescribed burning of savannas	IE	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	0.02
G. Liming										
H. Urea application										
I. Other carbon-containing fertilisers										
J. Other										
4. Land use, land-use change and forestry[2]	0.59	0.59	0.60	0.62	0.65	0.66	0.68	0.69	0.70	0.68
A. Forest land	0.41	0.42	0.45	0.48	0.53	0.55	0.56	0.57	0.57	0.56
B. Cropland	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
C. Grassland	0.16	0.14	0.12	0.11	0.09	0.08	0.09	0.08	0.09	0.07
D. Wetlands	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
F. Other land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. Harvested wood products										
H. Other										

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
5. Waste	0.33	0.34	0.34	0.35	0.35	0.36	0.36	0.36	0.37	0.37
A. Solid waste disposal										
B. Biological treatment of solid waste	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
C. Incineration and open burning of waste	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
D. Wastewater treatment and discharge	0.32	0.33	0.34	0.34	0.35	0.35	0.36	0.36	0.36	0.36
E. Other										
6. Other *(as specified in summary 1.A)*										
Total CH_4 emissions without CH_4 from LULUCF	19.10	19.40	19.61	20.26	20.89	21.70	22.12	22.66	22.34	22.61
Total CH_4 emissions with CH_4 from LULUCF	19.70	19.99	20.21	20.87	21.54	22.36	22.81	23.35	23.04	23.28
Memo items:										
International bunkers	0.08	0.07	0.07	0.07	0.09	0.09	0.08	0.08	0.08	0.08
Aviation	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Navigation	0.04	0.04	0.03	0.03	0.05	0.04	0.04	0.04	0.04	0.03
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass										
CO_2 captured										
Long-term storage of C in waste disposal sites										
Indirect N_2O	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO
Indirect CO_2[3]										

Table A.3: Emissions trends (N_2O – part 2 of 3)

Greenhouse gas source and sink categories	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	0.94	0.95	0.99	1.06	1.11	1.12	1.10	1.05	1.03	0.96
A. Fuel combustion (sectoral approach)	0.94	0.95	0.99	1.06	1.11	1.12	1.10	1.05	1.03	0.96
1 Energy industries	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	0.22	0.22	0.24	0.25	0.26	0.25	0.25	0.25	0.24	0.22
3. Transport	0.61	0.60	0.62	0.65	0.67	0.67	0.65	0.64	0.61	0.60
4. Other sectors	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.10
5. Other										
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
1. Solid fuels	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	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	0.21	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
C. Metal industry										
D. Non-energy products from fuels and solvent use	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	0.21	0.20	0.19	0.18	0.16	0.15	0.14	0.15	0.18	0.18
H. Other										

Greenhouse gas source and sink categories	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)
3. Agriculture	22.48	23.59	24.39	25.16	25.42	25.68	25.42	24.34	24.35	24.18
A. Enteric fermentation										
B. Manure management	0.23	0.24	0.25	0.26	0.27	0.26	0.26	0.27	0.27	0.27
C. Rice cultivation										
D. Agricultural soils	22.23	23.33	24.13	24.89	25.14	25.41	25.14	24.06	24.07	23.89
E. Prescribed burning of savannas	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
F. Field burning of agricultural residues	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.02
G. Liming										
H. Urea application										
I. Other carbon-containing fertilisers										
J. Other										
4. Land use, land-use change and forestry[2]	0.67	0.66	0.64	0.63	0.60	0.59	0.57	0.58	0.53	0.51
A. Forest land	0.56	0.55	0.53	0.51	0.48	0.45	0.43	0.42	0.41	0.40
B. Cropland	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05
C. Grassland	0.08	0.07	0.07	0.07	0.07	0.08	0.09	0.10	0.07	0.06
D. Wetlands	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
F. Other land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
G. Harvested wood products										
H. Other										
5. Waste	0.37	0.37	0.38	0.39	0.39	0.40	0.40	0.40	0.41	0.41
A. Solid waste disposal										
B. Biological treatment of solid waste	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE

Greenhouse gas source and sink categories	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)
C. Incineration and open burning of waste	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Wastewater treatment and discharge	0.37	0.37	0.38	0.38	0.39	0.39	0.39	0.40	0.40	0.40
E. Other										
6. Other *(as specified in summary 1.A)*										
Total CH_4 emissions without CH_4 from LULUCF	24.00	25.11	25.95	26.79	27.08	27.35	27.06	25.94	25.96	25.72
Total CH_4 emissions with CH_4 from LULUCF	24.68	25.77	26.60	27.41	27.68	27.93	27.63	26.51	26.48	26.24
Memo items:										
International bunkers	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.09
Aviation	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Navigation	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03
Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass										
CO_2 captured										
Long-term storage of C in waste disposal sites										
Indirect N_2O	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO
Indirect CO_2[(3)]										

Table A.3: Emissions trends (N_2O – part 3 of 3)

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
1. Energy	0.93	0.91	0.91	0.88	0.86	0.84	29.13
A. Fuel combustion (sectoral approach)	0.93	0.91	0.91	0.88	0.86	0.84	29.06
1. Energy industries	0.03	0.03	0.05	0.03	0.03	0.02	44.03
2. Manufacturing industries and construction	0.23	0.23	0.23	0.23	0.23	0.23	45.33
3. Transport	0.57	0.55	0.52	0.51	0.49	0.47	27.28
4. Other sectors	0.09	0.10	0.10	0.10	0.11	0.10	6.70
5. Other							
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	258.03
1. Solid fuels	NO,NA	NO,NA	NO,NA	NO,NA	NA,NO	NA,NO	0.00
2. Oil and natural gas and other emissions from energy production	0.00	0.00	0.00	0.00	0.00	0.00	258.03
C. CO_2 transport and storage							
2. Industrial processes	0.18	0.18	0.19	0.20	0.20	0.20	–41.33
A. Mineral industry							
B. Chemical industry	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.00
C. Metal industry							
D. Non-energy products from fuels and solvent use	NA	NA	NA	NA	NA	NA	0.00
E. Electronic industry							
F. Product uses as ODS substitutes							
G. Other product manufacture and use	0.18	0.18	0.19	0.20	0.20	0.20	–41.33
H. Other							

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
3. Agriculture	24.60	25.43	26.06	26.16	26.70	26.89	51.19
A. Enteric fermentation							
B. Manure management	0.28	0.29	0.30	0.30	0.31	0.31	70.46
C. Rice cultivation							
D. Agricultural soils	24.30	25.13	25.74	25.84	26.38	26.57	51.06
E. Prescribed burning of savannas	IE	IE	IE	IE	IE	IE	0.00
F. Field burning of agricultural residues	0.02	0.01	0.02	0.02	0.02	0.01	–20.64
G. Liming							
H. Urea application							
I. Other carbon-containing fertilisers							
J. Other							
4. Land use, land-use change and forestry(2)	0.51	0.49	0.47	0.44	0.38	0.34	–42.40
A. Forest land	0.39	0.39	0.37	0.34	0.29	0.26	–38.29
B. Cropland	0.05	0.04	0.04	0.04	0.04	0.04	44.27
C. Grassland	0.06	0.05	0.05	0.05	0.05	0.04	–73.21
D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	1,439.75
E. Settlements	0.00	0.00	0.00	0.00	0.00	0.00	1,100.00
F. Other land	0.01	0.01	0.01	0.01	0.01	0.01	4,685.91
G. Harvested wood products							
H. Other							
5. Waste	0.41	0.41	0.42	0.42	0.43	0.44	32.60
A. Solid waste disposal							
B. Biological treatment of solid waste	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	0.00

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
C. Incineration and open burning of waste	0.00	0.00	0.00	0.00	0.00	0.00	–21.77
D. Wastewater treatment and discharge	0.41	0.41	0.41	0.42	0.43	0.43	33.48
E. Other							
6. Other *(as specified in summary 1.A)*							
Total CH_4 emissions without CH_4 from LULUCF	26.12	26.94	27.57	27.66	28.19	28.36	48.46
Total CH_4 emissions with CH_4 from LULUCF	26.62	27.43	28.04	28.10	28.57	28.70	45.72
Memo items:							
International bunkers	0.09	0.10	0.10	0.10	0.10	0.11	40.89
Aviation	0.06	0.07	0.07	0.07	0.07	0.08	107.46
Navigation	0.03	0.03	0.03	0.03	0.03	0.03	–23.06
Multilateral operations	NO	NO	NO	NO	NO	NO	0.00
CO_2 emissions from biomass							
CO_2 captured							
Long-term storage of C in waste disposal sites							
Indirect N_2O	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	NO,NE,IE	NO,NE,IE	0.00
Indirect CO_2[(3)]							

Note: C = carbon; CO_2 = carbon dioxide; CH_4 = methane; IE = included elsewhere; kt CO_2-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land, land-use change and forestry; N_2O = nitrous oxide; NA = not applicable; NE = not estimated; NO = not occurring; ODS = ozone-depleting substance.

Table A.4: Emissions trends (HFCs, PFCs, SF_6 and NF_3 – three parts)

Table A.4: Emissions trends (HFCs, PFCs, SF_6 and NF_3 – part 1 of 3)

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
Emissions of HFCs and PFCs (kt CO_2-equivalent)	909.95	903.79	461.92	210.33	204.73	207.61	390.50	353.78	273.67	321.48
Emissions of HFCs (kt CO_2-equivalent)	NO,NA	NO,NA	0.04	0.17	18.55	57.87	129.18	132.74	156.35	252.81
HFC-23	NO,NA	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	0.01
HFC-41	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-43-10mee	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-125	NO,NA	NO,NA	NO,NA	NO,NA	0.00	0.00	0.00	0.01	0.01	0.01
HFC-134	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-134a	NO,NA	NO,NA	0.00	0.00	0.01	0.03	0.08	0.06	0.08	0.13
HFC-143	NA	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	0.00	0.01
HFC-152	NA	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	0.00
HFC-161	NA	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	0.00
HFC-236cb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-236ea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-236fa	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-245ca	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
HFC-245fa	NO,NA	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	NO,NA
Unspecified mix of HFCs[4] (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions of PFCs (kt CO_2-equivalent)	909.95	903.79	461.88	210.16	186.18	149.75	261.32	221.04	117.32	68.67
CF_4	0.11	0.10	0.05	0.02	0.02	0.02	0.03	0.02	0.01	0.01
C_2F_6	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_3F_8	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.00	0.00	0.00	0.00	NO,NA
C_4F_{10}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
$c\text{-}C_4F_8$	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C_5F_{12}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C_6F_{14}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
$C_{10}F_{18}$	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
$c\text{-}C_3F_6$	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of PFCs[4] (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions of SF_6 (kt CO_2-equivalent)	19.97	20.86	21.91	22.69	23.43	24.42	24.65	25.58	24.86	24.56
SF_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emissions of NF_3 (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF_3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A.4: Emissions trends (HFCs, PFCs, SF_6 and NF_3 – part 2 of 3)

Greenhouse gas source and sink categories	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)
Emissions of HFCs and PFCs (kt CO_2-equivalent)	313.81	372.15	557.15	766.54	776.54	807.63	932.79	1,013.54	1,084.22	1,145.34
Emissions of HFCs (kt CO_2-equivalent)	246.20	301.54	477.50	642.84	673.78	738.25	831.16	960.75	1,039.53	1,090.82
HFC-23	NO,NA	NO,NA	0.00	0.00	NO,NA	NO,NA	0.00	NO,NA	NO,NA	NO,NA
HFC-32	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02
HFC-41	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-43-10mee	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-125	0.01	0.01	0.03	0.04	0.05	0.06	0.06	0.07	0.08	0.09
HFC-134	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-134a	0.12	0.13	0.16	0.18	0.20	0.19	0.23	0.25	0.27	0.28
HFC-143	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-143a	0.01	0.01	0.03	0.05	0.05	0.06	0.06	0.07	0.08	0.08
HFC-152	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-152a	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
HFC-227ea	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
HFC-236ea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-236fa	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-245ca	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HFC-245fa	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	0.00	0.00	0.00	0.00	0.00	0.00
Unspecified mix of HFCs[(4)] (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink categories	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)
Emissions of PFCs (kt CO_2-equivalent)	67.61	70.61	79.65	123.70	102.76	69.38	101.63	52.79	44.69	54.52
CF_4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
C_2F_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_3F_8	NO,NA	NO,NA	0.00	0.00	0.00	NO,NA	0.00	0.00	0.00	0.00
C_4F_{10}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
$c\text{-}C_4F_8$	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C_5F_{12}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C_6F_{14}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
$C_{10}F_{18}$	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
$c\text{-}C_3F_6$	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of PFCs[4] (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unspecified mix of HFCs and PFCs (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emissions of SF_6 (kt CO_2-equivalent)	20.34	20.82	24.11	26.40	29.72	25.96	21.89	20.74	20.23	23.48
SF_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emissions of NF_3 (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NF_3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A.4: Emissions trends (HFCs, PFCs, SF_6 and NF_3 – part 3 of 3)

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
Emissions of HFCs and PFCs (kt CO_2-equivalent)	1,206.23	1,406.12	1,409.76	1,439.74	1,463.78	1,582.09	73.87
Emissions of HFCs (kt CO_2-equivalent)	1,158.82	1,370.97	1,362.30	1,391.62	1,390.37	1,523.50	100.00
HFC-23	0.00	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.00
HFC-32	0.02	0.04	0.03	0.04	0.03	0.04	100.00
HFC-41	NA	NA	NA	NA	NA	NA	0.00
HFC-43-10mee	NA	NA	NA	NA	NA	NA	0.00
HFC-125	0.10	0.12	0.12	0.12	0.12	0.13	100.00
HFC-134	NA	NA	NA	NA	NA	NA	0.00
HFC-134a	0.29	0.36	0.36	0.38	0.37	0.41	100.00
HFC-143	NA	NA	NA	NA	NA	NA	0.00
HFC-143a	0.09	0.09	0.09	0.09	0.09	0.10	100.00
HFC-152	NA	NA	NA	NA	NA	NA	0.00
HFC-152a	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.00
HFC-161	NA	NA	NA	NA	NA	NA	0.00
HFC-227ea	0.00	0.00	0.00	0.00	0.00	0.00	100.00
HFC-236cb	NA	NA	NA	NA	NA	NA	0.00
HFC-236ea	NA	NA	NA	NA	NA	NA	0.00
HFC-236fa	NA	NA	NA	NA	NA	NA	0.00
HFC-245ca	NA	NA	NA	NA	NA	NA	0.00
HFC-245fa	0.00	0.00	0.00	0.00	0.00	0.00	100.00
HFC-365mfc	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Unspecified mix of HFCs(4) (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	0.00

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
Emissions of PFCs (kt CO_2-equivalent)	47.41	35.15	47.46	48.13	73.41	58.59	–93.56
CF_4	0.01	0.00	0.01	0.01	0.01	0.01	–93.75
C_2F_6	0.00	0.00	0.00	0.00	0.00	0.00	–92.46
C_3F_8	NO,NA	0.00	0.00	0.00	0.00	0.00	100.00
C_4F_{10}	NA	NA	NA	NA	NA	NA	0.00
c-C_4F_8	NA	NA	NA	NA	NA	NA	0.00
C_5F_{12}	NA	NA	NA	NA	NA	NA	0.00
C_6F_{14}	NA	NA	NA	NA	NA	NA	0.00
$C_{10}F_{18}$	NA	NA	NA	NA	NA	NA	0.00
c-C_3F_6	NA	NA	NA	NA	NA	NA	0.00
Unspecified mix of PFCs(4) (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	0.00
Unspecified mix of HFCs and PFCs (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	0.00
Emissions of SF_6 (kt CO_2-equivalent)	23.85	19.97	22.38	19.92	18.13	17.85	–10.61
SF_6	0.00	0.00	0.00	0.00	0.00	0.00	–10.61
Emissions of NF_3 (kt CO_2-equivalent)	NA	NA	NA	NA	NA	NA	0.00
NF_3	NA	NA	NA	NA	NA	NA	0.00

Note: HFCs = hydrofluorocarbons; kt CO_2-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land, land-use change and forestry; NF_3 = nitrogen trifluoride; NA = not applicable; NO = not occurring; PFCs = perfluorocarbons; SF_6 = sulphur hexafluoride.

Table A.5: Emissions trends summary (three parts)

Table A.5: Emissions trends summary (part 1 of 3)

Greenhouse gas source and sink categories	Base year (1990)(1) (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)	1999 (kt CO_2-equivalent)
CO_2 emissions without net CO_2 from LULUCF	25,428.64	26,116.59	28,107.90	27,705.40	27,887.47	28,151.65	29,374.88	31,355.60	29,934.03	31,528.93
CO_2 emissions with net CO_2 from LULUCF	–4,964.09	–6,268.47	–3,778.59	–4845.38	–4,727.06	–3,008.72	–1,371.03	–395.09	–2,251.82	–2,230.43
CH_4 emissions without CH_4 from LULUCF	32,522.20	32,734.98	32,433.48	32,469.35	33,182.56	33,597.24	34,209.58	34,835.42	34,130.15	34,437.13
CH_4 emissions with CH_4 from LULUCF	32,615.40	32,814.52	32,522.36	32,573.08	33,286.78	33,708.98	34,332.60	34,946.24	34,267.34	34,528.74
N_2O emissions without N_2O from LULUCF	5,693.06	5,782.31	5,844.30	6,036.37	6,224.70	6,466.83	6,592.70	6,751.82	6,657.63	6,737.22
N_2O emissions with N_2O from LULUCF	5,870.20	5,957.41	6,022.20	6,220.59	6,417.82	6,663.65	6,796.75	6,957.38	6,865.47	6,938.93
HFCs	NO,NA	NO,NA	0.04	0.17	18.55	57.87	129.18	132.74	156.35	252.81
PFCs	909.95	903.79	461.88	210.16	186.18	149.75	261.32	221.04	117.32	68.67
Unspecified mix of HFCs and PFCs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6	19.97	20.86	21.91	22.69	23.43	24.42	24.65	25.58	24.86	24.56
NF_3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (without LULUCF)	64,573.82	65,558.53	66,869.50	66,444.14	67,522.89	68,447.75	70,592.31	73,322.21	71,020.33	73,049.33
Total (with LULUCF)	34,451.43	33,428.11	35,249.79	34,181.32	35,205.70	37,595.94	40,173.47	41,887.90	39,179.52	39,583.29
Total (without LULUCF, with indirect)	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

Greenhouse gas source and sink categories	Base year (1990)[1] (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)	1999 (kt CO_2-equivalent)
1. Energy	23,748.50	24,139.60	26,041.18	25,475.07	25,761.91	25,869.80	27,360.01	29,298.53	27,761.83	29,193.18
2. Industrial processes and product use	3,584.36	3,733.12	3,378.42	3,217.91	3,098.38	3,209.34	3,427.85	3,297.90	3,267.12	3,478.87
3. Agriculture	33,122.91	33,470.95	33,148.65	33,363.55	34,340.01	34,983.73	35,357.75	36,232.68	35,472.84	35,822.43
4. Land use, land-use change and forestry[5]	–30,122.39	–32,130.42	–31,619.71	–32,262.82	–32,317.20	–30,851.81	–30,418.84	–31,434.31	–31,840.82	–33,466.05
5. Waste	4,118.05	4,214.87	4,301.26	4,387.61	4,322.58	4,384.88	4,446.70	4,493.09	4,518.55	4,554.86
6. Other										
Total (including LULUCF)[5]	34,451.43	33,428.11	35,249.79	34,181.32	35,205.70	37,595.94	40,173.47	41,887.90	39,179.52	39,583.29

Table A.5: Emissions trends summary (part 2 of 3)

Greenhouse gas source and sink categories	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	32,358.64	34,587.07	34,768.50	36,495.10	36,060.32	37,642.41	37,515.69	36,645.12	37,666.27	34,791.66
CO_2 emissions with net CO_2 from LULUCF	–297.12	2,554.22	5,150.35	5,756.31	5,333.00	8,512.04	10,027.34	11,254.84	3,768.23	4,233.72
CH_4 emissions without CH_4 from LULUCF	35,297.09	35,492.76	35,436.59	35,659.08	35,593.17	35,868.57	36,017.47	34,759.87	33,698.96	34,083.69
CH_4 emissions with CH_4 from LULUCF	35,383.83	35,578.86	35,521.67	35,751.35	35,682.60	36,006.97	36,165.62	34,955.85	33,786.05	34,195.44
N_2O emissions without N_2O from LULUCF	7,152.93	7,482.43	7,733.26	7,982.79	8,070.39	8,149.12	8,063.09	7,729.55	7,735.11	7,665.89
N_2O emissions with N_2O from LULUCF	7,353.59	7,679.83	7,925.42	8,169.49	8,248.64	8,324.17	8,233.39	7,901.26	7,892.51	7,818.87
HFCs	246.20	301.54	477.50	642.84	673.78	738.25	831.16	960.75	1,039.53	1,090.82
PFCs	67.61	70.61	79.65	123.70	102.76	69.38	101.63	52.79	44.69	54.52
Unspecified mix of HFCs and PFCs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6	20.34	20.82	24.11	26.40	29.72	25.96	21.89	20.74	20.23	23.48
NF_3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (without LULUCF)	75,142.80	77,955.23	78,519.60	80,929.90	80,530.14	82,493.69	82,550.94	80,168.82	80,204.79	77,710.07
Total (with LULUCF)	42,774.45	46,205.88	49,178.70	50,470.09	50,070.49	53,676.77	55,381.04	55,146.23	46,551.24	47,416.85
Total (without LULUCF, with indirect)	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

Greenhouse gas source and sink categories	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	30,001.99	32,077.51	32,100.95	33,590.91	33,126.33	34,573.81	34,740.10	33,453.64	34,858.78	32,116.59
2. Industrial processes and product use	3,462.02	3,566.33	3,758.25	4,059.64	4,054.91	4,112.67	4,205.67	4,486.56	4,355.01	4,297.28
3. Agriculture	37,067.47	37,647.73	37,954.36	38,623.31	38,676.52	39,114.55	38,989.67	37,631.20	36,460.77	36,815.92
4. Land use, land-use change and forestry(5)	–32,368.35	–31,749.35	–29,340.90	–30,459.81	–30,459.65	–28,816.92	–27,169.90	–25,022.59	–33,653.55	–30,293.22
5. Waste	4,611.31	4,663.67	4,706.04	4,656.04	4,672.38	4,692.65	4,615.49	4,597.43	4,530.23	4,480.27
6. Other										
Total (including LULUCF)(5)	42,774.45	46,205.88	49,178.70	50,470.09	50,070.49	53,676.77	55,381.04	55,146.23	46,551.24	47,416.85

Table A.5: Emissions trends summary (part 3 of 3)

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
CO_2 emissions without net CO_2 from LULUCF	35,017.74	34,332.22	35,654.67	35,086.94	35,584.98	35,911.43	41.22
CO_2 emissions with net CO_2 from LULUCF	4,142.31	7,946.72	9,945.64	10,724.05	11,594.78	11,947.43	–340.68
CH_4 emissions without CH_4 from LULUCF	34,046.81	34,165.81	34,626.37	34,608.32	34,800.29	34,191.91	5.13
CH_4 emissions with CH_4 from LULUCF	34,157.05	34,245.24	34,710.96	34,686.03	34,880.10	34,271.26	5.08
N_2O emissions without N_2O from LULUCF	7,782.56	8,027.00	8,216.36	8,242.24	8,400.69	8,451.85	48.46
N_2O emissions with N_2O from LULUCF	7,933.54	8,174.40	8,357.31	8,372.43	8,515.12	8,553.88	45.72
HFCs	1,158.82	1,370.97	1,362.30	1,391.62	1,390.37	1,523.50	100.00
PFCs	47.41	35.15	47.46	48.13	73.41	58.59	–93.56
Unspecified mix of HFCs and PFCs	NA	NA	NA	NA	NA	NA	0.00
SF_6	23.85	19.97	22.38	19.92	18.13	17.85	–10.61
NF_3	NA	NA	NA	NA	NA	NA	0.00
Total (without LULUCF)	78,077.20	77,951.12	79,929.55	79,397.17	80,267.87	80,155.14	24.13
Total (with LULUCF)	47,462.99	51,792.44	54,446.07	55,242.18	56,471.91	56,372.51	63.63
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	0.00
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	0.00

Greenhouse gas source and sink categories	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)	Change from base to latest reported year %
1. Energy	32,184.55	31,272.51	32,466.20	31,906.16	32,269.10	32,455.18	36.66
2. Industrial processes and product use	4,655.46	4,826.41	4,811.47	4,925.18	5,067.03	5,279.68	47.30
3. Agriculture	36,861.67	37,590.15	38,460.38	38,450.41	38,847.04	38,419.63	15.99
4. Land use, land-use change and forestry[5]	–30,614.21	–26,158.68	–25,483.48	–24,154.99	–23,795.96	–23,782.63	–21.05
5. Waste	4,375.52	4,262.05	4,191.51	4,115.43	4,084.71	4,000.66	–2.85
6. Other							
Total (including LULUCF)[5]	47,462.99	51,792.44	54,446.07	55,242.18	56,471.91	56,372.51	63.63

Note: CO_2 = carbon dioxide; CH_4 = methane; HFCs = hydrofluorocarbons; kt CO_2-equivalent = kilotonnes of carbon dioxide equivalent; LULUCF = land, land-use change and forestry; N_2O = nitrous oxide; NA = not applicable; NF_3 = nitrogen trifluoride; NO = not occurring; PFCs = perfluorocarbons; SF_6 = sulphur hexafluoride.

(1) The column 'Base year' should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the Conference of Parties. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

(2) Fill in net emissions/removals as reported in table summary 1.A. For the purposes of reporting, the signs for removals are always negative (–) and for emissions positive (+).

(3) In accordance with the UNFCCC reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

(4) In accordance with the UNFCCC reporting guidelines, HFC and PFC emissions should be reported for each relevant chemical. However, if it is not possible to report values for each chemical (ie, mixtures, confidential data, lack of disaggregation), this row could be used for reporting aggregate figures for HFCs and PFCs, respectively. Note that the unit used for this row is kt of CO_2-equivalent and that appropriate notation keys should be entered in the cells for the individual chemicals.

(5) Includes net CO_2, CH_4 and N_2O from LULUCF.

Annex B: Supplementary information under Article 7.2 of the Kyoto Protocol

New Zealand's national inventory system: Supplementary information under Article 7.2 of the Kyoto Protocol

Overview

The Climate Change Response Act 2002 (updated 26 September 2012) was enacted to enable New Zealand to meet its international obligations under 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 prepares its greenhouse gas inventory.

A prime ministerial directive for the administration of the Climate Change Response Act 2002 names the Ministry for the Environment as New Zealand's 'inventory agency'. The Ministry for the Environment is responsible for the overall development, compilation and submission of the *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 management for 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, the Ministry for the Environment (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 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 the Environmental Protection Authority (EPA), the Ministry for Primary Industries (MPI) and the Ministry of Business, Innovation and Employment (MBIE). The main roles and expectations of RGG include:

- guiding, conferring on and approving inventory and emissions projection improvements and assumptions (on the basis of advice from technical experts), planning and priorities, key messages, management of stakeholders and risks
- focusing on delivery of reporting commitments to meet national and international requirements
- providing reporting leadership and guidance to analysts, modellers and technical specialists
- sharing information, providing feedback and resolving any differences between departments that impact on the delivery of the work programme
- monitoring and reporting to the Climate Change Directors Group (a cross-agency group that oversees New Zealand's international and domestic climate change policy) on the 'big picture' of the reporting work programme, direction, progress in delivery and capability to deliver.

MfE is New Zealand's single national entity for the inventory. It 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 a greater understanding of the reporting requirements has been attained.

As well as its overall inventory coordination role, MfE compiles emissions estimates for the industrial processes and product use (IPPU) sector (carbon dioxide (CO_2) data provided by MBIE and non-CO_2 gases 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 within the LULUCF sector. It undertakes land-use mapping from satellite imagery to report on emissions and removals for 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-CO_2 emissions collected through surveys of the sector.

MBIE estimates all emissions from the energy sector and CO_2 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, Statistics New Zealand.

Statistics New Zealand also provides population census data for producing the waste and IPPU sectors' emissions estimates.

The Ministry of Foreign Affairs and Trade provides information on the minimisation of adverse impacts 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.[421] Refer to chapter 12 of the inventory report[422] for further information.

Statistics New Zealand provides many of the official statistics for the agricultural sector through regular agricultural censuses and surveys. Population (human) census data from Statistics New Zealand are used in the waste and industrial processes and product use sector.

Consultants are used to provide essential data for the IPPU, waste, agriculture and LULUCF sectors of the inventory.

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 responsible for Climate Change Issues. 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
- Ombudsman Act 1975
- Public Records Act 2005
- Crown Entities Act 2004.

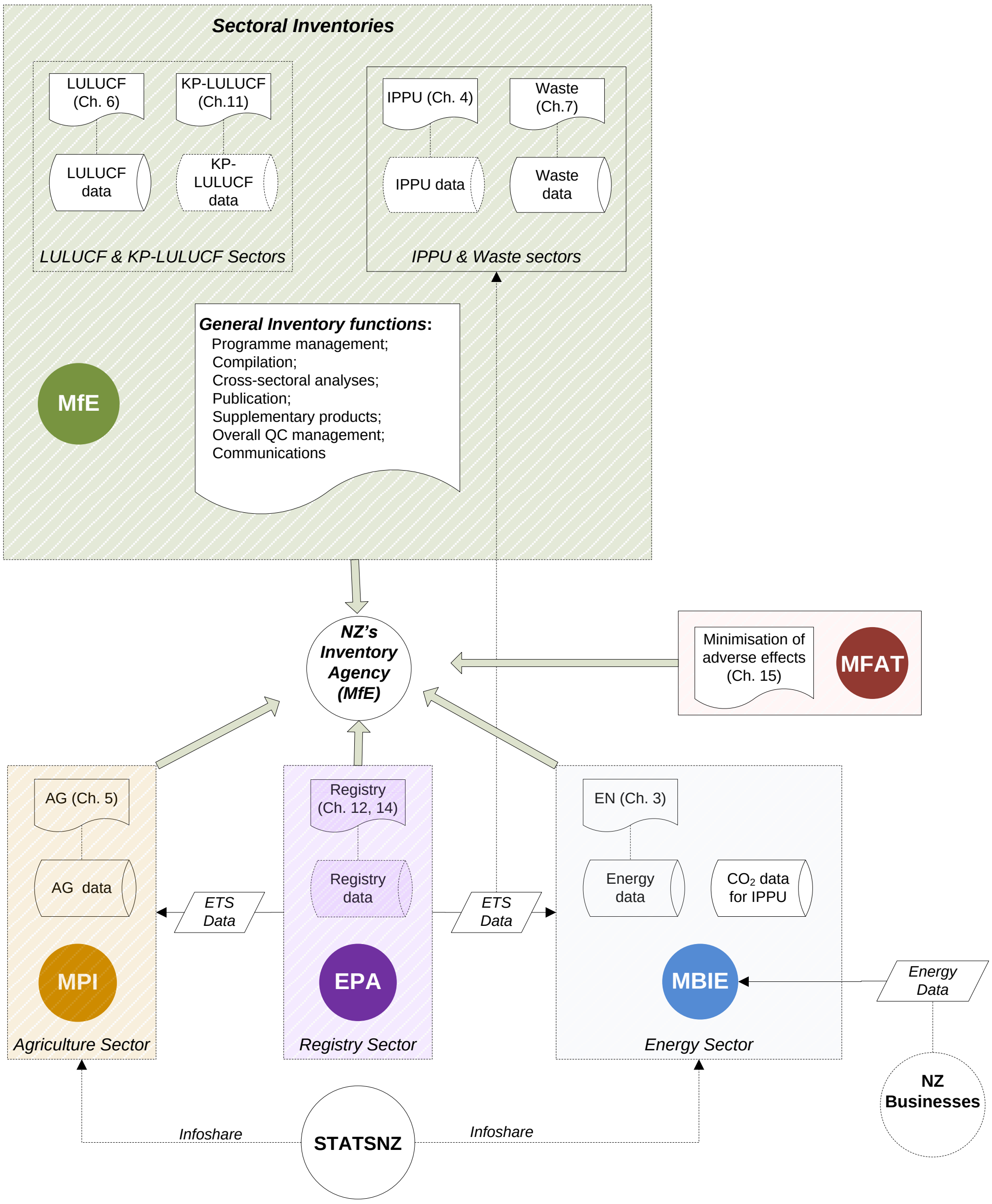
Contractors for the annual *Greenhouse Gas Inventory* are selected for being experts in their fields. Although it is preferable to use the same contractor each year, contractors are reviewed regularly, depending on the terms of each specific contract. Through this competitive process the best contractor is selected, ensuring inventory data are of the highest quality in accordance with 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines.

Figure B.1 shows the specific responsibilities of different agencies involved in the inventory production as well as their contribution to the inventory submission.

421 https://emissionsregister.govt.nz

422 Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Retrieved from www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/nzs-greenhouse-gas-inventory.

Figure B.1: New Zealand's inventory system at a glance: how different agencies are involved



Note: AG = agriculture; EN = energy; EPA = Environmental Protection Authority; ETS = Emissions Trading Scheme; IPPU = industrial processes and product use; KP-LULUCF = Kyoto Protocol land use, land-use change and forestry; 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; MPI = Ministry for Primary Industries; QC = quality control; STATSNZ = Statistics New Zealand.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

Changes to arrangements

No changes have been made in the legal or institutional arrangements in the National Inventory System since the *Second Biennial Report* and *Sixth National Communication* were submitted in December 2015 and December 2013 respectively.

Although there were no major changes in the structure of the national system, operational improvements designed to improve the quality of *New Zealand's National Inventory Report*

(NIR) 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 *First Biennial Report* and *Sixth National Communication* were submitted, improvements in the inventory have focused on:

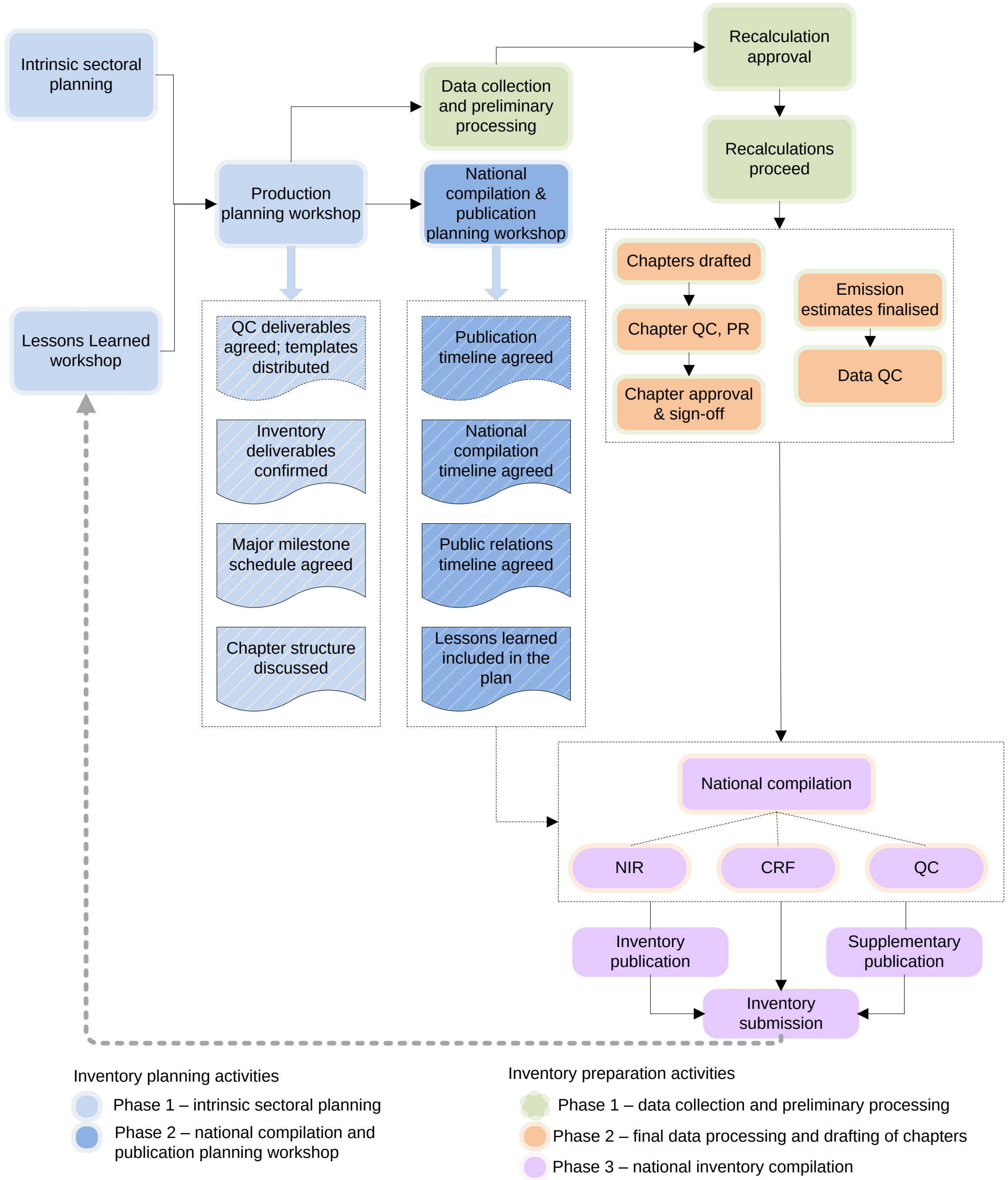
- significant mandatory changes and improvements as part of adopting the IPCC 2006 guidelines.[423] First applied in the inventory published in 2015, these included changing to the web-based CRF Reporter software
- additional improvements to the accuracy of emissions and removals in all five sectors
- the review of the Terms of Reference for the Reporting Governance Group, which is responsible for approving all changes, improvements and major recalculations in the inventory
- updated quality control (QC) processes and procedures for sectors
- design and development of computerised QC tools to ensure better quality of the CRF tables and comparability between the NIR and the CRF
- developing the expertise of inventory officials
- inventory officials undertaking reviewer training under the UNFCCC for expert reviews of annual greenhouse gas inventories prepared using the 2006 IPCC Guidelines.

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 data to be collected and analysed. Figure B.2 summarises New Zealand's inventory preparation cycle.

[423] The IPCC 2006 Guidelines for National Inventories as decided at the UNFCCC Conference of the Parties in Warsaw, November 2013 (Decision 24/CP.19).

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. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

The inventory preparation cycle has three phases: data collection and preliminary processing, final data processing and chapter preparation, and the inventory compilation.

The first phase, data collection and preliminary processing (June–October), includes data cleansing, data checks and preliminary formatting of data for further use. This phase may also include analysis of potential improvements and related recalculations involved in the inventory.

The second phase of the inventory preparation (October–January) includes final data processing and drafting of chapters. During this phase, emissions estimates are finalised, final data quality control and verification is performed, data are loaded into the CRF Reporter and sectoral chapters are updated, reviewed and approved.

The final phase of the inventory preparation (February–April) includes cross-sectoral analyses, national inventory compilation and publication, as well as producing supplementary materials for the Minister for Climate Change Issues and the general public.

The inventory is reviewed within MfE, MBIE, MPI and EPA before being approved and submitted to the UNFCCC secretariat.

During the inventory planning and preparation cycle, the National Inventory Compiler has regular meetings with sector leads and experts to ensure that all issues are addressed and the production process goes as planned. The inventory QC Manager also has regular meetings with sector leads to monitor QC processes and procedures that are in place to ensure the quality of the final product meets the UNFCCC standards and the QC deliverables are produced according to the agreed plan. Both the National Inventory Compiler and the QC Manager provide technical support and advice to the sector leads when required.

The inventory and all required data for the submission to the UNFCCC secretariat are stored on MfE's central computer network in a controlled filing system. The inventory submission is available from the websites of both MfE and the UNFCCC.

Activity data, emission factors and methods

The guiding documents in the inventory's preparation are the:

- *2006 IPCC Guidelines for National Greenhouse Gas Inventories*[424]
- *Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*[425]
- revised *UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention*[426]
- Kyoto Protocol[427, 428]

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424 IPCC. 2006. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe (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.

425 IPCC. 2014. T Hiraishi, T Krug, K Tanabe, N Srivastava, J Baasansuren, et al (eds). *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*. Geneva, Switzerland: IPCC.

426 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*.

427 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.*

428 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.*

- decisions 3/CMP.11 and 4/CMP.11 that cover a range of reporting and review issues[429, 430]
- guidelines on reporting and review.[431]

The concepts contained in the good practice guidance 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.[432] 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.

- 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.

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429 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.*

430 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.*

431 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)*.

432 IPPC. 2006. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe (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.

Methodology for each sector in the inventory is described briefly in the sections below. Refer to each sector chapter in the NIR[433] for more detail.

Energy

Greenhouse gas emissions from the energy sector are calculated using a detailed sectoral approach. This bottom-up approach is based on energy demand; it involves processing energy data collected on a regular basis through various surveys. For verification, New Zealand has also applied the IPCC reference approach to estimate CO_2 emissions from fuel combustion for the time series 1990–2015 (see annex 4 in the inventory report).[434]

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 2015*.[435] Note that due to the time interval between the publication of *Energy in New Zealand* and the preparation of this submission, some data revisions may have occurred. See chapter 3 of the inventory report[436] for further details on methodologies applied in the energy sector and 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, where only one or two companies in New Zealand are involved, activity data are reported as confidential in the CRF tables. Also, emissions data for the *Glass production* category are aggregated under the *Other process uses of carbonates* category to preserve confidentiality. Similarly, data on emissions from hydrogen making at the Marsden Point oil refinery are reported in the *Chemical industry* source category, which allows data from New Zealand's only industrial hydrogen making process to be aggregated and kept confidential.

For the *Product uses as substitutes for ODS (*ozone-depleting substances) source category, updated activity data are obtained by a detailed annual survey covering the electrical, refrigeration and other industry participants as well as importers of hydrofluorocarbons (HFCs) and other substances in this source category.

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433 Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Retrieved from www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/nzs-greenhouse-gas-inventory.

434 Ibid.

435 Ministry of Business, Innovation and Employment. 2016. *Energy in New Zealand 2015*. Wellington: Ministry of Business, Innovation and Employment.

436 Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Retrieved from www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/nzs-greenhouse-gas-inventory.

New Zealand uses a combination of Tier 1 and Tier 2 methodologies 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. Emissions and activity data have been extrapolated for the years since 2006.

Country-specific emission factors have been used where available, including for emissions of indirect greenhouse gases.

Agriculture

The Tier 2 methodology with country-specific emission factors developed by New Zealand uses detailed data on livestock population and productivity to calculate livestock energy requirements for the major livestock categories. Animal population census data are collected by Statistics New Zealand every five years (through the Agricultural Production census) and survey statistics annually between censuses (through the Agricultural Production survey). Productivity data are available from the Livestock Improvement Corporation (dairy statistics), non-government industry organisations such as Beef and Lamb New Zealand and Deer Industry New Zealand, which regularly collect animal sector statistics. Statistics on animal carcass weights are collected by MPI. Livestock population data are obtained from Statistics New Zealand through the Agricultural Production census and surveys. Slaughter statistics are collected by MPI and are used as a proxy to establish changes in animal liveweight over time.

Other livestock species (*Swine*, *Goats*, *Horses*, *Llamas and alpacas*, *Mules and asses*, and *Poultry* – referred to as 'minor' livestock categories) account for only 0.5 per cent of New Zealand's agriculture emissions. Emissions from these minor livestock species are generally estimated using Tier 1 methods but, where information is available, New Zealand has used country-specific emissions methods and factors.

For estimating emissions from *Agricultural soils*, New Zealand uses methodologies based on the IPCC Guidelines, as well as the outputs of the Tier 2 livestock population characterisation and modelling of the livestock nutrition and energy requirements. New Zealand uses a combination of default and country-specific emission factors and parameters to calculate nitrous oxide (N_2O) emissions from *Agricultural soils*. Details on these emission factors and parameters are listed in tables 5.5.2 and 5.5.3; in tables A3.1.2.3 and A3.1.2.4; and in table 5.5.4 for mitigation technologies.

Activity data on the *Liming* category are obtained from Statistics New Zealand and data on synthetic fertiliser containing nitrogen are provided by the New Zealand Fertiliser Association. A Tier 2 (model) approach is used to calculate emissions from burning of agricultural residues. There is no rice cultivation in New Zealand and no CO_2 emissions from other carbon-containing fertilisers.

Land use, land-use change and forestry

New Zealand uses a combination of Tier 1, 2 and 3 methodologies for estimating emissions and removals for the LULUCF sector under the Convention and Article 3.3 and Article 3.4 activities under the Kyoto Protocol. Tier 2 or Tier 3 approaches have been used to estimate biomass carbon in the pools with the most living biomass at steady state; *Pre-1990 natural forest*, *Pre-1990 planted forest*, *Post-1989 forest*, *Perennial cropland* and *Grassland with woody* *biomass*. For all other land-use categories, a Tier 1 approach is used for estimating biomass carbon. A Tier 2 modelling approach has also been used to estimate carbon changes in the mineral soil component of the soil organic matter pool, while Tier 1 is used for organic soils.

New Zealand has established a data collection and modelling programme for the LULUCF sector called the Land Use and Carbon Analysis System (LUCAS). The LUCAS programme includes the:

- use of field plot measurements for natural and planted forests
- use of allometric equations and models to estimate carbon stock and carbon stock change in natural and planted forests respectively[437]
- wall-to-wall land-use mapping for 1990, 2008 and 2012 using satellite and aircraft remotely sensed imagery, with additional information on post-1989 forest afforestation and deforestation of planted forest used for estimating change
- development of databases and applications to store and process all data associated with LULUCF activities.

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 it was available (2010 onwards). Activity data for all other sources were based on specific surveys. Interpolation based on gross domestic product 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 in the waste sector.

Country-specific emission factors have been used where available, including parameters for municipal waste and for treatment of some types of industrial wastewater.

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.[438]

Key categories identified within the inventory are used to prioritise inventory improvements.

As some categories in the inventory apply default uncertainty values for emission 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)

[437] Holdaway et al., unpublished; Beets et al., unpublished; Paul et al., unpublished.

[438] IPPC. 2006. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe (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.

methodologies from the 2006 IPCC Guidelines.[439] 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 2015, or the trend of emissions.

The key categories identified in the 2015 year are summarised in appendix B, table B.1. 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 NIR 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
- activity data and emission factors that became available for certain sources that were previously reported as not estimated (NE) because of insufficient data.

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. For the 2010 inventory submission and beyond, all recalculations are required to be approved through a recalculations approval form before changes are made to the inventory data tables.

[439] IPCC. 2006. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe (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.

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. MfE developed a QA/QC plan in 2004, as required by the reporting guidelines under the UNFCCC[440] to formalise, document and archive the QA/QC procedures. Details of the QA/QC activities performed during the compilation of the 2017 submission are discussed in the relevant sections of the inventory.[441] 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 (TACCC) 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. Reviews are performed by qualified personnel, and the review records are included in the submission of the inventory to the United Nations Framework Convention on Climate Change. These reviews act as a source of ideas for inventory improvements.
QC 1	Planned recalculations and improvements are approved by the Reporting Governance Group that oversees all climate change reporting by the New Zealand Government. The role of this group is further described in chapter 1 of the NIR.
QC 2	Planned improvements are peer reviewed prior to being implemented when they affect the emission factor, parameter, methodology or activity data source. This is superseded in sectors that have a dedicated panel.
QC 3	Tier 1 checklist QC sheets are completed to ensure transparency, accuracy, completeness, comparability and consistency (TACCC) principles are met. Examples are included in the submission of the inventory.
QC 4	The chapter text for each sector is peer reviewed and follows the checklist provided to ensure that the peer review is comprehensive and consistent.
QC 5	Recalculations that exceed a certain threshold (see figure A6.1.1 of the NIR) are analysed and clearly documented. This includes changes resulting from planned improvements, errors, recommendations from the expert review team, and changes to guidelines.
QC 6	Automated checks are performed in the common reporting format web tool to ensure completeness of the entire time series.

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440 IPPC. 2006. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe (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.

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*.

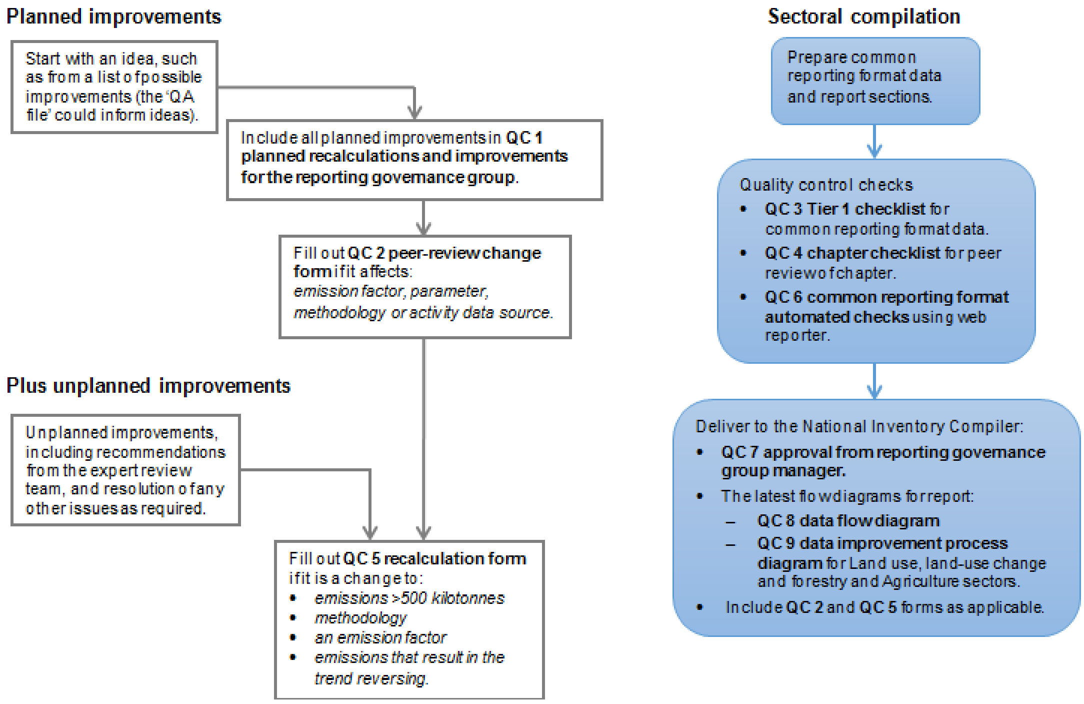
441 Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Retrieved from www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/nzs-greenhouse-gas-inventory.

ID	QA/QC process or activity description
QC 7	All chapters in the inventory are approved by members of the Reporting Governance Group that oversees all climate change reporting by the New Zealand Government.
QC 8	Data flow and QC processes are documented and mapped for each sector and the maps are updated as required. These maps identify when QC is happening in the process, to what data, the type of check and who is responsible.
QC 9	The diagram of the data improvement process depicts the process to approve data improvements via a panel. This also applies to the agriculture sector and the land use, land-use change and forestry sector.

Source: Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* 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. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Wellington: Ministry for the Environment.

New Zealand's greenhouse gas inventory QA/QC plan has been designed to improve the transparency, consistency, comparability, completeness and accuracy of New Zealand's annual Greenhouse Gas Inventory in order to align with IPCC good practice. The plan closely follows the definitions, guidelines and processes presented in chapter 8 of the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*.[442] New Zealand's plan is an open document and is subject to modification and improvement when changes in processes are updated, or on advice from independent reviewers.

[442] IPCC. 2000. J Penman, D Kruger, I Galbally, T Hiraishi, B Nyenzi, et al (eds). *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.* Hayama: Institute of Global Environmental Strategies.

The QA/QC plan is intended to ensure transparency and the 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 Greenhouse Gas 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 QC plan is to meet the TACCC principles (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 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 the IPCC 2006 Tier 1 QC check sheets for each sector is the responsibility of the sector leads. The Tier 1 checks are based on the procedures suggested in the 2006 IPCC Guidelines.[443] 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 were entered into the web-based CRF database by sector compilers by 15 February 2017, with a possibility of further updates. The additional flexibility compared

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443 IPPC. 2006. HS Eggleston, L Buendia, K Miwa, T Ngara, K Tanabe (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.

with the previous year is to allow time for the agencies leading each sector to complete their own QC activities and accommodate the changes in sectoral compilation plans due to disruptions resulting from the Kaikōura earthquake (November 2016).

The sectoral contributions to the inventory and Tier 1 QC checks were signed off by the responsible agency before final approval of the inventory and submission to the UNFCCC.

MfE used 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 were also checked for anomalies, errors and omissions.

The energy and agriculture activity data provided by Statistics New Zealand 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 quality assurance are explained in detail below.

All sector leads are encouraged to schedule QA audits of their systems at least every five years. The agriculture sector commenced a major QA review of its calculation models with an external party in 2012 (for additional details, see sections 5.1.4 and 5.1.5 of the 2015 inventory submission). In 2013–14 a comprehensive QA review of estimates from non-municipal landfills in the waste sector was undertaken. In 2014–15 external contractors completed a review of estimation methods for the *Industrial wastewater* category in the waste sector.[444] In 2016–17 an expert study of non-energy fuel use in the IPPU sector has been undertaken. The results of the review were used during compilation of the IPPU sector data in 2017.

Discussions with inventory experts from the Austrian inventory agency (Environment Agency Austria) were held as part of the preparation process for the 2017 submission. These were mostly focused on QA/QC arrangements of both Parties. The main points of the discussions included further development of quantitative QC objectives, automated QC tools, automating consistency checks between the CRF and the NIR, the main challenges involved in delivering the inventory under the 2006 IPCC Guidelines, and confidentiality issues for the inventory.

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 2017 inventory submission, see and annex 6 of the NIR.[445]

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[444] Cardno. 2015. Greenhouse gas emissions from industrial wastewater treatment. Unpublished report commissioned by the Ministry for the Environment.

[445] Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Retrieved from www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/nzs-greenhouse-gas-inventory.

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 Tier 1 and 2 QC checks have been completed
- the results of the QC checks have been included in the appropriate Excel tables
- QA exercises have been completed
- mandatory checks in the CRF software are complete for all sectors.

Before submitting the inventory to the UNFCCC secretariat, internal review is undertaken by staff within the Ministry for the Environment who have not been involved in the inventory compilation process.

The UNFCCC annual inventory review

New Zealand's inventory was reviewed[446] 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 2007–2009 and 2011–12 inventory submissions were reviewed during centralised reviews, as were the 2011–15 submissions. The 2010 inventory submission was subject to an in-country review in August–September 2010. The review report for the 2015 inventory submission under the Kyoto Protocol and 2016 inventory submission were not fully completed at the time of finalising the 2017 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 UNFCCC Roster of Experts.

Because of New Zealand's consistency in meeting 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. New Zealand's registry holding official records of transactions and balance of New Zealand's 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 team compiling the inventory within the Ministry for the Environment. The final approval is by the director who is the designated management sign-off individual for the Chief Executive Officer at the Ministry for the Environment.

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[446] The review reports for each review event mentioned in this section are published by the UNFCCC and can be retrieved from http://unfccc.int/national_reports/annex_i_ghg_inventories/inventory_review_reports/items/6616.php.

National registry

Overview

The New Zealand Emissions Trading Register (the Register) went live on the weekend of 27 August 2016. The Register replaced New Zealand's Emission Unit Register (NZEUR), which had been operational since December 2007. The Register is New Zealand'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.

The Register is currently managed by the Environmental Protection Authority, 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, and holding accounts in the registry systems of other Parties to the Kyoto Protocol. 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 Kyoto Units and other information between the Register and other official overseas registries via the International Transaction Log (ITL) under the Kyoto Protocol[447]
- 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 2016. The report was submitted to the UNFCCC secretariat as part of the national inventory submission package in 2017.

In January 2008 New Zealand's national registry was issued with New Zealand's assigned amount of 309,564,733 metric tonnes of CO_2 equivalents.

In July 2015 New Zealand's 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 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 New Zealand's 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.

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[447] Since 18 November 2015 the international transfer of first commitment period Kyoto Units has not been allowed. New Zealand is unable to receive second commitment period Kyoto Units other than directly from the UN Clean Development Mechanism.

The number of Kyoto Units held in New Zealand's national registry did not change during 2016. At the beginning and end of 2016 New Zealand's 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	*Environmental Protection Authority* Private Bag 63002, Wellington 6140, New Zealand Phone: +64 4 916 2426 Fax: +64 4 914 0433 Web: www.epa.govt.nz
Main contact	*Guy Windley* Team Leader, Registry Operations, Emissions Trading Scheme, Climate Land and Oceans Group, Environmental Protection Authority Phone: + 64 4 474 5514
Alternative contact	*Justin Bloomfield* Systems Analyst, Information Technology, Finance and Systems Group, Environmental Protection Authority Phone: + 64 4 474 5435

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 1990–2015* at: www.mfe.govt.nz/node/23304.

National registry: a detailed description

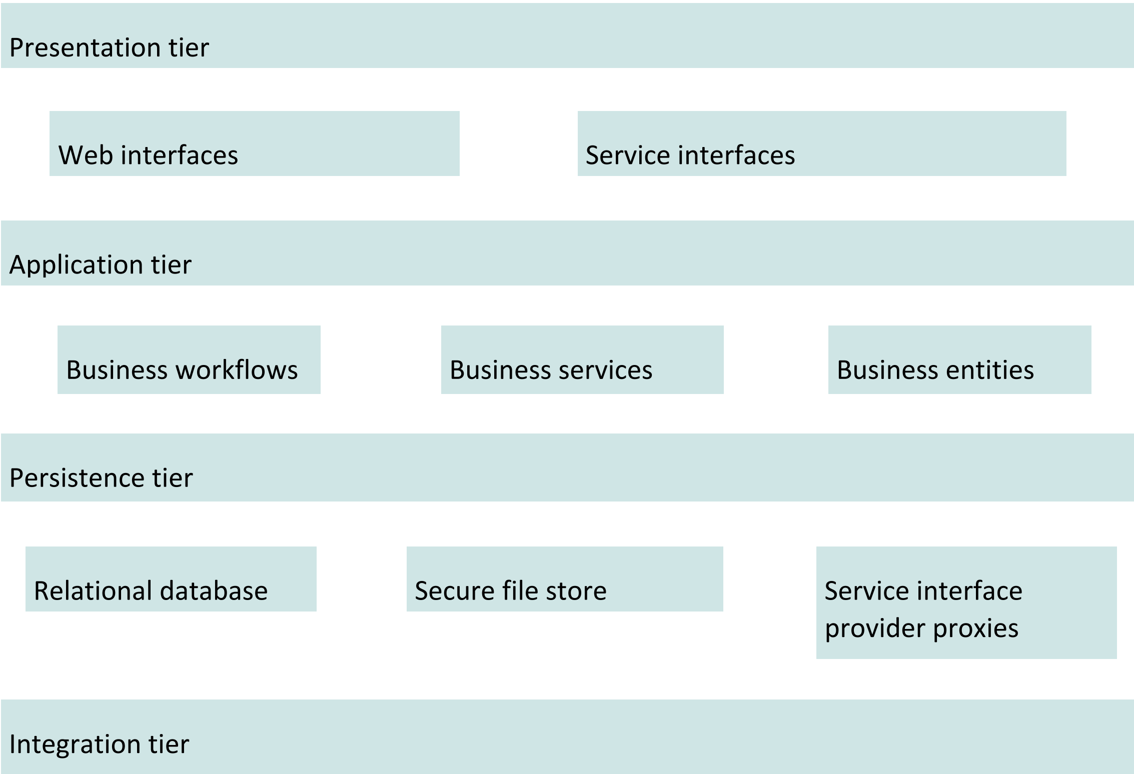
Database structure and capacity

During 2016 New Zealand replaced its registry system. The new register is called the New Zealand Emissions Trading Register. The Register is a customised application solution developed by Datacom NZ and based on the Emissions Trading Scheme Workflow Automation Project (ETSWAP) and Greenhouse Gas Registry for Emissions Trading Arrangements (GRETA) 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:

- the sending of SMS messages
- the sending and processing of messages to and from the International Transaction Log (ITL).

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 (DES) as published by the UNFCCC.

Prior to Register go-live, DES Annex H testing of the Register was completed successfully in late July 2016. This testing, in combination with ITL review and collective assessment of readiness documentation, confirmed that the Register conforms to required technical standards of data exchange.

Minimising discrepancies

The Register has multiple checks in place to ensure discrepancies in transactions are minimised. 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.

In order 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 New Zealand 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 New Zealand Government.

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, such as:

- secured communications between all internal 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 critical application(s) services/processes running on the infrastructure.

ITL review and collective assessment of Register readiness documentation prior to go-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 online[448] 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.

A detailed list of publicly accessible information is provided in table 12.4.1 of *New Zealand's Greenhouse Gas Inventory 1990–2015*.[449]

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, where 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.

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448 https://emissionsregister.govt.nz

449 Ministry for the Environment. 2017. *New Zealand's Greenhouse Gas Inventory 1990–2015.* Retrieved from www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/nzs-greenhouse-gas-inventory, p 401.

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

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 prior to go-live confirmed that the Register conforms to required backup and disaster recovery standards.

Test results

ITL review and collective assessment of Register readiness documentation prior to go-live confirmed that the Register system is operated under satisfactory and well-documented arrangements. It also confirmed the Register is ready to be connected to the ITL system without conditions.

Results of Annex H testing prior to go-live of the Register led to official confirmation that the functionalities of the registry software tested on 19 and 20-July 2016 have been deemed compliant with the requirements of the technical specifications of the ITL for a non-CP2 QELRC party (with the caveat that carry-over was not tested, because it was not implemented by the software provider).[450]

Supplementary notes related to Articles 6, 12 and 17

While 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. New Zealand will not participate in the mechanisms established by Articles 6, 12 and 17 of the Kyoto Protocol during this period.

Policies and measures in accordance with Article 2

Sustainable development

All of New Zealand's climate change policies promote sustainable development (see chapter 4).

450 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

Because New Zealand is geographically remote and has international tourism as a significant economic earner, addressing international aviation emissions is an important consideration. New Zealand participated actively in negotiation of the Carbon offsetting and Reduction Scheme for International Aviation, has joined the voluntary first phase of the scheme and has in place national action plan for managing New Zealand's international and domestic aviation emissions.

International maritime transport is critical for New Zealand's primary products, which make up two-thirds of exports. The Government plays an active role on the International Maritime Organization's Maritime Environment Protection Committee, where a sector-wide strategy for reducing greenhouse gas emissions from the maritime sector is being negotiated.

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, concerns about and issues relating to the proposed measure can be raised by any person or organisation.

Through the New Zealand Government's regular trade, economic and political consultations with other governments, including some developing country Parties, there are opportunities for those who may be concerned about the possible or actual impacts of New Zealand policies to raise concerns and have them resolved within the bilateral relationship. No specific concerns have been raised about any negative impact of New Zealand's climate change response policies.

The New Zealand Government, through the New Zealand Aid Programme,[451] has regular official development assistance talks with partner country 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. Based on these discussions, New Zealand works closely with the partner country to prepare a country strategic framework for development. These engagement frameworks are relatively long term (5 or 10 years) and convey New Zealand's development assistance strategy in each country in which it provides aid. They are aligned to the priorities and needs of the partner country, while also reflecting New Zealand's priorities and policies.

On many of the issues related to the implementation of Article 3.14, New Zealand gives priority to working with countries broadly in the South Pacific region. The New Zealand Aid Programme also works with partner developing countries to strengthen governance and improve their ability to respond to changing circumstances.

Climate change features annually as a regional priority at Pacific Islands Forum Leaders meetings. New Zealand has continued to work with other Forum members on a range of climate change initiatives to address concerns raised by Leaders. This includes strongly supporting the Framework for the Resilient Development of the Pacific, which draws together climate change and disaster risk reduction.

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[451] www.aid.govt.nz

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 New Zealand's market regardless of the response measures undertaken.

Domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures

The Climate Change Response Act 2002 is the primary legislative instrument that enables New Zealand to meet its international obligations under the UNFCCC and the Kyoto Protocol. It includes powers for the Minister of Finance to manage New Zealand's holdings of units, which represent New Zealand's target allocation for greenhouse gas emissions under the Kyoto Protocol. It enables the Minister to trade those units on the international market and establishes a register 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 New Zealand's international obligations.

The Climate Change Response (Emissions Trading) Amendment Act 2008 amended the Act to establish the New Zealand Emissions Trading Scheme. The Act describes the legal details of the NZ ETS. Regulations relating to the NZ ETS have also been made under the Climate Change Response Act 2002. The NZ ETS is described in more detail in chapter 4.

Information under Article 10

Activities undertaken by New Zealand in fulfilment of commitments under Article 10 of the Kyoto Protocol are reported on in chapters 4, 6, 7, 8 and 9. The steps taken by New Zealand to promote, finance and facilitate the transfer of technology to developing countries are reported in chapter 7.

Financial resources

The steps taken for New Zealand to meet its obligations under Article 11 of the Kyoto Protocol are outlined in chapter 7.

Biodiversity and sustainable use of natural resources

New Zealand has national legislative arrangements that seek to ensure that the implementation of activities under Article 3.3 contribute 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 Permanent Forest Sink Initiative (PFSI) promotes the establishment of permanent forests on non-forest land and is particularly suited to natural forests contributing to the conservation of biodiversity and sustainable use of natural resources. The East Coast Forestry Project was established in 1992 to encourage afforestation in areas susceptible to severe erosion in the Gisborne district. The Sustainable Land Management (SLM) Hill Country Erosion Programme aims to increase protection of erosion-prone land. Severe erosion causes long-term damage to land productivity, threatens communities and infrastructure, lowers water quality and harms the natural values of the land and the coastal environment.

The New Zealand Emissions Trading Scheme penalises the conversion of pre-1990 plantation forest land to any non-forest land use by imposing a deforestation liability on the land owner. 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 New Zealander's natural forests (approximately two-thirds of New Zealand's total natural forests) are publicly owned and are protected by the Conservation Act 1987. These forests are not able to be deforested. No timber is legally harvested from the natural forests in the publicly owned conservation estate other than in exceptional circumstances where legislation allows. The West Coast Wind-blown Timber (Conservation Lands) Act 2014 was created to allow the removal of timber from trees that were irreversibly damaged by Cyclone Ita. The Act does not allow timber removal from ecological areas or national parks, and there are restrictions on the volume of timber that can be removed.

Annex C: Supplementary material for emissions projections

Appendix C.1: Summary of key variables and assumptions used in the projections analysis

Table C.1: Summary of key variables and assumptions used in the projections analysis

		Historical							Projected		
Key underlying assumptions	**Unit**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2020**	**2025**	**2030**
Population	million	3.46	3.68	3.86	4.14	4.35	4.60	4.69	4.98	5.25	5.47
Gross domestic product	real 09/10 NZ$ billion	105.79	122.45	141.79	171.48	180.97	206.67	225.53	246.78	271.32	296.30
Exchange rate*	(NZ$/US$)	0.62	0.55	0.46	0.70	0.72	0.70	0.65	0.65	0.66	0.66
Oil price	real 2014 US$/barrel	40.22	27.35	41.84	69.03	84.41	47.96	34.71	55.16	84.08	113.00
Gas supply from new discovery	PJ/year	0	0	0	0	0	0	0	0	81.47	140.35
Carbon price for non-forestry projections	$/t$CO_2$.e	0	0	0	0	19.5	15.21	17.15	19.57	22.58	25.00
Carbon price for forestry projections (average value from the mid-scenario range of $12.5–$25/tCO_2-e)	$/t$CO_2$-e	0	0	0	0	18.75	18.75	18.75	18.75	18.75	18.75
Afforestation area (from mid-scenario)	ha/year	11,793	55,062	24,901	4,399	6,176	1,965	5,000	7,000	12,500	15,000
Deforestation area (from mid-scenario; post-1989)	ha/year	0	0	0	2,358	1,404	646	1,000	2,250	2,250	2,250
Deforestation age (from mid-scenario; post-1989)	years	0	0	0	11	12	24	24	28	30	30
Deforestation area (from mid-scenario; pre-1990)	ha/year	0	0	2,031	11,210	6,176	3,146	2,500	1,200	1,200	1,200
Deforestation age (from mid-scenario; pre-1990)	years	0	0	28	28	24	28	28	28	28	28
Harvest area (from mid-scenario; post-1989)	ha/year	0	0	0	200	1,513	4,562	13,023	14,901	42,837	23,119
Harvest age (from mid-scenario; post-1989)	years	0	0	0	12	17	24	24	28	30	30
Harvest area (from mid-scenario; pre-1990)	ha/year	19,427	29,275	35,530	27,056	35,650	40,547	42,382	49,712	37,756	33,876

Key underlying assumptions	Unit	1990	1995	2000	Historical 2005	2010	2015	2016	2020	Projected 2025	2030
Harvest age (from mid-scenario; pre-1990)	years	28	28	28	28	28	29	30	35	33	31
Total solid waste disposal	kt/yr	7,561.56	8,012.06	8,427.77	9,081.96	8,714.15	9,938.58	9,968.29	10,405.51	10,952.04	11,498.56
Milk solids	NZ cents/kg (2010 prices)	605.38	516.43	560.74	566.78	631.50	407.76	381.61	590.69	586.41	586.41
Lamb	NZ cents/kg (2010 prices)	428.58	362.03	461.39	481.22	467.27	453.47	431.20	460.15	460.77	460.77
Prime beef	NZ cents/kg (2010 prices)	508.51	367.65	452.54	379.92	335.30	423.08	453.94	410.40	412.08	412.08
Days of soil moisture deficit for deer	days	67.23	67.02	53.33	57.73	91.27	87.93	103.3	78.18	78.16	78.16
Days of soil moisture deficit for beef cattle	days	59.50	59.95	55.86	55.05	89.11	88.60	99.4	74.95	74.95	74.95
Days of soil moisture deficit for dairy cattle	days	52.01	48.26	51.12	64.38	81.13	77.67	85.1	67.19	67.19	67.19
Days of soil moisture deficit for sheep	days	73.89	69.41	57.91	60.63	89.68	93.29	109.6	82.01	82.01	82.01
Fleet size (number of vehicles)											
Light passenger vehicles	thousands						2,965.57	3,045.13	3,299.44	3,512.32	3,637.56
Light commercial vehicles	thousands						496.73	505.19	549.57	587.96	614.88
Motorcycles	thousands						148.40	159.88	170.81	178.59	181.99
Heavy commercial vehicles	thousands						156.45	162.45	174.46	184.57	189.75
Buses	thousands						9.59	10.40	12.39	14.63	16.79
Engine technology (share of fleet)											
Light vehicles											
Internal combustion engines	%						99.9	99.9	99.0	94.3	85.0
Electric and plug-in	%						0.1	0.1	1.0	5.7	15.0
Heavy vehicles											

					Historical					Projected	
Key underlying assumptions	**Unit**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2020**	**2025**	**2030**
Internal combustion engines	%						100.0	100.0	99.9	99.5	98.0
Electric and plug-in	%						0.0	0.0	0.1	0.50	2.0
Energy intensity											
Light petrol vehicles	litres/km						0.10	0.10	0.09	0.09	0.08
Light diesel vehicles	litres/km						0.11	0.11	0.10	0.10	0.09
Heavy commercial vehicles	litres/km						0.41	0.41	0.41	0.41	0.41
Buses	litres/km						0.37	0.36	0.34	0.32	0.30

Note: * Fluctuations in the exchange rate are expected and it is assumed that the exchange rate falls from current levels to the long run exchange rate of 0.65 NZ$/US$. ha = hectares; kg = kilograms; kt = kilotonnes; PJ = petajoules; t CO_2-e = tonnes of carbon dioxide equivalent.

Appendix C.2: Additional agricultural data

Table C.2: Actual and projected land-use scenario figures, 1990–2030

	Absolute land-use figures (hectares)			
Year	Dairy	Sheep and beef	Forestry	Other
1990	1,023,545	12,054,139	1,261,000	3,150,714
2005	1,398,966	9,825,432	1,811,000	2,270,445
2015	1,751,704	8,415,447	1,717,715	2,044,509
Scenario assumptions 2030:				
with measures	1,952,722	7,554,127	1,834,418	1,862,508
without measures	2,036,917	7,602,692	1,726,618	1,838,804
2030 difference compared with the 'with measures' scenario:				
without measures	4.31%	0.64%	–5.88%	–1.27%
	Percentage change in land use			
	Dairy	Sheep and beef	Forestry	Other
% change 1990–2015	71.1%	–30.2%	36.2%	–35.1%
Projected % change by scenario 2015–30:				
with measures	11.5%	–10.2%	6.8%	–8.9%
without measures	16.3%	–9.7%	0.5%	–10.1%
Annual average change from 1990 – 2015 (%):	2.8%	–1.2%	1.4%	–1.4%
Projected annual average change (%):				
with measures	0.8%	–0.7%	0.5%	–0.6%
without measures	1.1%	–0.6%	0.0%	–0.7%

Table C.3: Actual and projected animal population figures, 1990–2030

Year	Absolute animal population Dairy	Sheep	Beef	Deer
1990	3,440,815	57,852,192	4,593,160	976,290
2005	5,087,176	39,879,668	4,423,626	1,705,084
2015	6,485,535	29,120,827	3,547,228	900,100
Scenario assumptions 2030:				
with measures	6,915,649	21,219,264	3,529,265	697,151
without measures	7,339,617	22,132,372	3,615,429	723,134
2030 difference compared with base 'with measures' scenario				
without measures	6.13%	4.30%	2.44%	3.73%
	Percentage change in animal population **Dairy**	**Sheep**	**Beef**	**Deer**
% change 1990–2015	88.5%	–49.7%	–22.8%	–7.8%
Projected % change by scenario 2015–30				
with measures	6.6%	–27.1%	–0.5%	–22.5%
without measures	13.2%	–24.0%	1.9%	–19.7%
Annual average change from 1990–2015 (%):	3.5%	–2.0%	-0.9%	–0.3%
Projected annual average change (%):				
with measures	0.4%	–1.8%	0.0%	–1.5%
without measures	0.9%	–1.6%	0.1%	–1.3%

Appendix C.3: Comparison of *Seventh National Communication* projections (current projections) with those listed in the *Sixth National Communication*

Table C.4: Differences in emissions reported by each sector in New Zealand's *Seventh National Communication* and New Zealand's *Sixth National Communication*, 2020

Sector	Projected Emissions 2020			
	7NC	6NC	Difference	
	Total (kt CO_2-e)	Total (kt CO_2-e)	Absolute (kt CO_2-e)	Percentage (%)
Energy	16,418	18,058	–1,640	–9.1
Transport	16,188	14,876	1,312	8.8
IPPU*	5,487	6,311	–824	–13.1
Agriculture	37,888	41,516	–3,628	–8.7
LULUCF	–15,694	–2,191	–13,504	616.5
Waste	3,976	2,453	1,523	62.1
Total gross emissions (excluding LULUCF)	79,958	83,215	–3,257	–3.9
Total net emissions (including LULUCF)	64,264	81,025	–16,761	–20.7

Note: * IPPU aggregates industrial processes and solvents for the 6NC. 6NC emissions are given in the IPCC's *Fourth Assessment Report* global warming potentials (for comparative purposes).
6NC = *Sixth National Communication*; 7NC = *Seventh National Communication*; IPPU = industrial processes and product use; kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

Table C.5: Differences in emissions reported by each sector in New Zealand's *Seventh National Communication* and New Zealand's *Sixth National Communication*, 2030

Sector	Projected emissions 2030			
	7NC	6NC	Difference	
	Total ($kt\ CO_2$-e)	Total ($kt\ CO_2$-e)	Absolute ($kt\ CO_2$-e)	Percentage (%)
Energy	14,324	18,522	–4,199	–22.7
Transport	15,014	15,902	–888	–5.6
IPPU	6,185	6,304	–119	–1.9
Agriculture	37,737	44,302	–6,565	–14.8
LULUCF	–4,043	2,598	–6,641	–255.6
Waste	3,978	2,705	1,273	47.1
Total gross emissions (excluding LULUCF)	77,239	87,736	–10,498	–12.0
Total net emissions (including LULUCF)	73,196	90,334	–17,138	–19.0

Note: * IPPU aggregates industrial processes and solvents for the 6NC. 6NC emissions are given in the IPCC's *Fourth Assessment Report* global warming potentials (for comparative purposes).
6NC = *Sixth National Communication*; 7NC = *Seventh National Communication*; IPPU = industrial processes and product use; kt CO_2-e = kilotonnes of carbon dioxide equivalent; LULUCF = land use, land-use change and forestry.

Annex D: New Zealand’s report on the Global Climate Observing System

Executive summary

This report describes 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 carried out in New Zealand by multiple providers including:

- sub-national and local authorities: regional 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: Land Information New Zealand (LINZ), Department of Conservation, New Zealand Transport Agency and the National Rural Fire Authority
- private organisations: energy companies, irrigation companies and others.

A range of national initiatives is in place to ensure consistent and comprehensive environmental monitoring across New Zealand. Supported by recent advances in data management standards and tools, various data providers and institutions are working on building up comprehensive institutional and cross-institutional catalogues about New Zealand observation data holdings.

There are four primary or core observation programmes for New Zealand ECV observations.

1. Surface climate observations, upper air observations and atmospheric constituent measurements undertaken by the MetService and NIWA are provided to the GCOS Global Observing Network.
2. Surface oceanic ECV observations are carried out by a range of organisations, 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.
4. Terrestrial ECV observations are conducted in New Zealand by a range of organisations, with most observations being carried out by regional councils. These include freshwater (groundwater, lake and river quality, and river quantity) observations and vegetation surveys.

Introduction

New Zealand maintains observation programmes for atmospheric, terrestrial, and oceanic measurements for a suite of Global Climate Observing System (GCOS) Essential Climate Variables (ECVs). 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, presented in accordance with the revised United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines on global climate change observing systems.[452] These guidelines focus on the contribution of Parties to the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC.*[453]

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452 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.

453 GCOS. 2004. *Update of the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* (GCOS-138, August 2010). Retrieved from http://jcomm.info/components/com_oe/oe.php?task =download&id=10710&version=1.0&lang=1&format=1; GCOS. 2006. *Systematic Observation Requirements for Satellite-based Products for Climate ('Satellite Supplement'), GCOS-107, September 2006*.

National observations in New Zealand – situation and general approach

Data collection by multiple providers

In New Zealand, GCOS ECVs observations are carried out by multiple providers including:

- sub-national and local authorities: regional councils and others
- Crown Research Institutes (CRIs): 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: Land Information New Zealand (LINZ), Department of Conservation, New Zealand Transport Agency, the National Rural Fire Authority and others
- private organisations: energy companies, irrigation companies and others.

Some of these observations are mandated by legislation or policy, or covered by agreements between institutions. Some voluntary coordination is happening between organisations to ensure national consistency and comprehensiveness, as outlined below.

High-quality observations vs 'fit-for-purpose'

GCOS ECVs observations are used for a variety of practical purposes, including regional management of environmental resources or mitigation of hazards. This includes the following.

- All regional authorities operate flood warning monitoring networks on major rivers.
- The National Rural Fire Authority 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.

As the data are collected for different purposes, different standards for data collection 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 various 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 (see next section).

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 New Zealand, several legislative frameworks and a range of 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 2011 and requires government agencies to commit to actively releasing high-value public data for reuse. The Open Government Information and Data Work Programme[454] aims to make non-personal, government-held data and information more widely available and discoverable, easily usable and compliant with open government data principles within the New Zealand legal context; and to facilitate agencies' release of the non-personal, government-held data and information that people, communities and businesses want to use and reuse.
- The Environmental Reporting Act 2015[455] 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 new 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

- National Environmental Monitoring Standards (NEMS)[456] is a multi-agency project, led by regional councils, NIWA, energy companies and 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 14 standards documents to date and a range is under development. In addition, NEMS champions workshops to support data collection agencies to implement those standards. A key 'backbone' of the NEMS system is a National Quality Coding Scheme[457] 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 regional councils and MfE with the goal of developing a standardised national framework to support national freshwater state-of-the-environment reporting. The project has developed a framework for national freshwater monitoring, based on institutionally operated (but nationally optimised) monitoring networks.
- Tier 1 statistics[458] are compiled by Statistics New Zealand 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/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

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454 www.ict.govt.nz/guidance-and-resources/open-government/declaration-open-and-transparent-government

455 www.mfe.govt.nz/more/environmental-reporting/about-act

456 http://nems.org.nz

457 http://nems.org.nz/documents/quality-code-schema

458 www.statisphere.govt.nz/tier1-statistics.aspx

atmosphere, and ocean climate change. Tier 1 statistics rely on consistent and comprehensive national data sets; for this reason when developing these new Environmental Tier 1 statistics it is necessary to increase efforts to ensure consistency, representativeness and longevity in the collected data across different agencies.

- Land Air Water Aotearoa (LAWA)[459] is a regional council-led initiative that aims 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 freshwater, coastal and air quality information, and displaying it on the LAWA website. This will be further enhanced through a federated approach supported by national data standards.[460]
- LINZ promotes and supports a work programme for a New Zealand Geospatial Strategy for a New Zealand Spatial Data Infrastructure (SDI).[461] Part of that work programme forms support of fundamental data sets (including climate, freshwater and marine data sets), their curatorship principles and accessibility rules. It also supports the development and implementation of data interoperability standards.
- Statistics New Zealand[462] and the New Zealand Department of Internal Affairs promote and support work programmes for Open Government Information and Data[463] to support the Declaration on Open and Transparent Government. This includes provision of Data and Information Management Principles and Licence frameworks.

Data archives and data centres

A set of 'Nationally Significant Databases' has been set up over the last decades by individual institutions, and supported by the New Zealand Government, as archives of key data sources. These include the Climate Database (NIWA), Water Resources Archive (NIWA), National Groundwater Database (GNS Science) and National Freshwater Fish Database (NIWA). Contribution to these data sets is voluntary. In addition, some agencies maintain national data archives or data sets (see table D.1).

A range of data providers is working on building up comprehensive catalogues of New Zealand data holdings; for example, the GNS Science Data Catalogue,[464] the NIWA Data Catalogue,[465] the Landcare Research Datastore,[466] the New Zealand Geospatial Data Catalogue,[467] the New Zealand Government Data Catalogue "data.govt.nz",[468] the LINZ Data Service[469] and Land Air

459 www.lawa.org.nz

460 A "federated" (or distributed) approach means empowering individual institutions to manage and publish their data according to well-defined national standards, so that (distributed) data users can access the information using these standards (as opposed to a centralised or data warehouse approach).

461 www.linz.govt.nz/about-linz/our-location-strategy

462 www.linz.govt.nz/news/2017-03/open-data-nz-shift-statistics-nz

463 www.linz.govt.nz/about-linz/what-were-doing/projects/open-government-information-and-data-programme

464 http://data.gns.cri.nz/metadata

465 http://dc.niwa.co.nz

466 https://datastore.landcareresearch.co.nz

467 http://geodata.govt.nz

468 https://data.govt.nz

469 http://data.linz.govt.nz

Water Aotearoa.[470] This area of work also includes catalogues contributing to international archives such as the Global Biodiversity Information Facility (GBIF)[471] and the Integrated Marine Observing System (IMOS).[472] Some efforts have been made to aggregate these catalogues into national registries.

Table D.1: Some relevant maintained data sets and data archives in New Zealand

Data archive	Organisation	Content
Climate Database	NIWA	Data from historical and operating climate stations; about 10,000 stations
Water Resources Archive	NIWA	Data from historical and operating river-flow, lake-level and water-quality observations; about 1000 stations
National Groundwater Database	GNS Science	Reference data set of groundwater quality data from about 100 stations
Freshwater Fish Database	NIWA	Freshwater fish observations; about 125,000 records
Sea-level data	NIWA	Data from 17 sea-level monitoring sites
Sea-level data	LINZ	Data from 18 sea-level tsunami warning sites
Land Cover Database (LCDB)	Landcare Research	The LCDB is a multi-temporal, thematic classification of New Zealand's land cover
National Soils Database	Landcare Research	'Point' database containing descriptions of about 1500 New Zealand soil profiles, together with analytical data on their chemical, physical and mineralogical characteristics
S-Map	Landcare Research	Landcare Research's ongoing project to map New Zealand's soil resources at a nominal 1:50 000 scale; currently about 30% coverage
New Zealand Ocean Data Network	NIWA	Data from ocean observations, including moorings, CTD data and more; about 100,000 observations
National invertebrate collection	NIWA	Marine invertebrate specimen collection from New Zealand region, the southwest Pacific and the Ross Sea, Antarctica
Southwestern Pacific Ocean Biogeographic Information System (OBIS) Node	NIWA	Marine biological observations from New Zealand, provided to OBIS and the Global Biodiversity Information Facility (GBIF); about 1,500,000 observations
LINZ Data Service	LINZ	Various geospatial and related data from Land Information New Zealand
MfE Data Service	MfE	Various environmental datasets published by the Ministry for Environment
National Vegetation Survey Databank (NVS)	Landcare Research	NVS is a physical archive and electronic databank containing records of over 104,000 vegetation survey plots – including data from over 24,000 permanent plots
Land Air Water Aotearoa (LAWA)	Local authorities	Consolidation and Portal for local authorities' environmental observations

Note: CTD = conductivity, temperature and depth; LINZ = Land Information New Zealand; MfE = Ministry for the Environment; NIWA = National Institute of Water and Atmospheric Research.

Note: not a comprehensive list.

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[470] www.lawa.org.nz

[471] www.gbif.org

[472] http://imos.org.au

Federated information system supported by standards

Data collection in New Zealand is conducted by multiple data providers and agencies. New Zealand has adopted the approach to integrated data access by implementing federated information systems supported through standards. The development of these standards is heavily based on existing international standards such as those developed by or through the International Organization for Standardization (ISO), the World Meteorological Organization (WMO), the Open Geospatial Consortium (OGC), GBIF, IMOS and the Group on Earth Observations (GEO). It will support the WMO Information System (WIS) through improving the availability of consistent environmental data.[473]

National standards include standards for:

- data collection and quality assurance (for example through the NEMS initiative, see above)
- data management
- data delivery
- management of metadata (a set of data that describes and gives information about other data) (see below).

Together these standards ensure that data are collected consistently and are available through a common interface. This allows users (including portals and models) to access data provided by a range of agencies.

Metadata Management and Federation

It is important that metadata are captured consistently across agencies and made available through common interfaces to enable discovery of environmental data and information. Through the New Zealand Geospatial Strategy and other initiatives, the Australia New Zealand Land Information Council (ANZLIC) Metadata Profile[474] is the recommended metadata standard for use by New Zealand government agencies. The ANZLIC Metadata Profile was endorsed by the New Zealand State Services Commission in July 2010, following consultation with the geospatial community. Local government, CRIs and the private sector are all encouraged to use the ANZLIC Metadata Profile. As the ANZLIC Metadata Profile is based on ISO19115, it is compatible with the WMO Core Metadata Profile as part of the WIS.

Federation of metadata catalogues should be enabled through adequate exchange standards – for example, the OGC catalogue services for the web (OGC-CSW). This is to ensure that metadata from institutional data providers can be easily shared across systems and platforms and harvested into international catalogues such as those provided by GEO or WMO. These metadata management and federation principles applied in New Zealand are consistent with WIS principles. Several providers in New Zealand are already using WIS-compliant systems (for example, the geonetwork software suite[475]).

Pacific Island region coordination and capacity building

MetService helps to ensure the continuity of GCOS ECV observation programmes in a number of Pacific Island countries and territories (PICTs), by providing in-kind advice and technical

473 www.wmo.int/pages/prog/www/WIS

474 www.linz.govt.nz/about-linz/what-were-doing/projects/anzlic-metadata-profile

475 http://geonetwork-opensource.org

assistance. This is done in the Cook Islands, Fiji, Kiribati, Niue, Samoa, Tuvalu, Tokelau and Tonga, in cooperation with the Pacific Islands-Global Climate Observing System (PI-GCOS) programme. As part of a New Zealand – US National Oceanic and Atmospheric Administration (NOAA) PI-GCOS Technical Support Project, MetService has provided preventive, routine and emergency site inspections, maintenance and technical support to GCOS Upper Air Network (GUAN) stations in the Cook Islands (Rarotonga), Fiji (Nadi), Solomon Islands (Honiara), Papua New Guinea (Port Moresby) and Vanuatu (Bauerfield). These PI GUAN stations are part of the GCOS GUAN programme. Funding from the US National Oceanic and Atmospheric Administration (NOAA) GCOS office for maintenance and technical support of GUAN stations ceased in August 2017.

Under a joint Secretariat of the Pacific Regional Environment Programme (SPREP) – Met Office UK Pacific Trust Fund partnership, MetService also assists in the management and operation of the GUAN stations in Tuvalu (Funafuti) and Kiribati (Tarawa). Targeted technical training and maintenance activities are routinely carried out within PICTs. At the Wellington Regional Telecommunication Hub of the Global Telecommunication System (GTS), MetService facilitates the transfer of observations from a number of PICTs' national meteorological centres to the GTS. Wellington Regional Telecommunication Hub also relays forecasts, analyses and other products from the GTS to these islands.

In recent years, the PICTs' national meteorological centres have also had access to many GCOS ECVs data, information and products via the MetConnect Pacific website, which is hosted by MetService. The MetConnect Pacific website is the hub for the WMO-led Severe Weather Forecasting Disaster Risk Reduction Demonstration Project.

A key cross-cutting component of MetService's work in PICTs described above is targeted in-country capacity development. The goal is to ensure PICTs' national meteorological services are able to manage, operate and sustain their own GCOS ECVs observation programmes.

NIWA works with the United Nations Development Programme (UNDP) under the Global Environment Facility (GEF), and with other bilateral arrangements and partner agencies, to support climate adaptation work in a number of PICTs, including Kiribati, Fiji, 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 services in Fiji and Samoa with in-filling of climate stations in their national climate networks, near real-time data cellular or satellite based telemetry, and in-country data archiving.

Palaeoclimate data

Several New Zealand CRIs and universities are collecting palaeoclimate data. Their goals are to provide a window into how the Earth's environment was affected by past warm periods; and provide data on natural climate change over time, and the accompanying environmental signals extending the context for historical records.

New Zealand is actively involved in the international Antarctic DRILLing (ANDRILL) programme.[476] The goal of ANDRILL is to investigate past Antarctic climate from sediment cores. It has retrieved two cores from deeper than 1100 metres in the McMurdo region and plans to drill two new cores near the seaward edge of the Ross Ice Shelf. The resultant cores

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476 http://andrill.org

provide a unique record of the history of the Ross Ice Shelf and Antarctic ice sheets spanning the last 20 million years, comprising numerous cycles of ice advance and retreat under a range of climatic conditions. Some of these data may represent extended periods when the climate was a few degrees warmer and atmospheric carbon dioxide (CO_2) higher than at present, much like that projected for the future under many current climate change scenarios. ANDRILL palaeoclimate data are being integrated with the latest ice sheet models to better predict the future response of Antarctic ice sheets to global warming.

Although understanding of palaeoclimatology in specific marine regions (eg, the Chatham Rise, Campbell Plateau, eastern North Island) is reasonable, 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, with the exception of a few spatially restricted localities along East Cape. 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.

New Zealand is leading the international Roosevelt Island Climate Evolution Project (RICE).[477] RICE is a collaboration between New Zealand, the United States, Denmark, the United Kingdom, Germany, Australia, Italy, China and Sweden. The project recovered ice core to a depth of 764 metres from Roosevelt Island in Antarctica to determine the stability of the Ross Ice Shelf and West Antarctica in a warming world. The RICE core is 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. For the past millennia 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 concentration of methane (CH_4) and CO_2. The paleo-reconstructions are integrated with earth system and ice sheet modelling studies to quantify the sensitivity of the Ross Ice Shelf and West Antarctica to warming and assess the potential of this region to future sea-level rise.

Over the past three years, over 100 scientists collaborated to rigorously assess available temperature reconstructions for the past 2000 years with the aim of providing a robust global data set. This effort is initiated by the Past Global Changes (PAGES) programme,[478] a core project of the 'FutureEarth'[479] initiative and a partner of the World Climate Research Programme (WCRP). This data set is an important evaluation tool for climate models providing future projections. The CMIP6 models used for IPCC evaluations will be tested against this new data set to assess and improve their ability to accurately capture regional variability and trends. Only records with excellent age control, sufficient resolution and a demonstrated robust temperature proxy were included in the data base after careful assessments by the team. New Zealand's contribution to this data set are three ice core records from the Ross Sea Region. From New Zealand, three tree ring records developed by US scientists in collaboration with New Zealand researchers are also included in the data set. Together these records provide important dipsticks for the South Pacific.

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[477] www.victoria.ac.nz/antarctic/research/research-prog/rice

[478] www.pastglobalchanges.org

[479] http://futureearth.org

Atmospheric essential climate variables

Atmospheric ECVs that can be feasibly measured and are highly relevant to the UNFCCC (according to GCOS[480]) relate to surface measurements, upper-air measurements and atmospheric composition. They include:

- **surface**: air temperature, wind speed and direction, water vapour, air pressure, precipitation, surface radiation budget
- **upper-air**: earth radiation budget (including solar irradiance), upper-air temperature (including MSU radiances), wind speed and direction, water vapour, cloud properties
- **composition:** CO_2, CH_4 and other long-lived greenhouse gases,[481] ozone and aerosol properties.

General situation: National data collection and support

There are three primary and ongoing observation programmes for New Zealand GCOS atmospheric ECVs:

- surface weather observations undertaken by MetService and NIWA
- upper-air 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 a large number (several thousands) of meteorological (weather and climate) observations for regional and local purposes, especially rainfall monitoring for flood hazard management. Observations are often carried out for very specific purposes. Instrument and data quality varies, and station locations can change due to local requirements. While a lot of data are collected, there are some challenges in maintaining long-term time series for these observations.

MetService and NIWA both pay particular attention to quality control. NIWA's climate monitoring and archiving programme carries ISO9002 certification, and MetService has ISO9001 certification. NIWA is also assisted by many voluntary observers, especially for rainfall monitoring.

NIWA supports its observational programmes and the related quality assurance and archiving systems through government and its own funding as part of the New Zealand Crown Research Institutes Act 1992.[482]

MetService supports its observation collection, storage and processing operations through a contract with the New Zealand Ministry of Transport.

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480 www.wmo.int/pages/prog/gcos/index.php?name=EssentialClimateVariables

481 Including nitrous oxide, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, sulphur hexafluoride and perfluorocarbons.

482 The Act states: "The CRI agrees to maintain nationally significant databases and collections to ensure they remain current and fit for the purpose of end-users. The CRI will also pursue best data management practices to ensure appropriate access to and reusability of the data in the databases and collections."

Surface weather observations

NIWA reviewed the national operating climate stations in 2011 and identified 143 stations, operated by NIWA and MetService, as the New Zealand National Climate Station Network (NCSN) 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 49 stations (including 19 back-up stations) located across mainland New Zealand, the outlying islands (Raoul, the 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 currently 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 Kaitaia, Paraparaumu Aerodrome and Invercargill Aerodrome are operated automatically but occasionally observers on contract to MetService and NIWA take readings. The other seven stations are automatic stations owned and operated by MetService. Detailed metadata for these stations are compiled and site inspections are regularly carried out by NIWA staff and MetService engineers. Copies of inspection reports are available through NIWA's Instrument Systems group in Christchurch.

Pyranometers, pyrgeometers and photometers at NIWA's Lauder research station record radiation data submitted to the Baseline Surface Radiation Network (BSRN).

Upper-air weather observations

As part of the GCOS Upper Air Network (GUAN), New Zealand operates three GUAN stations and one non-GUAN station. New Zealand GUAN stations are Paraparaumu Aerodrome, Invercargill Aerodrome and Raoul Island. The station at the Royal New Zealand Air Force base Whenuapai is not a full GUAN station. Raoul Island releases one balloon a day, while the three remaining stations each release two balloons a day. All four stations measure air temperature, humidity, wind speed and wind direction. Since the last GCOS report, the Invercargill and Paraparaumu balloon-tracking radars have been retired, and all stations have been upgraded to the Vaisala RS-41SG radiosonde, which uses a global positioning system (GPS) module to calculate wind speed and direction.

Since the last New Zealand GCOS report, the Lauder Atmospheric Research Station became the fourth site globally to host a measurement programme certified by the GCOS Reference Upper Air Network (GRUAN) (RS-92 radio soundings, in March 2015) and is now part of the GRUAN. As of July 2017, there are 9 GRUAN-certified sites and Lauder is the only one in the southern hemisphere. Lauder's radiosonde data, ozone sonde 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 GUAN radiosondes launched at Invercargill are also being submitted to GRUAN through a partnership between NIWA and the MetService. NIWA have provided the Invercargill site with a Standard Humidity Chamber (SHC) to incorporate into their 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 GUAN site is the first of its kind and is being lauded as a great way to pass the best practices of GRUAN sites on to GUAN sites.

Atmospheric constituents measurements

New Zealand has three stations (Baring Head, Lauder and Arrival Heights in Antarctica) providing atmospheric constituent data to international data centres (World Data Center for Greenhouse Gases), as part of the Global Atmosphere Watch (GAW) programme. In situ concentrations of CO_2, CH_2, CO, O_3 and N_2O 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 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)[483] and Orbiting Carbon Observatory 2 (OCO-2)[484] and form part of the Total Carbon Column Observing Network (TCCON).[485]

In collaboration with NOAA, continuous in situ ozone measurements at Arrival Heights and Lauder were initiated in 2002 and 2003 respectively. In August 2006, a prototype in situ Fourier Transform Spectrometer (FTS) greenhouse gas analyser (CO_2, $^{13}CO_2$, CH_4, CO and N_2O) was installed as part of TCCON. A Licor-7000 CO_2 analyser was installed in 2008 along with weekly flask sampling (CO_2, $^{13}CO_2$, CH_4, CO and N_2O) to provide additional measurement redundancy and also as part of in situ FTS validation activities. There is an unexplained bias in between the in situ FTS and Licor-7000 CO_2 measurements; for this reason the CO_2 from the Licor-7000 is now used as the Lauder standard. The in situ FTS CO, N_2O and CH_4 measurements show good agreement with the co-located flask measurements. The in situ FTS CH_4 data are submitted annually to the GAW 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 profile GNSS/GPS system installed at Lauder started in May 2012.

Vertical ozone profile measurements are made at Lauder using ozone sondes, an ozone lidar, a Mid-Infrared Fourier Transform Spectrometer (MIR-FTS) and a microwave radiometer. 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).

Through the US NOAA GCOS programme and NIWA support, New Zealand also collects air samples in the data-sparse western Pacific in collaboration with the National Institute of Environmental Studies, (NIES) Japan, 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 are 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 are made when sky conditions allow, and these data are available as part of the National Aeronautics and Space Administration (NASA) Aeronet Maritime Aerosol Network.

GNS Science holds a 20-year (and ongoing) record of atmospheric black carbon and a 12-year (and ongoing) record of atmospheric multi-site particulate matter elemental composition

483 www.gosat.nies.go.jp/en

484 https://oco.jpl.nasa.gov

485 www.tccon.caltech.edu

(sodium to uranium) for observations in Auckland. While these records are directed at Auckland air-quality management, they also form a record of atmospheric composition due to the significant background marine influence. Results indicate a decrease in PM2.5 marine aerosol (seasalt) concentrations. This is surprising given that marine aerosol generation would be expected to be randomised and meteorologically driven. The result has been reported to Auckland Council.

Satellite-based measurements

While New Zealand does not have a dedicated satellite-based measurement programme of atmospheric ECVs, a number of 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, a number of agencies operate satellite receiver stations and data archives, as outlined below.

MetService operates two satellite reception systems from Wellington. The first receiver ingests imagery for all channels provided by the Himawari-8 satellite, and the second ingests X and L band data (all instruments) from polar orbiter satellites – currently NOAA16, 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 received HRPT data from all available NOAA satellites from 1992 to the present, including NOAAs 10, 11, 12, 14, 15, 16, 17, 18 and 19 (of which only N15, 18 and 19 remain operational) and also SeaWiFS HRPT data from SeaStar (Orbview2) from May 2000 until mission end in 2011. At Lauder a dual X/L-band receiver was installed in August 2007. It receives HRPT data from all available NOAA satellites N15, 16, 17, 18 and 19 (currently only N15, 18, 19 operational), SeaWiFS (until 2011), and also MetOp-B (since April 2014). It receives X-band data from Terra (MODIS only), Aqua (all instruments) and Suomi NPP (since April 2014, all instruments) and is expected to receive all instrument data from JPSS-1 following launch in September 2017. 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 prior to 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 HimawariCloud service (all channels, full resolution, full scan every 10 mins, 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 (HIRS) (20 spectral channels), and an advanced, very high-resolution radiometer (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, and 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.

Measurements of stratospheric trace gases and aerosols at Lauder and at Arrival Heights support a number of 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 actions to ensure that all their surface climate networks are operating according to GCOS climate monitoring principles.

Incorporating atmospheric pressure sensors into drifting buoy programmes

All of 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 three-hourly data are available from GSN stations. There are still some gaps, which these agencies are endeavouring to resolve as resources become available.

Operating the WWW/GOS radiosonde network in full compliance with the GCOS climate monitoring principles and coding conventions

NIWA and MetService have taken the necessary actions to ensure that 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 radiosondes 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 the research sector did occur, but so far New Zealand is not in a position to actively pursue the development of a network of ground-based 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 coordinating the collation of a searchable database of historical severe weather events for New Zealand going back to the 1840s, including information on impacts, damage, casualties and disruption. This work is now completed.[486]

NIWA also works on a number of projects focusing on Pacific Island climate data rescue and provides training, in-kind staff and facilities for data rescue. The project is a joint collaboration between NIWA, US NOAA GCOS Program and the Australian Bureau of Meteorology (BoM).

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486 http://hwe.niwa.co.nz

Oceanic essential climate variables

Oceanic ECVs (according to GCOS) relate to ocean surface measurements and ocean water column measurements. They include:

- **surface:** sea-surface temperature, sea-surface salinity, sea level, sea state, sea ice, current, ocean colour (for biological activity), CO_2 partial pressure
- **sub-surface:** temperature, salinity, current, carbon, ocean tracers, ocean acidity, phytoplankton
- **water column:** temperature, salinity, current, nutrients, CO_2 partial pressure, ocean acidity, oxygen, tracers.

Surface ocean measurements

In New Zealand, a range of agencies is 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.[487] NIWA currently operates four sea-level gauges for monitoring long-term, sea-level changes. Port companies operate 16 sea-level gauges at major ports (Standard Ports) and around another 27 gauges are operated by councils 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 commenced 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.[488] 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 Statistics New Zealand for the national *State of the Environment Report* released in October 2017.

Of the four New Zealand GLOSS sea-level sites,[489] those at Wellington, Auckland and Bluff are operated by port companies (or the regional authority on behalf of the port company). The site at Waitangi, in the Chatham Islands, formerly operated by the Pacific Tsunami Warning Center (PTWC), is no longer operational. The site at Scott Base, Antarctica, is operated by LINZ and Antarctica New Zealand.

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 regional councils, and at a further six sites operated by ports. Remote coastal video cameras have been installed by NIWA for long-term monitoring of beach conditions and erosion at seven sites.[490]

Since the mid-1980s, MetService has maintained a network of free-drifting buoys in the Tasman Sea. Until approximately 2002, the network consisted of buoys like the First Global

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487 www.linz.govt.nz/sea/tides/sea-level-data

488 www.niwa.co.nz/our-science/coasts/tools-and-resources/sea-levels

489 www.gloss-sealevel.org

490 www.niwa.co.nz/our-services/online-services/cam-era

Atmospheric Research Programme's (GARP) Global Experiment (FGGE) 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. MetService maintains a network of at least 20 drifting buoys and, as of June 2017, 24 were operational 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 approximately 20 buoys are deployed annually during the southern summer months.

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). Approximately 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, the metadata, the co-located model data and the delayed mode data are all supplied to the United States Data Assembly Centre for archiving for future research and climate applications.

Water column observations

NIWA has contributed and deployed two profiling floats under the Argo programme annually. Of the 30 Argo floats deployed, nine are still active.[491] The data from the New Zealand floats are administered by the Scripps Institution of Oceanography and are available from the Argo Global Data Assembly Centers. NIWA intends to continue to deploy Argo floats at the rate of two per year.

NIWA is also deploying buoys in the southern hemisphere from the research vessel (R/V) *Kaharoa* in 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 and Indian Oceans. In addition, over 50 deployments in the Southern Ocean have been made from R/V *Tangaroa*.

New Zealand has maintained two global reference mooring network sites in deep waters (about 3000 metres) to the east of the country. These have provided long-term, time-series biophysical data (currents, temperature, salinity, fluorometry and particle flux) in subtropical and subantarctic waters on either side of the Subtropical Front, north and south of Chatham Rise. Measurements were made between 2002 and 2012 and included a repeated, across-front transect measuring currents, nutrients, fluorometry and, more recently, 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 to the northeast of New Zealand and was in place for 6.5 years (1998–2005).

Time series data of currents, temperature, salinity, light and fluorometry have also been collected at a shallow mooring site (approximately 40 metres) in the Firth of Thames, in the

[491] www.jamstec.go.jp/ARGORC/status_top.html

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 approximately 30 metres deep 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.

Although New Zealand does not formally participate in providing carbon inventory survey line data to the International Ocean Colour Coordinating Group, measurements of partial pressure of CO_2 (pCO_2), pH, alkalinity and supporting data are routinely taken on cruises out of Dunedin as part of the Munida time series programme. These surface measurements, undertaken in accordance with the GCOS climate monitoring principles (GCMP), have been made for the last 17 years. The ocean carbon data will be submitted to the Carbon Dioxide Information Analysis Centre – Ocean CO_2. In 2013, an under-way pCO_2 recorder was purchased and installed on NIWA's research vessel.

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, pCO_2, carbonate ion concentration and saturation states are monitored. This network is linked into the Global Ocean Acidification Observing Network (GOA-ON).[492]

NIWA, collaborating with the International Marine Observing Systems (IMOS), has set up a New Zealand Ocean Data Network (NZODN) platform for making ocean data (at the moment mooring and conductivity, temperature and depth (CTD) data) available to complement the Australian Ocean Data Network (AODN).

Satellite-based measurements

New Zealand does not have a dedicated satellite-based measurement programme of oceanic essential climate variables. However, the NIWA sea-surface temperature archive (NSA) contains 1-kilometre resolution sea-surface temperatures retrieved from all NOAA orbits over the southwest Pacific region (1993 to the present).

Response to GCOS implementation plan

The following actions have been initiated in response to the recommendations on oceanic essential climate variables in the GCOS implementation plan.

Improving metadata acquisition and data management for the VOSClim subset of the VOS

The observations made by VOSClim ships adhere to the GCOS climate monitoring principles. The collection of metadata for VOSClim is well documented under the VOSClim project, and MetService collects the full range of variables for its VOSClim ship. MetService's VOSClim 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.

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[492] https://marinedata.niwa.co.nz/nzoa-on

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. Data have not been submitted from GLOSS site 127 (Auckland) for several years. Data from other sea-level gauges are being made available to the Permanent Service for Mean Sea Level as time permits.

Including sea-level objectives in the capacity-building programmes of GOOS, JCOMM, WMO, other related bodies and the system-improvement programme of GCOS

NIWA has been carrying out a number of 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 developing mitigation strategies.

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, R/V *Tangaroa*, is equipped to make under-way measurements of sea-surface temperature and salinity. Efforts are being made to maintain and calibrate the sensors so that the salinity data are accurate and stable. Once this is achieved, under-way data could be collected from some research voyages.

MetService VOS and drifting buoy programmes are robust, operational programmes with proven track records. VOS ships are issued with calibrated instruments (which are traceable to WMO and international standards). There is an ongoing programme of inspection, 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 Co-operation 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 pCO_2

Surface pCO_2 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 pCO_2 has also been measured during eight ocean cruises in New Zealand's Exclusive Economic Zone 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

A number of 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)

There are currently no systematic long-term full-depth water column observations in New Zealand.

Performing the 41 SOOP XBT/XCTD trans-oceanic sections

NIWA assists Australian (Commonwealth Scientific and Research Organisation) and United States (Scripps Institution of Oceanography) research institutions to maintain three high-resolution expandable bathythermograph sections (XBT) in the Tasman–Coral Sea area to monitor ocean temperature changes in the upper 800 metres. The lines are PX34, PX06 and PX31.[493]

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 the International Marine Observing Systems (IMOS), has set up a 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 going back 50 years.

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493 www-hrx.ucsd.edu

Terrestrial essential climate variables

Terrestrial[494] ECVs (according to GCOS[495]) that can feasibly be measured and are highly relevant to the UNFCCC include the following:

- snow cover
- glacier and ice caps
- permafrost and seasonally – frozen ground
- river discharge
- groundwater
- lake levels
- soil moisture
- water use
- albedo
- land cover (including vegetation type)
- fraction of absorbed photosynthetically active radiation (fAPAR)
- leaf area index (LAI)
- biomass
- fire disturbance
- soil carbon.

Ice, snow and permafrost monitoring

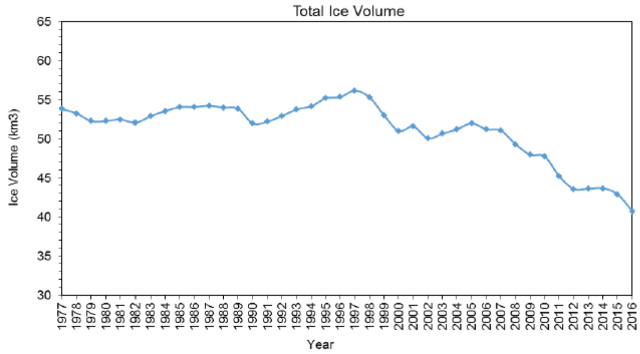
End-of-summer snowline elevations and photographic images of 50 glaciers from special aircraft flights are available annually, dating from 1979. The data are being used to estimate changes in glacier ice volume (see figure D.1. The terminus positions of key glaciers in the Southern Alps are available from 1800 to the present.[496]

494 Includes runoff ($m^3 s^{-1}$), groundwater extraction rates ($m^3 yr^{-1}$) and location, snow cover extent (km^2) and duration, snow depth (cm), glacier/ice cap inventory and mass balance ($kg\ m^2\ yr^{-1}$), glacier length (m), ice sheet mass balance ($kg\ m^2\ yr^{-1}$) and extent (km^2), permafrost extent (km^2), temperature profiles and active layer thickness, above-ground biomass ($t\ ha^{-1}$), date and location of active fire, burn efficiency (percentages of vegetation burned per unit area).

495 www.wmo.int/pages/prog/gcos/index.php?name=EssentialClimateVariables

496 www.sirg.org.nz

Figure D.1: Modelled glacier ice volume change, 1977–2016, and end of summer snowline of Rolleston Glacier, Arthurs Pass area, March 2016



Over recent years NIWA has established the National Snow and Ice Monitoring Network. It currently constitutes 11 high-elevation stations, which have been collecting information mainly since 2008. This network is complemented by two snow-monitoring sites operated for commercial clients at Rose Ridge and Panorama Ridge. Three sites have been fitted with solid precipitation gauges as part of the WMO Solid Precipitation Intercomparison Experiment (SPICE) project.[497] Initial analyses indicate that traditional precipitation gauges underestimate total precipitation by up to 50 per cent. Data from Mueller site are submitted to WMO as part of the SPICE project.

Although New Zealand has no permafrost measurement sites, it is supporting measurements in Antarctica 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 Landcare Research in collaboration with the United States Department of Agriculture.[498] Continuous monitoring data go back as far as 1999. Two permafrost boreholes are equipped with continuous temperature monitoring to a depth of 30 metres.

River flow, lake level, water quality, soil moisture, groundwater, water use

River flow and lake level monitoring is conducted in New Zealand by: regional councils, 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. Currently these agencies are working on a National Standard for discrete water quality to increase data consistency.

Regional councils, MfE and NIWA are working in a range of national initiatives (EMaR, NEMS, LAWA projects; see above) on national monitoring and quality coding protocols, and data aggregation standard systems to ensure local data collection is done consistently and data can

497 www.wmo.int/pages/prog/www/IMOP/intercomparisons/SPICE/SPICE.html

498 www.landcareresearch.co.nz/science/soils-and-landscapes/antarctic-soils/monitoring-soil-climate-in-the-ross-sea-region

be easily integrated. The New Zealand regional councils have set up the LAWA website as an integrated access portal to local authorities' freshwater, air quality and coastal data.[499]

NIWA is collating flow data from across the country on a monthly basis to assess and report on the country's river flows as part of the *New Zealand Climate Update*.[500]

NIWA submits river flow data from 40 gauging stations to the Global Runoff Data Centre (GRDC).[501]

NIWA submits river water quality data from about 50 sites currently to the GEMS/Water Global Environmental Monitoring System.[502]

Soil moisture is measured across the country by regional 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 Update*.[503]

At the national scale, groundwater quality, state and trends are assessed through the National Groundwater Monitoring Programme (NGMP). This Programme is a collaboration between GNS Science and all 15 regional authorities. In addition to the monitoring operations, the NGMP has dedicated research and database objectives, which is essential to ensure that the network remains relevant to current freshwater management issues. The NGMP network comprises around 110 monitoring sites, which are sampled quarterly by regional councils. 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 prior to sampling. Parameters such as pH, water temperature and electrical conductivity are measured in the field at the time of sampling. At the regional scale, state-of-the-environment groundwater monitoring programmes are operated by each of the 15 regional authorities. However, the sampling frequency, analytical suite, sampling protocol, monitoring objectives and site selection criteria vary between monitoring agencies.

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, using multivariate statistics conducted on an amalgamated state-of-the-environment data set and the NGMP data set, respectively. National-scale evaluations of groundwater quality have been reported by MfE since 1995 and have covered 10- and 12-year periods, with the most recent assessment covering data collected from 2004–13.[504]

Because of recent changes in New Zealand legislation,[505] an increasing number of water takes (for agriculture and other uses) are now being monitored – for example, by irrigation

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499 www.lawa.org.nz

500 www.niwa.co.nz/climate/nzcu

501 www.bafg.de/GRDC/EN/Home/homepage_node.html

502 www.unep.org/gemswater

503 www.niwa.co.nz/climate/nzcu

504 https://data.mfe.govt.nz/document/707-update-of-national-groundwater-quality-indicators-state-and-trends-december-2004-2013/

505 www.mfe.govt.nz/rma/central/measuring-reporting-water-takes.html

companies or individual farmers. Regional councils and MfE are working to ensure national consistency and national collection and accessibility of these data. It is expected that over the coming years there will be over 10,000 surface and groundwater takes being monitored and archived by local authorities in New Zealand.

Land cover and soil carbon

The Land Cover Database (LCDB) is a national compilation of land cover status conducted in New Zealand using satellite imagery;[506] it is a multi-temporal, thematic classification of New Zealand's land cover. So far four data sets have been compiled as part of the LCDB, representing New Zealand land cover layers for 1996/97, 2000/01, 2007/08 and 2012/13.

To meet its Kyoto Protocol commitments, New Zealand developed the Land Use and Carbon Analysis System (LUCAS).[507] LUCAS comprises components for measuring and reporting the carbon stock changes occurring from land-use change and forestry, through a combination of permanent forest sample plots and remote sensing-based mapping. LUCAS has so far established several snapshots of land use using Landsat and SPOT satellite data. These include the 1990, 2008 and 2012 land-use databases required to establish New Zealand's position at the beginning and end of the Kyoto Protocol's first commitment period. Carbon stock changes are calculated and reported from 1990 onwards with the assistance of these time-sequence measurements.

The Ministry for Primary Industries and Ministry for the Environment also maintain land-use databases (including planted forest cover databases) for New Zealand through the Climate Change Information System and LUCAS. These two systems are designed to monitor carbon stock changes resulting from afforestation, as well as deforestation following logging, fires and other forms of vegetation clearance.

To aid those national databases, a range of national research programmes are in progress to understand patterns and processes involved in current soil carbon storage.[508]

The National Vegetation Survey database maintained by Landcare Research[509] holds records from approximately 104,000 vegetation survey plots around New Zealand, including 24,000 permanent plots. Regional authorities are carrying out regular vegetation surveys to varying standards depending on local stressors and needs.

The National Soils Database (NSD) is a 'point' database maintained by Landcare Research containing descriptions of about 1500 New Zealand soil profiles, together with analytical data on their chemical, physical and mineralogical characteristics (including soil carbon). The information is obtained from physically sampling and observing the soil on site.

As part of the Smap project, Landcare Research is working on an ongoing project to map New Zealand's soil resources at a nominal 1:50,000 scale, currently with approximately 30 per cent coverage. The products include soil factsheets with physical soil characteristics.

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506 www.lcdb.scinfo.org.nz/

507 www.mfe.govt.nz/more/data/available-datasets/land-use-map

508 www.nzagrc.org.nz/soil-carbon.html

509 http://nvs.landcareresearch.co.nz/

Satellite-based measurements

New Zealand does not have a dedicated satellite-based measurement programme of terrestrial Essential Climate Variables. However, glaciers in the Southern Alps are monitored as part of the international satellite project Global Land Ice Mapping from Space (GLIMS).

Response to GCOS implementation plan

The following actions have been initiated in response to the recommendations on terrestrial ECVs within the GCOS implementation plans.

Developing a global network of approximately 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

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 94,000 plots over a period of 50 years, including 19,000 remeasured permanent plots. Data from this resource are used to calibrate the interpretation of satellite imagery for the creation of the national LCDB, ecosystem categorisation (EcoSat), environmental domains (LENZ) and national carbon reporting (LUCAS). In addition, the national biodiversity monitoring programme was established in 2011 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 2500 plots distributed on a national 8-kilometre grid, which are remeasured on a five-year rotation.

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 at the beginning of a phase of 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.

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 a 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 11 high-altitude specialised climate and snow stations.

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-P 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.

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 snow storms.[510]

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 the light of increased water- and land-use pressures.

510 The data are available at http://hwe.niwa.co.nz.

Acknowledgements

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Phil Sutton, NIWA

Richard Querel, NIWA

Appendix D1: Lists of observations

Contributing networks specified in the GCOS implementation plan	Essential climate variables	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2019	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
National contributions to surface-based atmospheric essential climate variables						
GCOS Surface Network (GSN)	Air temperature, precipitation	700 (est)	150 (est)	500 (est)	10	10
Full World Weather Watch / Global Observing System (WWW/GOS) surface network	Air temperature, air pressure, wind speed and direction, water vapour, precipitation	500 (est)	150(est)	500 (est)	100	100
Baseline Surface Radiation Network (BSRN)	Surface radiation	1	1	1	1	1
Solar radiation and radiation balance data	Surface radiation	100 (est)	4	100 (est)	0	0
Ocean-drifting buoys	Air temperature, air pressure	23	23	23	23	23
Moored buoys	Air temperature, air pressure	0	0	0	0	0
Voluntary Observing Ship Climate Project (VOSClim)	Air temperature, air pressure, wind speed and direction, water vapour	1	1	1	1	1
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
National contributions to upper-air atmospheric essential climate variables						
GCOS Upper Air Network (GUAN)	Upper-air temperature, upper-air wind speed and direction, upper-air water vapour	3	3	3	3	3
Full WWW/GOS Upper Air Network		4	4	4	4	4

Contributing networks specified in the GCOS implementation plan	Essential climate variables	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2019	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
National contributions to atmospheric composition observations						
World Meteorological Organization / Global Atmosphere Watch (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 surface drifting buoy array on 5 x 5 degree resolution	Sea-surface temperature, sea-level pressure, position-change based current	12	12	12	12	12
GLOSS Core Sea-level Network	Sea level	65	10 (est)	65	4	4
Voluntary observing ships (VOS)	All feasible surface essential climate variables	33	31	35	33	32
Ship of Opportunity Programme (SOOP)	All feasible surface essential climate variables	0	0	0	0	0

Contributing networks specified in the GCOS implementation plan	Essential climate variables	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2019	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
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	9	9	10	9	30
Carbon inventory survey lines (excluding XBTs)	Temperature, salinity, ocean tracers, biogeochemistry variables	2	2	2	2	2
National contributions to the terrestrial domain essential climate variables						
GCOS baseline river discharge network (GTN-R)	River flow	1,000 (est)	400 (est)	1,000 (est)	40	40
GCOS baseline lake level, area and temperature network (GTN-L)	Lake level	50 (est)	10(est)	50 (est)	0	0
WWW/GOS synoptic network	Snow cover	13	13	13	0	0
GCOS glacier monitoring network (GTN-G)	Glaciers' mass balance and length; ice sheet mass balance	50	50	50	50	50
GCOS permafrost monitoring network (GTN-P)	Permafrost borehole temperatures and active-layer thickness	9 (Note: All platforms are in Antarctica)	9	9	7	7

Note: CO_2 = carbon dioxide; est = estimated; GCMPs = GCOS climate monitoring principles; GCOS = Global Climate Observing System; GLOSS = Global Sea Level Observing System; GSN = GCOS Surface Network; CH_4 = methane; WMO/GAW = World Meteorological Organization / Global Atmosphere Watch; WWW/GOS = Full World Weather Watch / Global Observing System; XBTs = expandable bathythermographs.

Appendix D2: List of permanent stations

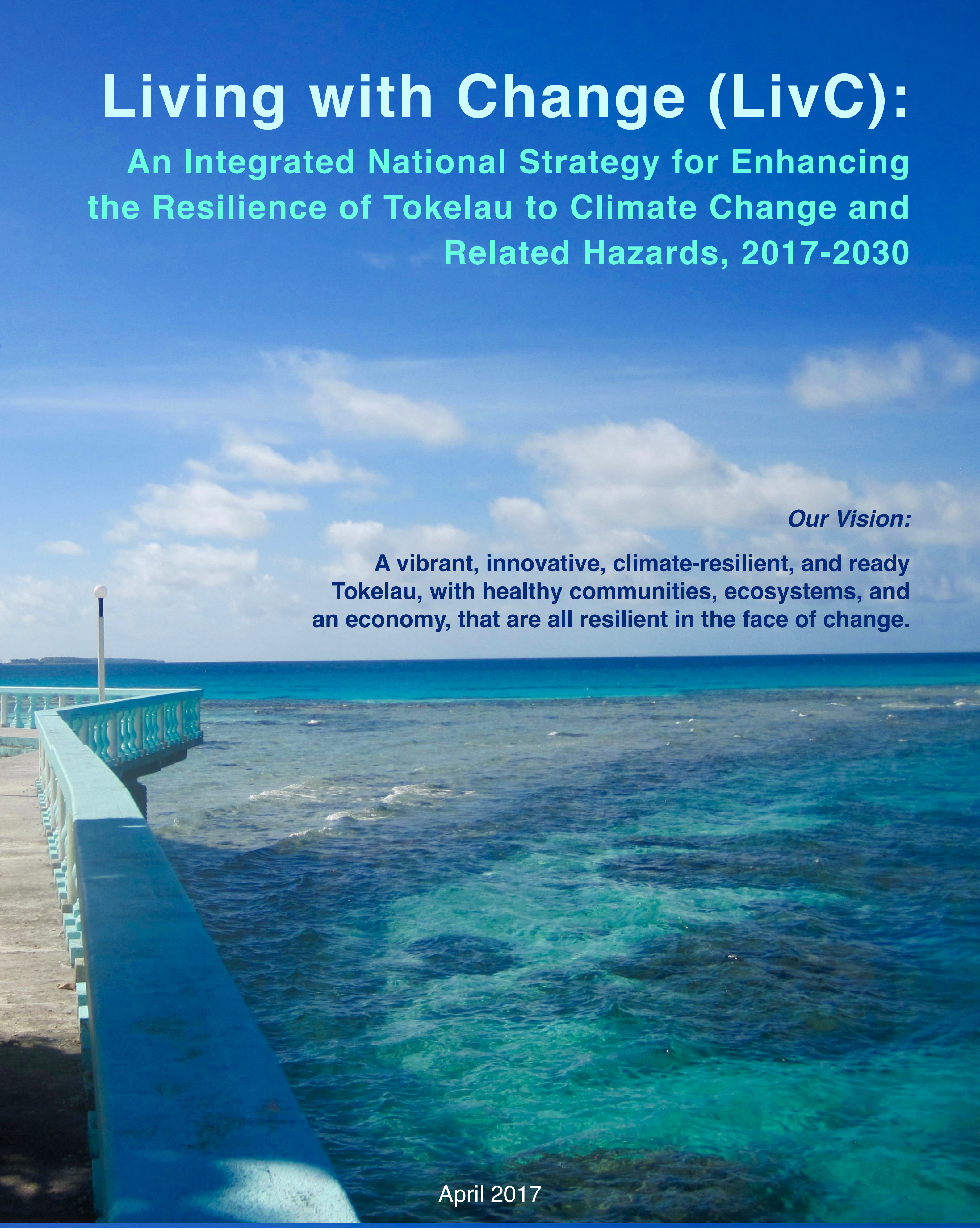
Station name	Latitude	Longitude	Responsible agency or agencies	GCOS system	Notes
Kaitaia AWS	–35.133	173.263	NIWA	GSN	
Gisborne Aero AWS	–38.659	177.985	MetService	GSN	
New Plymouth Aero AWS	–39.008	174.184	MetService	GSN	
Paraparaumu Aero AWS	–40.905	174.985	MetService	GSN	
Hokitika Aero AWS	–42.713	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 Aero	–40.905	174.985	MetService	GUAN	
Invercargill Aero	–46.417	168.330	MetService	GUAN	
Raoul Island	–29.245	–177.929	MetService	GUAN	
RNZAF base Whenuapai	–36.794	174.619	MetService	GUAN	Not full GUAN station
Lauder Research Station	–45.05	169.683	NIWA	GRUAN	
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	Local authorities	GLOSS	
Chatham Islands	–43.95	–176.55	Pacific Tsunami Warning Center	GLOSS	
Wellington	–41.17	174.47	Local authorities	GLOSS	
Bluff	–46.6	168.35	Local authorities	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 = Land Information New Zealand; MetService = Meteorological Service of New Zealand Limited; NIWA = National Institute of Water and Atmospheric Research; RNZAF = Royal New Zealand Air Force.

Annex E: Living with Change: An Integrated National Strategy for Enhancing the Resilience of Tokelau to Climate Change and Related Hazards, 2017–2030

Living with Change (LivC):

An Integrated National Strategy for Enhancing the Resilience of Tokelau to Climate Change and Related Hazards, 2017-2030



Our Vision:

A vibrant, innovative, climate-resilient, and ready Tokelau, with healthy communities, ecosystems, and an economy, that are all resilient in the face of change.

April 2017

Government of Tokelau

Office of the Council for the Ongoing Government

Photo Courtesy: Cover - Nukunonu Sea Wall, C.L. Anderson, 2016.

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FOREWORD

Climate change and related hazards pose an existential threat to our nation. This reality makes it critical for us to have a national climate change strategy.

The ***Living with Change: An Integrated National Strategy for Enhancing the Resilience of Tokelau to Climate Change and Related Hazards, 2017-2030 (LivC)*** is our response to the climate change and related hazards' challenge. It conveys our vision of the future, the issues we must address, the specific outcomes we aim to achieve, and the actions that we must take if climate change and related hazards and their impacts are to be managed. A companion document, ***The LivC Implementation Plan, 2017-2022*** provides details on how LivC aligns with the development plans of the three villages (Fakaofo, Nukunonu, Atafu) 2016-2020, our National Development Framework, 2016-2020, and relevant international frameworks.

LivC is well-timed, coming in the aftermath of the historic agreements achieved at COP21 in Paris on 12 of December 2015, COP22 in Marrakesh, Morocco, from 7 to 18 November 2016, and in preparation for the UN Conference on Oceans, from 5 to 9 June 2017. The ocean is an integral component of the global climate system. As such, it is particularly relevant to the vitality of our atolls' climate and weather, ecosystems, and our livelihoods.

To successfully implement LivC, the General Fono and the Taupulega, working together with our communities and development partners, need to commit to the strategic Climate Resilient Investment Pathways (CRIPs) plan. As a result, a number of actions will be required, along with the necessary attitudinal and behavioural changes required for success.

An important component of LivC is to track progress and evaluate success. Progress towards achieving the goals of LivC will be evaluated against specific outcomes every six months. This accountability will ensure that our nation's investment in LivC will not only result in enhancing our resilience and readiness to climate change, but will also serve as a blue print to ensure our atmosphere, land, water, ocean, and marine ecosystems are protected and managed sustainably for present and future generations.

I want to extend my sincere appreciation and *fakafetai* (thank you) to all those individuals and organisations who have worked tirelessly to complete our Strategy. Specifically, I would like to thank the General Fono, Taupulega, Fatupaepae, Aumaga, Youth and Public servants from the three villages; Aliki Faipule Afega Gaualofa, who was instrumental in getting the project off the ground; Jovilisi Suveinakama, General Manager; National Public Service; Senior Managers of the National Public Service; Penehuro Lefale and Dr Cheryl Lea Anderson of LeA International; Fatu Tauafiafi of the Pacific Guardians; Tokelau Administrator David Nicholson, and Marie Reynen Clayton, Office of the Tokelau Administrator, New Zealand (NZ) Ministry of Foreign Affairs and Trade (MFAT); Dr Howard Diamond, Victoria University of Wellington, NZ; Andrew Hickey, NZ Ministry of Civil Defence & Emergency Management (MCDEM); and, United Nations and Pacific Regional Organisations who assisted Tokelau.

Tokelau ke ola!

Aliki Faipule Siopili Perez
Ulu o Tokelau
April 2017

1 This document reflects the views of the Government of Tokelau. Its views may differ from the views of those who are acknowledged for their contributions.

ACRONYMS

Agenda 2030	Transforming Our World: the 2030 Agenda for Sustainable Development, 2015-2030
CRIPs	Climate Resilient Investment Pathways
LivC	Living with Change: An Integrated National Strategy for enhancing the resilience of Tokelau to Climate Change and related Hazards, 2017-2030.
MCDEM	Ministry of Civil Defence, Disaster and Emergency Management, New Zealand
MFAT	Ministry of Foreign Affairs and Trade, New Zealand
SDGs	Sustainable Development Goals
SIDS	Small Island Developing States
SRDP	Strategy for Resilience Development in the Pacific: An Integrated Approach to Climate Change and Disaster Risk Management (SRDP), 2017-2030
OCOG	Office of the Council of the Ongoing Government of Tokelau
TCR2O	Tokelau Climate Change, Resilient, Readiness & Emergency Services' Office.
TNDF	Tokelau National Development Framework, 2016-2020
UNFCCC	United Nations Framework Convention on Climate Change

TABLE OF CONTENTS

EXECUTIVE SUMMARY

As an atoll nation, Tokelau is highly susceptible to climate change and related hazards. This reality led the Tokelau General Fono, in July 2016, to include climate change as part of its national development priorities under the Tokelau National Development Framework, 2016-2020.

The Living with Change: An Integrated National Strategy for Enhancing the Resilience of Tokelau to Climate Change and Related Hazards, 2017-2030 (LivC) plan is Tokelau's response to the General Fono's resolution. Its vision is for Tokelau to be a vibrant, innovative, climate-resilient, and climate-ready nation, with healthy communities, ecosystems, and an economy, that are all resilient in the face of change.

LivC identifies three inter-related strategic ***Climate Resilient Investment Pathways (CRIPs)*** that need to be pursued by Tokelau, and her development partners to enhance her resilience, and readiness to climate change and related hazards, in the context of national sustainable development.

1. Mitigation: Decarbonisation Development

This pathway revolves around clean energy, low carbon, "no regrets" development policies, focusing on (i) reducing the carbon intensity of development processes, (ii) increasing the efficiency of end-use energy consumption, (iii) enhancing the resilience of energy and related infrastructure, and, (iv) increasing the protection and conservation of terrestrial and ocean ecosystems that are both vital to the Tokelauan people and could help capture carbon dioxide.

This pathway will contribute to emphasising clean energy, low carbon economic development policies, more resilient and a more climate-proof infrastructure. Putting these actions in place will not only increase energy security but will work to decrease the net emission of greenhouse gases (GHGs).

2. Adaptation: Strengthened integrated risk reduction and adaptation to enhance resilience in the face of climate change and disasters.

This pathway entails successfully managing risks caused by climate change and related disasters in an integrated manner where possible, within social and economic development planning processes and practices to reduce the accumulation of such risks, and prevent the creation of new risks or loss and damage.

This pathway will contribute to strengthening the development of sustainable and resilient practices while also achieving the added benefit of implementing efficiencies in the management of natural and human resources.

3. Human Development: Capacity Building, Education, Training, Public Awareness & Outreach

This pathway involves (i) Improving the capacity of the three villages to prepare for emergencies and disasters. This will ensure the timely and effective response and recovery in relation to both rapid and slow onset disasters, which may be exacerbated or caused by climate change; (ii) Enhancing disaster preparedness, response, and recovery initiatives, will reduce undue human losses and suffering, and; (iii) Minimising adverse consequences for national, village, and local communities' livelihoods, and environmental ecosystems will have beneficial effects across society.

The LivC and its companion LivC Implementation Plan, 2017-2022, set out priority areas that shall be undertaken at both the village and national level. The priority areas are supported by a set of institutional partnerships that bring together villages, national, and international agencies to implement the LivC.

WHY A CLIMATE CHANGE STRATEGY IS NECESSARY

It is widely accepted that climate change and related hazards pose an existential threat to Tokelau. This reality makes it critical for Tokelau to have a national climate change strategy in place.

The most significant climate change related hazards affecting Tokelau are tropical cyclones, severe weather systems (non-tropical cyclone storms resulting in heavy rains and flooding), drought, flooding associated with storm surges and king tides, sea level rise, water spouts, disease epidemics, bush fires, landslides and tsunamis, as summarised in Annex 1. While earthquakes are not related to climate change, they do cause tsunamis and can impact critical infrastructure. As such, the threat of tsunami run-up onto low-lying atolls can be exacerbated by climate-change induced sea-level rise.

Although Tokelau is in an area of relatively low tropical cyclone activity due primarily to its position far north in the southwest Pacific basin, the risk is elevated during El Niño seasons (Diamond, 2016). Diamond (2016) found five tropical cyclones possibly impacting Tokelau by coming within 278km from 1970-2015.

LivC was prepared using a simple model, based on answers to the following questions;

1. **Aims** What is Tokelau's vision of the future? What goals and objectives should drive her climate change and related hazards' strategy?
2. **Activities** What is Tokelau's mission? What types of services will allow Tokelau to achieve her aims?
3. **Partnerships** Who does what? Who are Tokelau's partners and what do they bring to the table?
4. **Approaches** How do they do it? In what ways does Tokelau conduct activities with other agents of both government and non-governmental organisations?
5. **Evaluations** How is success judged? What evidence informs pragmatic decisions?

LivC is a product of years of planning and discussions, desktop reviews of government reports and documents, and extensive consultations using a whole-of-community approach. LivC has two parts:

- The LivC Strategy, 2017-2030 (this document)
- The LivC Implementation Plan, 2017-2022 (companion document).

THE FUTURE WE WANT

Our Vision

Tokelau is a vibrant, innovative, climate-resilient, and ready nation, with healthy communities, ecosystems, and an economy that are all resilient in the face of change.

Our Mission

To provide Tokelauans with climate change and related hazards' intelligence services (CCS) to enhance their safety, resilience, freedom, sustainability, healthy ecosystems and well-being, and economic prosperity in the face of change.

FUTURE PATHWAYS

LivC identifies three inter-related strategic ***Climate-Resilient Investment Pathways (CRIP)*** that need to be pursued by Tokelau and her development partners to ensure that Tokelau is a vibrant, innovative, climate-resilient, and ready nation with healthy ecosystems, communities, and an economy that are all resilient in the face of change.

Solar Photovoltaic (PV) Array. Fakaofo, August 2016. *Photo courtesy*: C. L. Anderson

Mitigation: Decarbonisation development

Pursuing this pathway revolves around low carbon, no regrets development policies, focusing on reducing the carbon intensity of development processes, increasing the efficiency of end-use energy consumption, enhancing the resilience of energy and related infrastructure, and increasing the protection and conservation of terrestrial and marine ecosystems. This pathway will contribute to developing low carbon economic development policies, more resilient and climate proofing energy and related infrastructure in place, increased energy security, and decreased net emissions of greenhouse gases (GHGs).

Objective: Reduce carbon intensity of development processes, increase efficiency of end-use energy consumption, increase resilience of energy and related infrastructure on all three villages, and enhance policies and measures to protect and conserve Tokelau's terrestrial and marine ecosystems.

Adaptation: Strengthened integrated risk reduction and adaptation to enhance climate change and disaster resilience.

Pursuing this pathway entails successfully managing risks caused by climate change and disasters in an integrated manner, within social and economic development planning processes and practices to reduce the accumulation of such risks, and prevent the creation of new risks and loss and damage. This pathway will contribute to strengthening resilient developments and achieving efficiencies in natural and human resource management.

Objective: Successfully manage climate change and disaster risks in an integrated manner, reduce existing risks, and prevent the creation of new and additional risks.

Human Development: Capacity Building, Education, Training, Public Awareness, and Outreach

Pursuing this pathway includes improving the capacity of the three villages to prepare for emergencies and disasters, thereby ensuring timely and effective response and recovery in relation to both rapid and slow onset disasters, which may be exacerbated or caused by climate change. Disaster preparedness, response and recovery initiatives will reduce undue human losses and suffering, and minimise adverse consequences for national, village, and local communities, for economic, social, environmental, infrastructure, and ecological systems.

Objective: Enhance institutional, governance and public awareness of climate change and related hazards, disaster preparedness, response, and recovery.

The LivC Implementation Plan, 2017-2022, describes the key outcomes and development priority focused areas for each CRIP.

TURNING STRATEGY INTO ACTION

Institutional Arrangements

The successful implementation of LivC will depend on suitable governance structures and adequate institutional and human capacity, (i.e. well-resourced and fully functioning institutional arrangements). The fundamental principle for the implementation of the LivC is that the ownership, planning, and its implementation lies with the respective Taupulega of each village.

Under this arrangement, it is envisioned the implementation of LivC will be based on a combination of scientific, evidence-based information, complemented by indigenous knowledge, and Tokelau-specific experience under the guidance of the Taupulega of each village, as well as best practices and lessons learned from other low lying atolls in the Pacific. In identifying priorities and implementation strategies, the Taupulega will be supported by the principal administration institutions of governance in Tokelau (the General Fono and the Council of the On-Going Government of Tokelau). This support would include:

(i) Seeking new partnerships and further engaging traditional development partners;

(ii) Providing a central point, through a Tokelau Climate Change, Resilient, Readiness & Emergency Services' Office (TCR2O) to ensure enhanced coordination, information management and dissemination, and integration of government's climate change, disaster risks, response and recovery frameworks and development plans;

(iii) Organising and coordinating support from Pacific regional CROP agencies, UN agencies, development partners and key technical agencies to provide financial, policy relevant advice, and technical support, and

(iv) Promoting human development (capacity building, education, training and public awareness and outreach of climate change and related hazards' programmes).

Partnerships, Approaches, and Resourcing

The most critical success factor for the achievement of the LivC goals is to foster partnerships between the TCR2O and other departments of the Government of Tokelau, village councils, civil society, the private sector, regional and international organisations, and developmental partners.

LivC is designed with the understanding that the Government of Tokelau and developmental partners will help support the financing and implementation as outlined in the LivC Implementation Plan, 2017-2022. The present Tokelau climate change programme unit, managed by only one full-time staff member and supported by one external advisor on a fixed term contract, is currently under the Office of the Council of the Ongoing Government of Tokelau (OCOG). The resolution by the General Fono to place climate change as a national development priority under the Tokelau National Development Framework, 2016-2020, provides an opportunity for an immediate independent review of the functions and roles of the present Tokelau climate change programme unit, and how the unit shall be strengthened now and into the future.

MEASURING PROGRESS

The progress of LivC will be coordinated, monitored, reviewed, and evaluated through the Taupulega, the General Fono, and the OCOG.

As described in the Companion LivC Implementation Plan, 2017-2022, progress towards achieving the goals and objectives of LivC will be evaluated against strategic outcomes and development priority areas, every six months.

The TCR2O shall conduct a mid-tern review of the LivC every four years commencing on 30 June 2021.

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ANNEX 1. Tokelau Climate Change Profile.

Societal Impact by Atoll

HAZARD	Atafu	Nukunonu	Fakaofo
Tropical Cyclone	Extreme	Extreme	Extreme
Severe weather non-tropical cyclone systems	Extreme	Extreme	Extreme
Drought	Extreme	Extreme	Extreme
Flood - Storm Surges and King Tides	Extreme	High	High
Flood Runoff - Heavy Rain	High	Extreme	Extreme
Water Spout	High	High	High
Disease Epidemics	Medium	High	High
Bush Fire	Low	Medium	Low
Landslide	Low	Medium	Low
Tsunami and Coastal Inundation from Run-Up	Low	Low	Low

Sources: LivC Situational Analysis Mission (2016); NZ MCDEM (2016), DCRMP, Atafu, Nukunonu; Samoa Red Cross Society (2005); Fakaofo by extrapolation.

ANNEX 2: GLOSSARY

Aumaga The able bodied (men). The aumaga are responsible for looking after the village and do most of the required labour- intensive work in Tokelau society.

Climate Adaptation In human systems, the process of adjustment to actual or expected climate and its effects to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects, human intervention may facilitate adjustment to expected climate.

Climate change in Intergovernmental Panel on Climate Change (IPCC) usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is addition to natural climate variability observed over comparable time periods.

Climate-Resilient Investment Pathways Climate-resilient investment pathways include strategies, choices and actions that reduce climate change and its impacts. Climate-resilient investment pathways include two main categories of responses: (1) Actions to reduce both human induced climate change as well as affects from natural climate variability, and its impacts, including both mitigation and adaptation towards achieving sustainable development; (2) Actions to assure that effective institutions, strategies, and choices for risk management will be identified, implemented, and sustained as an integrated part of achieving sustainable development.

Telecommunications Infrastructure are critical lifelines for Tokelau Nukunonu, August 2016. *Photo courtesy: C.L. Anderson.*

Climate Resilience The capacity for a social-ecological system to (1) absorb stresses and maintain function in the face of external stresses imposed upon it by climate change, and (2) adapt, reorganise, and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future climate change impacts.

Solar Photovoltaic energy on each atoll contributes to Tokelau's decarbonisation scheme, Fakaofo, August 2016. *Photo courtesy*: C.L. Anderson.

Decarbonisation The reduction or removal or carbon dioxide from fossil fuel energy sources. A decarbonised (low-carbon) economy is an economy that has a minimal output of greenhouse gas emissions in general into the environment biosphere, but specifically refers to the greenhouse gas, carbon dioxide.

Disaster The severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Faipule A Government of Tokelau representative on each of the three atolls. The faipule are elected every 3 years during general elections. They are members of the Office of the

Government of Tokelau with portfolios (Ministers); the Ulu of Tokelau is a Faipule and is also the Head of Government.

Fatupaepae Women's committees which are comprised of those women who are finished with school. The wife of the faipule is the President assisted by the Pulenuku's wife. However, the elders of the Fatupaepae are accorded the highest respect.

Fatupaepae engage in LivC strategic planning. Fakaofo, August 2016. *Photo courtesy: Fatu Tauafiafi.*

General Fono The General Assembly, the legislative body that makes national decisions for Tokelau after consultation with the village Taupulega (Village Councils). It is also the Legislative National Committee and the National Budget Committee. The numbers of delegates on the General Fono are representative of the population from each of the three villages.

Hazard The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.

Impacts The effects on natural and human systems. In this document, the term 'impacts' is used to refer to the effects on natural and human systems of physical events, of disasters, and of climate change.

Mitigation (of climate change) A human intervention to reduce the sources or enhance the sinks of greenhouse gases. Note "mitigation" (in the context of disaster risk reduction) is defined as the "lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability." In LivC, we restrict the use of "mitigation" to the climate change definition.

No regrets policies Options or actions to reduce greenhouse gas emissions that have negative net costs. Net costs are negative because these options generate direct or indirect benefits, such as those resulting from reductions in market failures, double dividends through revenue recycling and ancillary benefits that are large enough to offset the costs of implementing the options.

Pulenuku The village mayor, who is also a matai in the village, and is elected every 3-years during the General elections. The Pulenuku traditional role is to take the lead in managing the village affairs from the decisions and policies made by the Taupulega (the Village Council).

Resilience The ability of people, households, communities, countries and systems to mitigate, adapt to and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth. As this definition suggests, the concept (and measurement) of resilience is complex and multidimensional.

Strategy A guide for achieving the sort of future that people want. It can help people, organisations, or a whole system work together more effectively on the most important and prioritised items. Without a strategy, small problems today can become big problems over time.

Taupulega The Village Council. Each atoll has its own council. Fakaofo village comprises of council of elders. Atafu and Nukunonu on the other hand comprise the village council of Matais.

Youth participate in Keyhole Garden Project for adaptation. Atafu, August 2016. *Photo courtesy: P.F. Lefale.*

Tupulaga Youth, including sports teams.

Vulnerability The propensity or predisposition to be adversely affected by climate-related risks.

Above: T**he MV Mataliki ship brings passengers and supplies from Apia, Samoa to Tokelau**. Nukunonu, August 2016. *Photo courtesy:* C.L. Anderson. Left: **Sunset in Atafu**. August 2016. *Photo courtesy:* P. F. Lefale.

Annex F: Companion to Living with Change: Implementation Plan, 2017–2022

Living with Change (LivC):

An Integrated National Strategy for Enhancing the Resilience of Tokelau to Climate Change and Related Hazards, 2017-2030

IMPLEMENTATION PLAN

2017-2022

April 2017

Government of Tokelau

Office of the Council for the Ongoing Government

Photo Courtesy: Cover - Fakaofo Fishing Boats, C.L. Anderson, 2016.

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Office of the Council for the Ongoing Government
Apia, Samoa
http://www.tokelau.org.nz

TABLE OF CONTENTS

ACRONYMS

Agenda 2030	Transforming Our World: the 2030 Agenda for Sustainable Development, 2015-2030
CEDAW	Convention on the Elimination of All Forms of Discrimination Against Women
CRIPs	Climate Resilient Investment Pathways
LivC	Living with Change: An Integrated National Strategy For Enhancing the Resilience of Tokelau to Climate Change and Related Hazards, 2017-2030.
MCDEM	Ministry of Civil Defence, Disaster and Emergency Management, New Zealand
MFAT	Ministry of Foreign Affairs and Trade, New Zealand
SAMOA Pathway	SIDS Accelerated Modalities of Action, 2014
SDGs	Sustainable Development Goals
SIDS	Small Island Developing States
SRDP	Strategy for Resilience Development in the Pacific: An Integrated Approach to Climate Change and Disaster Risk Management (SRDP), 2017-2030
OCOG	Office of the Council of the Ongoing Government of Tokelau
TCR2O	Tokelau Climate Change, Resilient, Readiness & Emergency Services' Office
TNDF	Tokelau National Development Framework, 2016-2020
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

This Implementation Plan, 2017-2022, is the companion document to the ***Living with Change: An Integrated National Strategy for Enhancing the Resilience of Tokelau to Climate Change and Related Hazards, 2017-2030 (LivC)*****.** It provides an overview of how implementation of LivC will occur during the first five years, 1 July 2017 to 30 June 2022. The implementation is the process of bringing LivC to life.

The Vision, Goals, Objectives, Mission, and Benefits of LivC

The vision of LivC is for Tokelau to become a vibrant, innovative, climate-resilient, and ready nation with healthy communities, ecosystems, and an economy that are all resilient in the face of change. This vision will be achieved through developing and incorporating *C*limate *C*hange and related hazards' intelligence *S*ervices (CCS) into decision making, planning, policy, and practice. These services (e.g. renewable energy, energy efficiency and conservation, ocean protection, early warnings, climate variability and change information, predictions and scenarios, etc.) are evidence-based and policy relevant.

LivC is intended to be long lived, and this Implementation Plan is only a first step towards achieving its long-term vision.

LivC has three inter-related strategic Climate Resilient Investment Pathways (CRIPs):

1. **Mitigation: Decarbonisation Development**, revolving around: (i) clean energy, (ii) low carbon, "no regrets"[1] development policies, (iii) reducing the carbon intensity of development processes, (iv) increasing the efficiency of end-use energy consumption, (v) enhancing the resilience of infrastructure, and (vi) increasing the protection and conservation of terrestrial and marine (ocean) ecosystems. This pathway will contribute to clean energy, low carbon economic developments, more resilient and climate proofing infrastructure in place, increase energy security, and enhanced carbon sinks, while decreasing net emissions of greenhouse gases (GHGs).

2. **Adaptation: Strengthened Integrated Risk Reduction and Adaptation to enhance climate change and disaster resilience** entails successfully managing risks caused by climate change and disasters in an integrated manner, within social and economic development planning processes and practices to reduce the accumulation of such risks, and prevent the creation of new risks or loss and damage. This pathway will contribute to resilient development and achieving efficiencies in resource management.

3. **Human Development: Capacity Building, Education, Training, Public Awareness & Outreach,** focusing on: (i) improving the capacity of the three villages (Fakaofo, Nukunonu, Atafu) to prepare for emergencies and disasters, thereby ensuring timely and effective response and recovery in relation to both rapid and slow onset disasters; (ii) Disaster preparedness, response and recovery initiatives to reduce human losses and suffering, and; (iii) minimising adverse impacts on national, villages and local communities' economic, social and environmental systems.

The long-term, high-level outcomes and benefits of LivC are human safety and well-being, climate resilient infrastructure, and Tokelau communities making climate change and related hazards' informed decisions based on CCS.

[1] No regrets policies are defined as "Options or actions to reduce greenhouse gas (GHG) emissions that have negative net costs. Net costs are negative because these options generate direct or indirect benefits, such as those resulting from reductions in market failures, double dividends through revenue recycling, and ancillary benefits that are large enough to offset the costs of implementing the options."

Implementation Plan, 2017-2022

The first phase, 1 July 2017 to 30 June 2019, of implementing LivC is **transitional**. During the transition phase, stakeholders will have the chance to become familiar with LivC. Some stakeholders[2] will be early adopters, working to integrate LivC into their existing organisational services, processes and systems. Key deliverables for the transition phase are; implementing the necessary governance and institutional frameworks; developing national and villages' capabilities, and building partnerships.

The second phase, 1 July 2019 to 30 June 2022, is **consolidation**. During this phase, stakeholders should be familiar with LivC, its established governance and institutional arrangements, and some of the selected concepts in Annex 2 will have progressed to implementable projects. Key deliverables for the consolidation phase are: (i) identification of lessons learned that would contribute to advancing the LivC vision; and, (ii) securing resources to turn the selected concepts in Annex 2 to implementable projects.

Enabling Mechanisms

Recognising the call from the villages during the consultation that LivC should build upon existing government initiatives and not duplicate, there are significant opportunities for synergy with existing programmes and activities within Tokelau Government Departments and Ministries, Village Councils, Civil Society, the Private Sector and Development Partners. However, it was also clear from the consultation that LivC will need a suitable governance structure to support its work in a sustained manner, to implement the proposed activities, and ultimately to meet the needs of Tokelau communities. This governance structure will enable representation of senior public servants of Tokelau government, while bringing experts in appropriate fields, into its structure.

The General Fono will be fully responsible for the high-level governance of the LivC's implementation.

A Tokelau national CCS advisory board (TCCS), is proposed to oversee the implementation of LivC, with the Tokelau Climate Change, Resilient, Readiness & Emergency Services' Office of the Council of the Ongoing Government of Tokelau (TCR2O/OCOG) providing administrative support. The TCCS and TR2O/OCOG will oversee the LivC's activities, but this should not preclude participants from designing and implementing other activities that would fill the gaps and address the LivC priorities.

To promote LivC and to inform its stakeholders of its activities, an effective communication strategy will be put in place. The communication strategy is anticipated to develop and implement local communication plans that will provide information on the implementation of LivC to stakeholders. Publishing early success stories will be a key focus of this strategy.

Resource Mobilisation

While continuing investments in existing development related CCS projects will be the largest component of the resources committed to the implementation of LivC, additional investments will be required to strengthen the capacity of the three villages.

Measuring Progress

Measuring implementation progress will be coordinated, monitored, reviewed, and evaluated through the Taupulega, the General Fono, Council, and the OCOG.

Two independent reviews will be carried out during the duration of this Plan. The first will be carried out after the completion of the first phase on 30 June 2019, and the second on completion of the second phase on 30 June 2022.

[2] The three villages, Tokelau Government Departments and Ministries, Civil Society, the Private Sector and Development Partners.

1. INTRODUCTION

Motorboats used for Local Transportation among Islands in the Atoll. Fakaofo, August 2016. *Photo courtesy*: C.L. Anderson.

Living with, and adapting to change, including climate change, is an everyday reality for Tokelau.

As an atoll nation, Tokelau is highly susceptible to climate change, sea level rise, extreme events, and related hazards. This reality led the Tokelau General Fono in July 2016 to include climate change as part of its national development priorities[3] under the Tokelau National Development Framework, 2016-2020. LivC is Tokelau's response to the General Fono's decision.

In stakeholders' forums in Fakaofo and Atafu, as well as remote engagement with Nukunonu, there was unanimous support by the communities to pursue actions on climate change and related hazards without delay. Informed by these consultations, and building on the work already completed over the years, LivC describes Tokelau's mission and vision of the future, the goals and objectives, specific outcomes, and strategies for action on climate change and related hazards, 2017-2030.

Central to achieving the LivC Vision and Objectives is an effective Climate Change and Related Hazards Intelligence Services (CCS). CCS will facilitate smart decisions and innovative ideas to: (i) reduce the impact of climate change and related disasters, and (ii) contribute to building a vibrant, innovative, climate-resilient, and ready Tokelau with healthy ecosystems, communities, and an economy that are all resilient in the face of change.

Although many of the foundational capabilities and infrastructure for CCS already exist, or are being established in Tokelau, such as the Tokelau Solar Photovoltaics project http://www.tokelau.org.nz/Bulletin/February+2016/Tokelau+Solar.html, coordination of the many programmes that address individual aspects of CCS requires improvement. These components often operate in isolation or independently, and with varying degrees of success. LivC will strengthen and coordinate existing initiatives and develop new ones where needed to meet LivC's goals and objectives.

2. BENEFITS FROM LivC

The vision of LivC is for Tokelau to become **a vibrant, innovative, climate-resilient and ready nation with healthy ecosystems, communities, and an economy that are all resilient in the face of change.** This will be done through developing and incorporating CCS into planning, policy and practice.

LivC is intended to be long lived, and this Implementation Plan, 2017-2022, is only a first step at achieving this long-term vision. It is designed for the first five years of actions.

[3] Sustainability, Infrastructure Development, Human Development, Good Governance and Partnerships.

LivC has three inter-related overarching goals:

1. **Mitigation: Decarbonisation development**, revolves around: (i) clean energy; (ii) low carbon, “no regrets” development policies; (iii) reduction of the carbon intensity of development processes; (iv) increased efficiency of end-use energy consumption; (v) enhanced resilience of infrastructure; and, (vi) increased protection and conservation of terrestrial and marine ecosystems. This pathway will contribute to clean energy, low carbon economic development, more resilient and ‘climate-proofed’ energy infrastructure in place, increased energy security, and enhanced capacity to use oceans (terrestrial and marine ecosystems) as carbon sinks, while decreasing net emissions of greenhouse gases (GHGs).

2. **Adaptation: Strengthened integrated risk reduction and adaptation to enhance climate change and disaster resilience** entails successfully managing risks caused by climate change and disasters in an integrated manner, within social and economic development planning processes and practices to reduce the accumulation of such risks, and prevent the creation of new risks, or loss and damage. This pathway will contribute to strengthening resilient development and achieving efficiencies in resource management.

3. **Human Development: Capacity Building, Education, Training, Public Awareness & Outreach** focuses on (i) improving the capacity of the three villages to prepare for emergencies and disasters, thereby ensuring timely and effective response and recovery in relation to both rapid and slow onset disasters, which may be exacerbated or caused by climate change; (ii) reducing undue human losses and suffering through disaster preparedness, response, and recovery initiatives; and, (iii) minimising adverse consequences for national, villages and local community economic, social and environmental systems.

LivC’s outcomes and benefits are that Tokelau people make climate-smart and innovative decisions, and that CCS are disseminated effectively and in a manner that lends themselves more easily to practical action. These outcomes need to be addressed at an early stage to demonstrate the value of LivC to decision makers, providers, and potential funders.

Effective development and use of CCS will add value for decision making on many economic and social areas, value that has not yet been properly assessed by providers or users.

3. ISSUES TO BE ADDRESSED IN IMPLEMENTATION

The first phase of implementing LivC, 1 July 2017 to 30 June 2019, is transitional. During the transition phase, stakeholders (villages, public servants, development partners) will have the opportunity to become familiar with LivC. Some stakeholders will be early adopters, working to integrate LivC into their exisiting organisational services, processes and systems.

The second phase, 1 July 2019 to 30 June 2022, is consolidation. During this phase, stakeholders should be familiar with LivC, its governance and institutional arrangements’ established, and some of the selected concepts in Annex 2 have progressed to implementable projects.

LivC will prioritise the development and delivery of CCS in three areas; Energy security; protection and conservation of terrestrial and ocean (marine) ecosystems; Integrated risk reduction, adaptation and disaster resilience, and, Human development. As LivC evolves, the needs of users in other areas such as water, health and food security will be addressed.

LivC’s priority areas are closely aligned with those addressed by the Fakaofo, Nukunonu, and Atafu Village Development Plans, 2016-2020, the Tokelau National Development Framework, 2016-2020, the SIDS Accelerated Modalities of Action, 2014 (SAMOA Pathway), the Strategy for Resilience Development in the Pacific: An Integrated Approach to Climate Change and Disaster Risk Management (SRDP), 2017-2030, Agenda 2030, the Paris Agreement 2015, and the Sendai Framework for Disaster Risk Reduction (DRR), 2015-2030.

Boys playing in rainwater. Fakaofo, August 2016. *Photo courtesy*: C.L. Anderson.

LivC was formulated with the understanding that the Tokelau government and development partners will help support its financing and implementation. In the first two years, the Tokelau Climate Change Programme Unit, presently under the Office of the Council for the Ongoing Government of Tokelau (OCOG) will facilitate and coordinate the implementation of LivC until a permanent institutional arrangement, such as the proposed Tokelau Climate Change, Resilient, Readiness & Emergency Services' Office (TCR2O), or a climate change department, is established.

Certain factors such as suitable governance structures and adequate institutional and human capacity (i.e. a well-resourced and fully functional and permanent institutional arrangements (e.g. proposed TCR2O or department) are critical for the successful implementation of LivC. These critical success factors would need to be addressed without delay.

Fostering of partnerships and cooperation between the Climate Change programme unit and other Government Departments and Ministries, Village Councils, Civil Society, the Private Sector and development partners are critical to the successful implementation of LivC.

Recognising the call from the villages during the consultation that LivC should build upon existing government initiatives and not duplicate, there are significant opportunities for synergy with existing programmes and activities within Tokelau Government Departments and Ministries, Village Councils, Civil Society, the Private Sector and development partners. LivC will be implemented by coordinating and promoting activities that help achieve its overall goals. Many of these activities will continue efforts already being made across Tokelau government departments and ministries but will now fit these efforts into a coherent national development framework with common goals.

4. IMPLEMENTATION PRIORITIES

This Implementation Plan identifies a series of project concepts, if fully developed, will address the priority areas. Implementing these projects will demonstrate the value of LivC to Tokelau and development partners, and ensure their sustained commitment while delivering benefits to Tokelau communities. The priorities emerged from the consultation process with the villages in August 2016. Discussions with ministries and key government officials enabled the identification of project concepts that could be developed with currently available or targeted sources of funding in the immediate term, and further expanded into implementable projects within the next five years.

Fatupaepae engage in LivC Strategic Planning. Fakaofo, August 2016. *Photo courtesy*: Fatu Tauafiafi.

Key deliverables over the immediate term include: implementing the necessary governance, management, and reporting frameworks; developing national and villages capabilities; engaging stakeholders (users and development partners); and, building partnerships.

During the five-year benchmark of this plan, LivC aims to facilitate access to improved CCS for Tokelau in the initial priority areas and initiate project activities in additional areas. After ten years, LivC aims to facilitate access to improved CCS across all climate-sensitive sectors and systems-.

The initial project concepts to be developed into implementable projects will be selected using guidelines aligned with the views of the three villages. They will also contribute to developing one or more village capacities, enhancing infrastructure, or building scientific and technical capacity.

The general approach will be to work with existing entities, build upon projects already underway, and identify and engage with key partners and organisations. An important outcome of these initial efforts will be to learn lessons from them to move steadily towards sustainable and valued services.

5. ENABLING MECHANISMS

Students learn how to build gardens. Nukunonu, August 2016. *Photo courtesy*: Litia Maiava.

LivC will need a suitable governance structure to support its work in a sustained manner, to implement the proposed activities successfully and ultimately to meet the needs of Tokelau people (see Annex 2).

This governance structure will enable high level representation of senior public servants of Tokelau government while bringing experts in appropriate fields and sectors into its structure.

The General Fono will be responsible for the high-level governance of the plan's implementation. A Tokelau national CCS advisory board (TCCS) is proposed to oversee the implementation of LivC with the Tokelau Climate Change, Resilient, Readiness & Emergency Services' Office (TCR2O/OGT) providing administrative support.

The TCCS and TR2O/OGT will oversee the LivC's activities, including initial project concepts. This should not preclude participants from designing and implementing other project activities that fill the gaps and address the LivC priorities.

To promote LivC and to inform stakeholders of its activities, an effective communications strategy will be put in place. Publishing early success stories will be a focus of the communication strategy.

6. RESOURCE MOBILISATION

CANCC Side Event during COP 22, November 2016 **.** *Photo Courtesy: Penehuro F. Lefale.*

While continuing investments in existing development related CCS projects will be the largest component of the resources committed to the LivC by far, additional investment will be required to strengthen the capabilities of the three villages.

Targeting sources of funding outside national budget processes will be required. Such sources include development banks, Climate Funds (e.g. Green Climate Fund), United Nations and regional agencies, Overseas Development Assistance, and the private sector.

7. MEASURING PROGRESS

Measuring implementation progress will be coordinated, monitored, reviewed, and evaluated through the Taupulega, the General Iono, Council, and the OCOG.

Two independent reviews will be conducted after the conclusion of the first phase on 30 June 2019, and the second phase on 30 June 2021.

Island environments are vulnerable to environmental change. Fakaofo, August 2016. Photo courtesy: C.L. Anderson.

8. CONCLUSIONS AND NEXT STEPS

LivC aims to enable Tokelau to better manage the risks of and opportunities arising from climate change. LivC emphasises village involvement and capacity building, and the engagement of development partners in this concerted effort designed to maximise benefits for Tokelau. Although the initial projects undertaken will focus on a few climate-sensitive areas, the strategy and implementable projects will benefit other areas impacted by climate change and related hazards in the long term. The initial successes from implementing high priority projects will give momentum to LivC .

Children learn gardening for sustainability. Nukunonu, August 2016. *Photo courtesy:* Litia Maiava.

Providing CCS to support development, planning, and actions will prove an essential component of LivC to further enhance the lives and livelihoods of Tokelau communities.

There are already existing mechanisms, activities, and development plans such as the villages' development plans, 2016-2020, that provide CCS for Tokelau; however, these need to be coordinated to address climate change and related issues. LivC will aid in coordination and alignment of activities. LivC will further create the necessary structures to deliver "needs-based" CCS for Tokelau.

Tokelauans have created safe, clean communities and are eager to sustain their livelihoods in the face of change. Atafu, August 2016. *Photo courtesy*: C.L. Anderson.

ANNEX 1: LivC MATRIX OF KEY OUTCOMES AND PRIORITY ACTIONS

1.1 MITIGATION: DECARBONISATION DEVELOPMENT

Strategic Objective: Reduced carbon intensity of development processes, more efficient end-use energy consumption, increased conservation of oceans (marine) and terrestrial ecosystems and enhancing the resilience of energy infrastructure.

OUTCOME	PRIORITY ACTIONS
Energy security is improved, net emissions of GHGs are decreased, and the resilience of energy infrastructure, oceans, and terrestrial ecosystems is enhanced.	Require energy infrastructure to be designed, located, operated and maintained in ways that minimize hazard risks, as well as the adverse consequences of weather extremes and climate change.
	Tokelau to seek technical and financial support to design and implement its Nationally Determined Contribution (NDCs) and long term decarbonisation development strategies.
	Develop and enforce efficient and effective legislation and regulations covering ocean and coastal management, ecosystem services, energy efficiency codes for public buildings and family households, energy efficiency standards for imported electrical goods.
	Increase resilience of climate change and ocean acidification through effective management.
	Introduce and strengthen environmentally friendly national, village sector policies that promote and achieve and cost-effective production and end-use of all forms of energy, both modern and traditional, with an increasing focus on using energy from local sources.
	Conserve and sustainably manage coasts, oceans and other natural ecosystems in ways that maintain and enhance carbon uptake and stocks in terrestrial and marine ecosystems.
	Establish programmes to support private investment in low carbon development.
	Assess, and if feasible implement, the installation of renewable energy generation for all community facilities including churches, schools, fale fono and community based organisation meeting places.
	Investigate the potential for integrated waste to energy options for village-scale bio-gas production
	Identify, and if feasible implement, financing mechanisms to promote the increased installation and maintenance of renewable energy systems for villages (e.g. Tokelau Renewable Solar Nation Programme) and individual households.

1.2 ADAPTATION: STRENGTHENED INTEGRATION OF CLIMATE CHANGE AND DISASTER RISKS INTELLIGENCE INTO DEVELOPMENT PLANNING AND DECISION MAKING

Strategic Objective: Climate change and disaster risks are successfully managed in an integrated manner, within social and economic planning processes and practices, to reduce accumulation of such risks and non-economic loss and damage (NELD) and to prevent the creation of additional risks.

OUTCOME	PRIORITY ACTIONS
Integration of climate change and disaster risks intelligence into development planning and decision making is strengthened.	Embed climate change and disaster resilient initiatives, using integrated approaches, within national and villages' development strategies, social development plans, sector plans, practices and resource mobilisation.
	Ensure that finance and planning institutions play a central role in strategic, whole of community approaches for climate change and related hazards' resilient development, and that all opportunities for climate change financing are pursued, supported by the Office of the Administration, other development partners, regional and UN agencies. Tokelau should also avail itself of opportunities for technical and financial support for National Adaptation Plans and Adaptation Communications available under the Paris Agreement
	Ensure that annual and medium term budgets include climate change and disaster resilient policy and investments
	Strengthen capacities at the village level through inclusive gender-responsive decision making systems to ensure effective delivery of development initiatives
	Develop and implement, through inclusive multi-sectoral and multi-stakeholder mechanisms, concrete actions on the ground to ensure the climate change and disaster resilience of key public infrastructures, including communications, transports, roads, water and sanitation, hospitals and schools
	Develop a village level set of weather and climate risk indicators to quantify and measure how climate-related risk levels vary over time (e.g. review of the Reducing the risks of storm surge inundation reports for each atoll
	Restore, upgrade and install new climate and weather monitoring, baseline and weather forecasts and early warning systems
	Implement water resource management recommendations in the Integrated Waste Management, Water and Sanitation Review and Action Plan.
	Conduct an updated assessment of drought risk for Tokelau and how it may change under climate change scenarios to assist: 1) Implementation of water resource management recommendations in the Integrated Waste Management, Water and Sanitation Review and Action Plan, 2) agricultural planning and 3) water resources and agriculture early warning

OUTCOME	PRIORITY ACTIONS
	Refine the village coastal hazard (cyclone inundation) maps initially developed in the *Reducing the risks of storm surge inundation* reports for each of atoll and make these available to each Taupulega and community based organisations (Fatupaepae, Aumaga and Youth) on each atoll
	Based on coastal hazard mapping, redefine the risk levels to community buildings and housing initially developed in the *Reducing the Risks of Storm Surge Inundation reports* for each atoll. Make these available to Taupulega and community based organisations (Fatupaepae, Aumaga and Youth) on each atoll.
	Identify and develop increased key crop diversity and resilience to rising temperature, rainfall variability, and soil salinity increases.
	Develop and implement a replanting programme in each village of endangered plant species, particularly those of cultural and economic importance including 'Kanava' (*Cordia sibcordata*), 'Puapua' (*Guetarda speciose*), 'Puka' (*Pisconia grandis*), and 'Fala' (Pandanua special. variety 'Kiekie')

Coastal hazard mapping will consider risks to critical infrastructure, such as bridges. Nukunonu, August 2016. *Photo courtesy:* C.L. Anderson.

1.3 HUMAN DEVELOPMENT: CAPACITY BUILDING, EDUCATION, TRAINING, PUBLIC AWARENESS, AND OUTREACH

Strategic Objective: Enhanced institutional, governance and public awareness of climate change, disaster preparedness, response and recovery.

OUTCOME	PRIORITY ACTIONS
A fully functional and well-resourced Tokelau Climate Change, Resilience, Readiness & Emergency Services (TCR2O).	**Institutional Strengthening**: Review the current functions and roles of the Tokelau Climate Change Programme unit, hire new personnel and establish a fully functional and well- resourced Develop a LivC communication strategy.
A well-informed public.	Ensure climate change and related hazards' services are incorporated in all education and related development areas
Climate Resilient and Ready Villages.	Strengthen each village capacity and capability to prepare and participate effectively in relevant village, national, regional and international forums on climate change and related hazards (e.g. Climate and Ocean Forums, Conferences of the Parties (COP)/ Meetings of the Parties (MOP) to the UNFCCC, Agenda 2030, etc.)
	Climate Change Resilient, Readiness, & Emergency Services
	Implement public awareness and outreach activities in the New Zealand Ministry of Defence Emergency Management Disaster and Climate Risk Management Plan (MCDEM DCRMP) (2016) of each village
	Increase community awareness on use of energy efficient lighting and electrical appliances and energy conservation
	Training by Red Cross Drills by each Village Disaster Management Committees (DMC).
	Create educational opportunities to build specialised knowledge and capacities for Tokelauans in the climate change and related fields.

Tokelauan enage in public awareness campaigns to keep the islands clean and safe. Atafu and Fakaofo, August 2016. Photo courtesy: C.L. Anderson.

ANNEX 2: SELECTED IMMEDIATE AND LONG-TERM CONCEPTS

CRIP 1-1: TOKELAU INTENDED NATIONALLY DETERMINED CONTRIBUTION REPORT

Preparing Tokelau's Intended Nationally Determined Contribution (INDC) Report

Results Areas: International/New Zealand/Pacific Islands' relations, UNFCCC/Paris Agreement Obligations, Climate Finance, Marine Transportation, Renewable Energy Technologies.

Agenda 2030 #3 Ensure healthy lives and promote well-being for all, #7 Access to affordable, reliable, sustained and modern energy for all, #8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, #9 Industry, innovation and infrastructure, #13 Climate Change, #14 Conserve Oceans, #17 Partnerships.

Background
During COP22 in Marrakesh, Morocco, in November 2016, Hon. Paula Bennett, New Zealand's Climate Change Minister announced New Zealand's intention to extend ratification of both the Climate Change Convention and the Paris Agreement to include Tokelau. **https://www.beehive.govt.nz/release/paris-agreement-will-be-extended-include-tokelau.**

All Parties to the UNFCCC and Paris Agreement must prepare an Intended Nationally Determined Contribution (INDC) report. INDC is the term used under the UNFCCC to refer to Parties' intended (voluntary) contributions to reduce their greenhouse gases for the post Kyoto Protocol (2020) period, in the lead up to the 2015 COP21 held in Paris, France, in December 2015.[4] These intended contributions were determined without legal prejudice to the legal nature of the contribution. Under the Paris Agreement, the INDC will become the first Nationally Determined Contribution (NDC) when a country ratifies the agreement, unless they decide to submit a new NDC at the same time. The NDC will become the first greenhouse gas targets under the UNFCCC that applied equally to both developed and developing countries once the Paris Agreement enters into force.

NDCs will be the key vehicle for Parties to communicate internationally how they will cut emissions for the post-2020 period. NDCs will allow Parties to demonstrate leadership on addressing climate change. While climate change is a global challenge, each Party faces unique circumstances, including different emissions profiles and emissions reduction opportunities, different risks from a changing climate and different resource needs.[5]

Through its INDC, Tokelau can tailor its contributions to their own national priorities, capabilities, and responsibilities. These individual measures can be the basis for collective action, and, if they are ambitious enough, set a path towards a decarbonisation (low-carbon) climate-resilient future of which Tokelau is committed to under LivC. A key sector for Tokelau to address under its INDC report is marine transportation. At present, the bulk (at least 90% (estimate) of Tokelau's carbon emissions come from marine transportation. Preparation of INDC Report will offer Tokelau the opportunity to address this major challenge.

Concept
The activity will assist Tokelau prepares her first INDC report. The activity will gather a team of experts to conduct technical dialogues with the three villages and Government of Tokelau officials about designing and preparing Tokelau's INDCs. The team will use the World Resource Institute (WRI) report "Designing and Preparing Intended Nationally Determined Contributions (INDCs" http://www.wri.org/publication/designing-and-preparing-indcs to guide the preparation and design of Tokelau's INDCs report. It is anticipated that the planning and implementation of this activity will be supported by INDC experts from New Zealand, and relevant international and regional (UN and CROP) agencies.

Proposed Outcomes

- Evidence-based, accurate, and reliable INDC report for Tokelau.
- INDC report will further guide the decarbonisation development pathway (CRIP) for Tokelau.

[4] https://en.wikipedia.org/wiki/Intended_Nationally_Determined_Contributions.

[5] http://www.wri.org/publication/designing-and-preparing-indcs

- Build local capacity on INDC.
- Increased awareness and knowledge of Tokelau communities about INDCs.
- Improved quality of life on the atolls of Tokelau.

Proposed Outputs

- Technical Assistance.
- INDC plans for each village and a national plan identifying human resources and contracted services needed to support villages to implement their INDC plans.
- Tokelau INDC Report.

CRIP 1-2: THE TOKELAU RENEWABLE ENERGY PROGRAMME

Reducing the carbon intensity of development processes by increasing the uptake of Renewable Energy Technologies.

Results Areas: Livelihoods of people, access to affordable renewable energy technologies, promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all.

Agenda 2030: SDGs #3 Ensure healthy lives and promote well-being for all at all ages, #7 Access to affordable, reliable, sustained and modern energy for all, #8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, #9 Industry, innovation and infrastructure, #13 Climate Change, #14 Conserve Oceans, #16 Promote peaceful and inclusive societies for sustainable development, and #17 Partnerships.

Background

Tokelau has been a world leader at shifting from diesel to renewable energy (RE) to generate electricity despite its binding constraints of geographic isolation, small population, small land area, skill shortages and a decentralised governance structure. When solar photo-voltaic (PV) systems were installed in 2013, they provided close to 100% renewable electricity. Since then demand for electricity has risen sharply and this additional demand has been met by diesel generation.

The goal of the Government of Tokelau (GoT) as stated in its National Energy Policy and Strategic Plan is to generate 100% of its electricity from renewable sources. To achieve this, the GoT has committed funding to upgrade village electricity distribution networks expand the existing PV systems and investigate other options.

The Tokelau Department of Energy (DOE) will soon install a trial wind turbine on Fakaofo, and collect data for six months to determine if wind-powered electricity is a viable option. GoT has also undertaken initial research on biogas options. This concept focuses on these alternative sources of renewable energy generation, reduction in electricity demand, policy responses and research to enable other Pacific countries to benefit from the lessons learned from Tokelau's pioneering RE experiences.

Concept

The Tokelau Renewable Energy Programme (TREP) featured in MWH's Evaluation of Infrastructure Investment in the Pacific, Stage 2 Report, August 2015. The TREP design used data from 2008 to estimate total demand across Tokelau. At the time of installation, the load had increased by 15% above baseline. Electricity demands on the islands have increased further since commissioning (Fakaofo load increased by 37% (1002 kWh/day to 1443 kWh/day), Nukunonu 24% (698 kWh/day to 920 kWh/day) and Atafu 11% (776 kWh/day to 907 kWh/day). This means the PV system is relying more heavily on the battery storage and diesel back up than was intended.

The benefits of TREP in the first full year of operation included reducing diesel consumption by 536,000 litres, saving an estimated NZ$1 million in the first year, and avoiding 1383 tonnes of carbon dioxide emissions. Tokelau's vulnerabilities to diesel prices and supply issues were reduced. Blackouts had been common, but the solar PV systems have provided reliable electricity.

Households are consuming more electricity because reliability has improved and the tariff (NZD 50 cents per kwh) is subsidised. This has led to higher household spending on electricity, whiteware and electronics to help with household chores, refrigeration and access to leisure activities and media (TV, DVDs). These changes are seen as improvements to quality of life. But there is, as yet, no data on the impacts of reliable electricity 24/7. The impacts include improving the ability to keep food, increasing flexibility in the timing of daily chores, reducing time spent on cooking, laundry and construction through use of power driven tools and appliances, guaranteed light in the evenings for study, and use of RE powered vehicles. MWH observed that the results achieved in Tokelau could "provide a body of knowledge and learning for the industry." One lesson that has been applied elsewhere is the need to design for significant increases in household consumption and higher total loads. With financing from the GoT budget, DOE is increasing the solar PV generation on each atoll, upgrading the overloaded village high and low voltage distribution systems and installing a trial wind turbine to confirm wind data. Should this wind prove effective, the DOE proposes to create hybrid RE (solar/wind) generation mini-grids to reducing the battery load demand, improve battery longevity and reduce diesel consumption. UNDP has worked with the DOE to implement energy efficiency measures (e.g. enabling the purchases of more efficient appliances). The DOE is continuing this work. It would welcome assistance to collect and analyse data on impacts of reliable electricity supply, the effectiveness of its policy settings (tariff, asset management, energy efficiency) and actions (energy efficiency incentives, community awareness) which will be of benefit to other Pacific countries. Expanding access to affordable, reliable clean energy is a strategic investment priority for the New Zealand Aid Programme for 2015/19. The GoT has a goal of generating 100% of its electricity from renewable sources. The GoT has used its RE achievements to advocate internationally for climate change mitigation. Its interests in this area are ultimately the same as New Zealand's.

Tokelau is a pilot country for the New Zealand Pacific Partnership on Ocean Acidification which aims to build the resilience of communities and ecosystems by enabling communities to gather data on ocean and lagoon health. This pilot can be linked to measuring the health of the atoll lagoons and the impact of the proposed biogas options on reducing the seepage of pollutants into the lagoons.

The proposed outcomes of the proposed investment are that the GoT will have:

- the capability to collect and analyse data to select the most effective options for generating electricity from alternative sources;
- the financial and human resources to implement cost-effective options;
- the commitment to collaborate with independent researchers to monitor the impacts of GoT policies and RE developments in order to generate research findings that would assist other Pacific countries with related policy settings and investment decisions.

The planned expansion of solar PV will not achieve GoT's goal of 100% electricity from RE so the following options have been considered:

(a) Bio oil from local coconut was considered first. There are many inhibiting factors that reduce the feasibility of this option including the large labour component and the small size of Tokelau coconuts compared to more fertile islands. Furthermore, most land is privately owned, most trees are old and producing fewer nuts, and coconuts are staple food source.

(b) Wind power data has been collected and data analysis indicates it will work as a back up to solar PV in low solar radiation to ease battery demand and reduce the use of diesel. The type of wind turbine identified has proven it withstands cyclone conditions. Minimal maintenance required. It requires little technical expertise and can be monitored remotely. The minimum pay back on investment is 9 years on an expected 25year life. Environmental impact is limited to possible bird strike because of low noise pollution.

(c) Biogas options are under consideration for the environmental benefits. The biogas could be captured for cooking, lighting and compressed to CNG for fuelling vehicles and generators. Once set up biogas requires minimal maintenance and its fertilizer by-product would increase local food production. The primary focus will investigate the costs, benefits, and cultural acceptability of converting piggery waste water (since family-owned pigs are penned in one place) and village septic waste water into biogas.

Proposed Outcomes

- Electricity demand met through alternative renewable sources.
- Reduction in importation of diesel and LPG.
- (For biogas) reduction in organic waste seeping into the lagoons.
- Reduction in greenhouse gas emissions.
- Battery state of health (SOH) improved.
- Improved quality of life on the atolls of Tokelau.

Proposed Outputs

- Staff training in RE asset management and maintenance.
- Data on causes of big increases in electricity demand analysed, shared with communities to raise awareness, used to identify GoT energy efficiency investment options and available to inform policy decisions of other Pacific nations.
- Independent analysis and assessment of trial wind turbine data. If viable, installation of nine wind turbines.
- Bio-gas feasibility study on each atoll.
- If viable, design and construction of piggery waste collection and biogas plants.
- If viable, co-finance with GoT and other partners the design and construction of waste water collection and biogas plants.
- Independent evaluation of impact of alternative RE options after implementation.

CRIP 2-1: REDUCING THE RISKS OF INUNDATION IN TOKELAU

Protecting Tokelau from the impact of rising sea levels and increasing extreme weather and climate events that threaten the islands' viability

Results Areas: Livelihoods of people, promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

Agenda 2030: #3 Ensure healthy lives and promote well-being for all at all ages, #8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, #9 Industry, innovation and infrastructure, #13 Climate Change, #14 Conserve Oceans, #17 Partnerships.

Background

The low-lying atolls of Tokelau are sensitive to climate change and related hazards. The islands that make up Tokelau's atolls are typically not more than 200 metres wide and no point on Tokelau is higher than five metres. This means Tokelau is particularly vulnerable to coastal erosion and inundation damage caused by rising sea levels and weather events (including cyclones, strong winds, storm tides). Dealing with the effects of climate change is a national development priority for Tokelau. The government has identified a number of priority actions which present the most immediate opportunities to increase human safety and well-being.

Concept

This activity aims to build coastal resilience and manage coastal inundation risks in all three villages by formulating and implementing a coastal hazard risk reduction plan to reduce the impact of increasingly intensive wave action on areas identified as most in need of coastal protection. It draws on technical recommendations from 2006 NIWA reports, commissioned by UNDP, which identify the inundation risks and options for reducing the risks associated with storm surges and tropical cyclones. The proposed activity will enable the Government of Tokelau (GoT) and villages to implement measures that are urgently required to reduce the impact of increasingly intensive wave action on coastlines and key infrastructure.

With New Zealand financing, it is expected that high-value vulnerable coasts will be made more resilient to the effects of waves, compared with the baseline of 2006. Expected direct benefits are significant with 1,499 people, 100% of the total population, benefiting. Further the atolls which are the home of Tokelau's language, culture and people (including Tokelauans living overseas) will be protected for future generations.

Climate change is one of five strategic areas of focus in the draft Tokelau National Strategic Plan (2016-2020) and resilience to the impacts of climate change and related hazards is identified as a long term outcome. The proposed activity is the immediate priority under Tokelau's National Strategy for Enhancing the Resilience of Tokelau to Climate Change and Related Hazards (LivC) approved by the General Fono in March 2017. Tokelau's constitutional status (non-self-governing territory administered by NZ) limits its funding options including, for example, eligibility to access the Green Climate Fund. At the General Fono, the village representatives welcomed the potential support they have been expecting for years.

It is intended that the design of this activity is supported by the planned updates by NIWA of its 2006 inundation risk reports, which are being funded under the Disaster Response and Risk Management activity, funded through NZ Partnerships and Humanitarian response programme.

The activity aligns with numerous international agreements including Agenda 2030 (specifically SDG13 which calls for urgent action on climate change and its impacts), the Paris Agreement, Sendai and the SIDS Accelerated Modalities of Actions (SAMOA) Pathway, 2014.

The following options for coastal protection are based on the lists of priority actions recommended in the 2006 NIWA inundation risks reports. The design team and villages would consider the current condition and impacts of coastline infrastructures that have been completed by the villages since 2006, and develop a comprehensive plan for coastal protection focused on vulnerable and high-value areas.

During the consultations with villages on the LivC strategy, they identified the following options:

- Demolition of existing seawalls which have deteriorated and construction of new seawalls;
- Maintenance of existing seawalls;
- Coastline planting;
- Structures to reclaim and extend land and to increase the resilience of vulnerable coasts;
- Employing a sand pump to build up beaches; and
- Raising awareness to limit sand minding or other activities that reduce the effectiveness of natural defences.

It is proposed the coastal hazard risk reduction plan and detailed designs for coastal resilience would cover not only what can be funded through this activity, but also identify specific work which agencies such as SPREP and other partners could assist with in subsequent phases. This the preferred option because human-made coastal structures are already having environmental, social and economic impacts on the atolls and Tokelau's small land masses and fragile ecosystems make it critical that these impacts are mitigated in a comprehensive long term plan.

Proposed Outcomes

- Effective coastal protection for public safety and community infrastructure, with an emphasis on inundation damage and hazards associated with extreme events;
- Strengthening integration of climate change and disaster risk into capital development planning and decision making, and human resource development plans to reduce the accumulation of existing risks and prevent the creation of additional risks;
- Increased awareness and knowledge of coastal management and risk reduction.

Proposed Outputs

- Technical Assistance.
- Coastal hazard risk reduction plans for each village and a national plan identifying human resources and contracted services needed to support villages to implement their plans.
- Preliminary and detailed designs for coastal protection infrastructure and measures.
- Construction and quality assurance services out-sourced where necessary to implement the plan.

CRIP 2-2: TOKELAU RESTORATION OF CLIMATE, WEATHER, WATER, AND OCEAN SERVICES

Protecting Tokelau from climate, weather, water and marine-related disasters by restoring, upgrading and installing new climate, weather, water and ocean monitoring and observational networks and related services.

Results Areas: Climate, Weather, Water, Ocean, Resilience and Readiness Services, Climate Science and Technologies.

Agenda 2030: SDG #3 Ensure healthy lives and promote well-being for all at all ages, #7 Access to affordable, reliable, sustained and modern energy for all, #8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, #9 Industry, innovation and infrastructure, #13 Climate Change, #14 Conserve Oceans, #17 Partnerships

Background

Climate change poses considerable challenges for Tokelau due to its small size, surrounded by large expanses of ocean, highly prone to natural disasters, particularly extreme events such tropical storms and droughts. Understanding and responding to the onset of extreme climate, weather, water and ocean related events as well as understanding current and future climate change requires a robust, sustained climate observing and monitoring programme. Tokelau does not have such a programme at present.

The need for a fully functional and operational National Meteorological and Hydrological Services (NMHS) for any country is critical to understanding and adapting to climate change. NMHs are responsible for protecting life and property and understanding climate change via research, monitoring and observing on a daily basis changes in the weather, climate, and water systems, and issuing weather bulletins and severe weather warnings. Article 5 of the UNFCCC specifically recognises the importance of research and systematic observation in understanding climate change. It states;

"*In carrying out their commitments under Article 4, paragraph 1(g), the Parties shall:*

(a) Support and further develop, as appropriate, international and intergovernmental programmes and networks or organisations aimed at defining, conducting, assessing and financing research, data collection and systematic observation, taking into account the need to minimise duplication of effort;

(b) Support international and intergovernmental efforts to strengthen systematic observation and national scientific and technical research capacities and capabilities, particularly in developing countries, and to promote access to, and the exchange of, data and analyses thereof obtained from areas beyond national jurisdiction; and

(c) Take into account the particular concerns and needs of developing countries and cooperate in improving their endogenous capacities and capabilities to participate in the efforts referred to in subparagraphs (a) and (b) above."

This activity will re-establish and build new weather, climate, water, ocean and related programmes in all three of Tokelau's atolls (Construction of 3 new meteorological buildings, weather, climate, water and ocean monitoring and observations programs, Public and Severe Weather Warning system, Climate Early Warning System (CLEWS), Water Monitoring and Management System, Ocean Monitoring Programme).

Concept

This activity will re-establish, restore, upgrade and build new climate, weather, water, ocean and related programmes, including construction of new NMHS buildings, in all three of Tokelau's atolls.[6] The goal is at least 90% of the country will be monitored and issued with daily weather bulletins (public and marine forecasts, severe weather and tropical cyclone warnings), seasonal climate and ocean outlooks, and climate change and seas level changes scenarios. The investments will build upon existing initiatives, using a range of measures for building and restoring weather, climate, water and ocean monitoring programmes. National capacity for climate, weather, water and ocean monitoring and management will also be developed and the project will help catalyse additional climate, weather, water and ocean monitoring and observations finance from development partners. The proposed activity will work with the three villages and relevant UN/CROP and other scientific organisations to undertake public awareness and outreach to ensure they understand and apply the information and services offered by the NMHSs.

Proposed Outcomes

- Effective climate, weather, water and related environmental conditions monitoring programme for public safety and community infrastructure, with an emphasis on severe weather and extreme climate events;
- Strengthening integration of weather, climate change and disaster risk into capital development planning and decision making, and human resource development plans to protect lives and property;
- Increased awareness and knowledge of weather, climate, water, ocean and related environmental hazards.

Proposed Outputs

- Technical Assistance.
- 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 to implement their plans.

[6] For full information on why Tokelau needs to restore its observing network, visit https://unfccc.int/files/science/workstreams/systematic_observation/application/pdf/gcos_ip_10oct2016.pdf.

- Preliminary and detailed designs for meteorological services infrastructure and measures.
- Construction of NMHs buildings.

CRIP 3-1: TOKELAU CLIMATE CHANGE, RESILIENCE, READINESS & EMERGENCY SERVICES' OFFICE

Establishing a new Tokelau Climate Change, Resilience, Readiness and Emergency Services' Office

Results Areas: Livelihoods of people, Governance and Institutional Arrangements, Applications of Weather, Climate, Resilience and Readiness Intelligence' Services (CCS), Human development.

Agenda 2030: #4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, #5 Achieve gender equality and empower all women and girls, #8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, #9 Industry, innovation and infrastructure, #11 Make human settlements inclusive, safe, resilient and sustainable, #13 Climate Change, #14 Conserve and sustainably use the Oceans, #17 Partnerships.

Background
LivC specifically identified the need for a suitable governance structure to support its implementation in a sustained manner, to implement the proposed activities successfully, and ultimately to meet the needs of Tokelauans. This activity will address this need.

Concept
The activity will review existing institutional arrangements in the environmental and sustainable development fields in Tokelau. The recently adopted LivC Strategy for Tokelau, 2017-2030, noted "[t]he successful implementation of the LivC Strategy depends on a well-resourced and function office". It further noted "[t]he LIVC Strategy is formulated with the understandi9ng that Tokelau Government and development partners will support its financing and implementation. The basis for the institutional; elements will be the Tokelau Climate Resilience and Ready Office (TCR2O)". The strategy details the roles and functions of the proposed office/department, including but not limited to the following.

"The TCR2O will lead and guide the implementation of the [LivC] Strategy. The TCR2O will also act as the political, legal and administrative entity responsible for implementing the Strategy together with the General Fono, Tapulega, and other appropriate and relevant partners and stakeholders."

The challenge right now is the fact that there is no fully functional TCR2O in place. The LivC Strategy rightly pointed out the current set up of one fulltime Climate Change Program Manager and 1 external advisor on a fixed term contract to manage Tokelau climate change and DRM programs and activities is not good enough and unsustainable. This activity will assess what the best options for Tokelau in strengthening its internal capacity to absorb and manage climate change and related hazards.

Proposed Outcomes
- 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 the creation of additional risks; and,
- Increased awareness and knowledge of climate change, risk management and risk reduction.

Proposed Outputs
- Expert Assistance.
- Report outlining options for a new 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.

CRIP 3-2: INCREASE RESILIENCE TO CLIMATE CHANGE AND OCEAN ACIDIFICATION

Provide training opportunities to Tokelauans to increase their understanding of the impacts of climate change, the predicted range of changes that will occur, including uncertainties associated with climate outlooks and climate change scenarios, and management strategies that address the impacts of climate change on marine and coastal ecosystems.

Results Areas: Livelihoods of people, Ocean (Marine) and Coastal Ecosystems, Climate Change, Ocean Acidification, Capacity Building.

Agenda 2030: #3 Ensure healthy lives and promote well-being for all at all ages, #4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, #5 Achieve gender equality and empower all women and girls, #6 Ensure availability and sustainable management of water and sanitation for all, #8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, #11 Make human settlements inclusive, safe. Resilient and sustainable, #9 Industry, innovation and infrastructure, #13 Climate Change, #14 Conserve and sustainably use the Oceans, #17 Partnerships.

Background

In March 2017, the Governments of Tokelau and New Zealand, together with Secretariat of the Pacific Regional Environment Programme (SPREP), Secretariat of the Pacific Community (SPC) and the University of the South Pacific (USP), hosted a Climate Change and Ocean Acidification workshop for Tokelau public servants, community leaders, youth and NGOs in Apia, Samoa. http://www.tokelau.org.nz/Bulletin/March+2017/Ocean+acidification+monitoring.html

The main objectives of the workshop were (i) to inform participants about Climate change and Ocean Acidification; (ii) to inform participants about the NZ Pacific Partnership on Ocean Acidification (PPOA) project; (ii) to build capacity on the importance of coral reef ecosystem and the stressors that threaten their survival, and; (iii) to discuss community management and adaptation activities for the proposed ocean acidification pilot site. This proposed activity will address the key priorities and recommendations that came out of the Apia workshop.

Concept

The New Zealand Pacific Partnership on Ocean Acidification (PPOA) project is a collaborative effort between the Secretariat of the Pacific Regional Environment Programme (SPREP), the University of the South Pacific, and the Pacific Community, which aims to build resilience to ocean acidification in Pacific Island communities and ecosystems, with financial support from NZ Ministry of Foreign Affairs and Trade and the Government of Monaco. The PPOA project follows the "*International Workshop on Ocean Acidification: State-of-the-Science Considerations for Small Island Developing States*" that was co-hosted by New Zealand and the United States, in partnership with SPREP, as an official side-event of the 3rd UN SIDS Conference.

The PPOA project is working to build resilience Ocean Acidification in Pacific Island countries by:

1. Identification and Implementation of Practical Adaptation Actions – Once a pilot site is selected in one of the chosen countries, the project will carry out an Ecosystem and Social Resilience Assessment and Mapping (ESRAM) study that will guide the implementation of adaptation activities at the site.

2. Research and Monitoring – As part of the ESRAM study, the project will establish chemical and biological baselines which will be followed up by routine monitoring of key parameters.

3. Capacity Building and Awareness Raising – During the ESRAM study and throughout the implementation of adaptation activities, the project will seek to build capacity within the local communities and partners, to address OA and to develop effective coastal zone management. Additionally, the project will seek to raise awareness of ocean acidification at all levels.

The PPOA project recently (October 2015) hosted a regional ocean acidification workshop in Auckland, attended by Tokelau and also contributed to formulation of a regional ocean acidification vulnerability assessment (available at http://www.sprep.org/attachments/Publications/CC/ocean-acidification.pdf). With the recent endorsement of the PPOA project by the Government of Tokelau, the next step for the project is to establish an ocean acidification adaptation pilot project site in Tokelau.

The Apia workshop is a follow up to the Auckland workshop. The Apia workshop identified key priority areas that Tokelau need to explore as it moves towards establishing a pilot site.

This activity aims to consolidate the key findings and recommendations from the Apia workshop. The goal is to identify ‘climate and ocean acidification’ champions from the Apia workshop participants and work with them to conduct in-villages public awareness and outreach activities on climate change, ocean acidification and the PPOA.

Proposed Outcomes

- 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; and,
- Improved ability to reduce risk and improve planning with knowledge of more effective methods for resource allocation.

Proposed Outputs

- 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.

CRIP 3-3 Tokelau Intergenerational Knowledge System

Establishing intergenerational and intercultural dialogue on climate change and related hazards among Tokelauan communities in Tokelau, Samoa, and New Zealand.

Results Areas: Livelihoods and knowledge transfer; integrating technology with indigenous learning systems to sustain and perpetuate cultural knowledge; sustaining dialogue among generations; enabling relocated Tokelauans to retain cultural knowledge.

Agenda 2030: #4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, #5 Achieve gender equality and empower all women and girls, #8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, #9 Industry, innovation and infrastructure, #11 Make human settlements inclusive, safe, resilient and sustainable, #13 Climate Change, #14 Conserve and sustainably use the Oceans, #17 Partnerships.

Background
One of the key components of LivC Strategy is the development of an Intergenerational Knowledge System (IKS). It is widely accepted there is an urgent need to document and rescue Tokelau Traditional Ecological Knowledge (TEK) which is fundamental to the long-term goals of LivC as it instils intergenerational collaboration and coordination to ensure sustainability of culture and climate knowledge in Tokelauan communities in Tokelau, Samoa, and New Zealand.

The IKS ensures that climate change policies, actions, and strategies are understood across generations and institutions to capture successes and lessons that are sustained through an intergenerational knowledge system (IKS). One of the inhibitors to moving forward in addressing climate change is the lack of institutional memory and knowledge transfer of Tokelau’s involvement in climate change actions, negotiations, and policy implementation. In the Pacific Islands, it has long been recognized that “brain drain” or loss of educated citizens to other countries results in challenges to staff and personnel retention as well as the loss in continuity of governmental and institutional actions. In many recent proposals and activities targeting resilience and sustainability, the challenge has been addressed by involving youth in strategic planning and programme development to ensure that governments, organizations, and communities retain knowledge.

Concept
The activity will aid in establishing the IKS with the LivC and climate change programme to ensure its longevity. Funding will be used to analyse dialogues and meeting results from LivC consultations in Tokelau, and to determine the appropriate ways to involve youth in engaging in dialogues with elders on

climate change. The intent is to design a culturally-appropriate means of using technology and database management to enable sustainability of culture.

The initial aspect of this activity will engage youth in thinking about climate change as they design questions for elders in their communities about climate, observed changes in climate, climate impacts, culturally appropriate interventions, and climate and disaster resilience. Youth will be trained in ethical research protocols, and will engage in dialogues with elders in culturally-appropriate settings. The activity will conduct meetings involving Tokelauan youth with Tokelauan diaspora communities in Samoa and/or New Zealand– both to build awareness of climate impacts, discuss culture knowledge and climate, and to engage students in interviews and intercultural discussions. The results of the interviews and discussions will be analysed and categorised for inclusion in a database on a web-based platform for use by Tokelauan communities to share climate experiences and protect cultural knowledge.

One aspect is that the LivC strategy and climate change programme will engage with the local schools to build awareness of climate change and involve students in visioning their climate future. There will be formal discussions of the integration of climate science into the science curriculum. Informally, there will be an approach to have children/youth "talk-story" with their elders about climate impacts or changes in relation to their livelihood activities or specialized skills (such as carving, navigation, traditional medicine, agriculture, or fishing). The activity will capture the conversations on videotape for archive and use in climate.

In addition, the activity will identify youth 'shadows' for regional and international climate meetings, with opportunities to train as interns, to learn climate diplomacy, and to understand the linkages with climate science and policy. Funding will be needed for travel costs to include youth in regional and international meetings.

Father and Son playing in the Fale Pa.
Nukunonu, August 2016. Photo courtesy: C.L. Anderson.

Proposed Outcomes

- Increased interest among Tokelauan youth in climate science and policy;
- Implementation of an assessment on cultural aspects of climate conducted by youth interviewing elders and adults, with youth trained in ethical research design;
- Identification of resilience indicators and strategies that are informed by culture and maintain links and dialogues among communities; and,
- Establishment of a process that supports ongoing, intergenerational, and intercultural dialogue among Tokelauan communities in Tokelau, Samoa, and New Zealand as the Tokelau Climate Programme grows and as LivC is implemented.

Proposed Outputs

- Determination of a culturally appropriate framework for the IKS developed by Tokelauan communities with input from elders, adults, youth, and children in the community.
- Intergenerational Knowledge System database and shared learning platform.
- Tokelauan youth trained in protocols for engaging in local, regional, and international climate change activities.

CRIP 3-4: GENDER-DIFFERENTIATED CLIMATE IMPACTS AND RESILIENCE ANALYSIS

Enhancing understanding of the current and potential impacts of climate change on women and men at different ages.

Results Areas: Improved understanding of climate change impacts throughout the community; gender-differentiated climate change impacts and impacts on livelihoods, resources, and divisions of labour; improved knowledge of resilience activities; improved disaster risk reduction planning and resource allocation.

Agenda 2030: #4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, #5 Achieve gender equality and empower all women and girls, #8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, #9 Industry, innovation and infrastructure, #11 Make human settlements inclusive, safe, resilient and sustainable, #13 Climate Change, #14 Conserve and sustainably use the Oceans, #17 Partnerships

Background

Experiences shared from a number of Pacific island countries show that women, and their families and communities, are undergoing increasing hardships in their daily lives as a result of climate change impacts on agriculture, land availability, water resources, fishing, mining and other sectors. At the same time, there is recognition that knowledge and capacity to deal with changes in natural resource management has not been adequately factored into assessments of resilience to climate change. Women are affected differently from men by climate change and associated natural disasters such as floods, droughts, cyclones, and storms. This is largely because men and women are bound by distinct socioeconomic roles and responsibilities, including different divisions of labour, that give rise to differences in vulnerability and ability to cope with these climate change consequences. As a result, vulnerable groups are likely to be faced with problems such as food insecurity, loss of livelihood, hardships due to environmental degradation that lead to displacement, and a host of other potentially devastating economic and social consequences. There remain significant analytical gaps for Tokelau about the changes and these impacts on communities.

There have not been sufficient gender-differentiated, intergenerational, or socioeconomic vulnerability assessments to demonstrate the impacts of climate change on men and on women in Tokelau at different ages. A gender study necessitates understanding the way that society works with respect to women and men, as well as consideration of age, community, and other socioeconomic and demographic factors. Because of the lack of knowledge and socioeconomic data applied to climate change, the LivC has not been informed adequately about the differential risks of climate change to members of the community.

Concept

Multiple methods will be used in conducting this study on the gender-differentiated impacts of climate change in Tokelau. The analysis, which are currently being used by the LivC Strategy, will be informed by:

Participatory Engagement: The three Taupulega (Council of elders) on each atoll will make it possible for this proposed activity to work with the villages and people. The Taupulega are led by the Pulenuku (village mayor). The three Pulenuku are also members of the Council of the Ongoing Government, and are essential to the implementation of this activity. The activity team will work through the General Managers and Coordinator for the Pulenuku for the Tokelau Atolls of Fakaofo, Nukunonu, and Atafu. The proposed groups the activity team will partner with in Tokelau will be: i) Taupulega (Council of Elders); ii) Aumaga (able-bodied men); iii) Fatupaepae (Women's group); and iv) Tupulaga (Youth/Sports). The assessment and analysis of differential impacts will involve consultation and group discussions, as well as key informant interviews and integration with updated demographic information.

Equality and Human Rights: The Constitution of Tokelau offers protection to all the people of Tokelau. The Constitution of Tokelau asserts that "…the Tokelau way, which includes a commitment to a life of interdependence where the less fortunate are cared for, the *inati* system of sharing resources, equal opportunity to participate in the life of the community, and the right to live happily." The approach to the research takes into account the cultural values and equality ensured to all the people of Tokelau.

Intergenerational Knowledge: The approach will ensure intersectional gender analysis by engaging with different age groups and integrating demographic data in the analysis. The intergenerational approach will ensure that there is an awareness of climate change and impacts in relation to activities and divisions of labour throughout the communities.

The proposed activity will: 1) Conduct a Document Review across Sectors to develop a literature review and analysis of gender understanding and approaches in Tokelau; 2) Conduct consultations with key people in ministries on their awareness and use of gender-responsive and intergenerational approaches in the design and development of programmes and projects; 3) Conduct consultations in Tokelauan communities (Fakaofo, Nukunonu, and Atafu) to determine gender-differentiated roles and divisions of labour at the community level; 4) Develop a draft report for review by ministries, project leaders, and community participants that integrates the findings from the consultations and the analysis from the literature review and review of gender; and, 5) Revise and refine the report with recommendations for gender mainstreaming and monitoring progress in implementation.

Proposed Outcomes

- Improved understanding of the impacts of climate change on women and men at different ages;
- Improved understanding of resilience and capacity that can be integrated into climate change strategies; and,
- Improved ability to reduce risk and improve planning with knowledge of more effective methods for resource allocation.

Proposed Outputs

- Report that contributes to the knowledge of gender-differentiated impacts of climate change in Tokelau.
- A process that uses approaches that will have co-benefits for understanding risks, identifying capabilities and capacities to reduce risks, and improving resilience.
- An analysis that can be used locally to improve planning and as a regional an international contribution towards legally binding agreements (i.e. CEDAW, SDGs).

Men engage in shipping transfer activities. Nukunonu, August 2016. *Photo courtesy*: C.L. Anderson.

Women of all ages relax after completing a community weaving project. Fakaofo, August 2016. *Photo courtesy*: C.L. Anderson

ANNEX 3: GLOSSARY

Aumaga The able bodied (men). The aumaga are responsible for looking after the village and do most of the required labour- intensive work in Tokelau society.

Climate Adaptation In human systems, the process of adjustment to actual or expected climate and its effects to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects, human intervention may facilitate adjustment to expected climate.

Climate change in Intergovernmental Panel on Climate Change (IPCC) usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is addition to natural climate variability observed over comparable time periods.

Climate-Resilient Investment Pathways Climate-resilient investment pathways include strategies, choices and actions that reduce climate change and its impacts. Climate-resilient investment pathways include two main categories of responses: (1) Actions to reduce both human induced climate change as well as affects from natural climate variability, and its impacts, including both mitigation and adaptation towards achieving sustainable development; (2) Actions to assure that effective institutions, strategies, and choices for risk management will be identified, implemented, and sustained as an integrated part of achieving sustainable development.

Telecommunications Infrastructure are critical lifelines for Tokelau Nukunonu, August 2016. *Photo courtesy: C.L. Anderson.*

Climate Resilience The capacity for a social-ecological system to (1) absorb stresses and maintain function in the face of external stresses imposed upon it by climate change, and (2) adapt, reorganise, and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future climate change impacts.

Solar Photovoltaic energy on each atoll contributes to Tokelau's decarbonisation scheme, Fakaofo, August 2016. *Photo courtesy*: C.L. Anderson.

Decarbonisation The reduction or removal or carbon dioxide from fossil fuel energy sources. A decarbonised (low-carbon) economy is an economy that has a minimal output of greenhouse gas emissions in general into the environment biosphere, but specifically refers to the greenhouse gas, carbon dioxide.

Disaster The severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Faipule A Government of Tokelau representative on each of the three atolls. The faipule are elected every 3 years during general elections. They are members of the Office of the

Government of Tokelau with portfolios (Ministers); the Ulu of Tokelau is a Faipule and is also the Head of Government.

Fatupaepae Women's committees which are comprised of those women who are finished with school. The wife of the faipule is the President assisted by the Pulenuku's wife. However, the elders of the Fatupaepae are accorded the highest respect.

Fatupaepae engage in LivC strategic planning. Fakaofo, August 2016. *Photo courtesy: Fatu Tauafiafi.*

General Fono The General Assembly, the legislative body that makes national decisions for Tokelau after consultation with the village Taupulega (Village Councils). It is also the Legislative National Committee and the National Budget Committee. The numbers of delegates on the General Fono are representative of the population from each of the three villages.

Hazard The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.

Impacts The effects on natural and human systems. In this document, the term 'impacts' is used to refer to the effects on natural and human systems of physical events, of disasters, and of climate change.

Mitigation (of climate change) A human intervention to reduce the sources or enhance the sinks of greenhouse gases. Note "mitigation" (in the context of disaster risk reduction) is defined as the "lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability." In LivC, we restrict the use of "mitigation" to the climate change definition.

No regrets policies Options or actions to reduce greenhouse gas emissions that have negative net costs. Net costs are negative because these options generate direct or indirect benefits, such as those resulting from reductions in market failures, double dividends through revenue recycling and ancillary benefits that are large enough to offset the costs of implementing the options.

Pulenuku The village mayor, who is also a matai in the village, and is elected every 3-years during the General elections. The Pulenuku traditional role is to take the lead in managing the village affairs from the decisions and policies made by the Taupulega (the Village Council).

Resilience The ability of people, households, communities, countries and systems to mitigate, adapt to and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth. As this definition suggests, the concept (and measurement) of resilience is complex and multidimensional.

Strategy A guide for achieving the sort of future that people want. It can help people, organisations, or a whole system work together more effectively on the most important and prioritised items. Without a strategy, small problems today can become big problems over time.

Taupulega The Village Council. Each atoll has its own council. Fakaofo village comprises of council of elders. Atafu and Nukunonu on the other hand comprise the village council of Matais.

Youth participate in Keyhole Garden Project for adaptation. Nukunonu, August 2016. *Photo courtesy:* Litia Maiava.

Tupulaga Youth, including sports teams.

Vulnerability The propensity or predisposition to be adversely affected by climate-related risks.