

A photograph of two cyclists riding on a paved coastal path. The cyclist in the foreground is wearing a pink helmet and a bright orange shirt. The cyclist behind them is wearing a light blue helmet and a white shirt. They are riding on a wide, grey asphalt path that curves along a rocky shoreline. To the left of the path is a body of water with several sailboats moored in the distance. A small white building on stilts is visible on the shore. The sky is clear and blue. The overall scene is bright and sunny, with long shadows cast on the path.

Our Atmosphere and Climate 2026 Tō Tātou Kōhauhau, Āhuarangi Hoki

New Zealand's Environmental Reporting Series
Te Kāhui Pūrongo Taiao o Aotearoa



Ministry for Cities, Environment,
Regions & Transport

Stats **NZ**
Tatauranga Aotearoa

Crown copyright ©

Unless otherwise stated, this copyright work is licensed for re-use under a [Creative Commons Attribution 4.0 International licence](#). Except for any photographs, in essence, you are free to copy, distribute, and adapt the work, as long as you attribute the work to the New Zealand Government and abide by the other licence terms. To view a copy of this licence, visit Creative Commons Attribution 4.0 International licence. To re-use a photograph please seek permission by sending a request to the stated image owner.

Please note that neither the New Zealand Government emblem nor the New Zealand Government logo may be used in any way which infringes any provision of the Flags, Emblems, and Names Protection Act 1981 or would infringe such provision if the relevant use occurred within New Zealand. Attribution to the New Zealand Government should be in written form and not by reproduction of any emblem or the New Zealand Government logo.

If you publish, distribute, or otherwise disseminate this work (or any part of it) to the public without adapting it the following attribution statement should be used:

Source: Ministry for Cities, Environment, Regions and Transport (MCERT), Stats NZ, and data providers, and licensed by MCERT and Stats NZ for re-use under the Creative Commons Attribution 4.0 International licence.

If you adapt this work in any way, or include it in a collection, and publish, distribute, or otherwise disseminate that adaptation or collection to the public, the following attribution statement should be used:

This work uses material sourced from the Ministry for Cities, Environment, Regions and Transport (MCERT), Stats NZ, and data providers, which is licensed by MCERT and Stats NZ for re-use under the Creative Commons Attribution 4.0 International licence.

Where practicable, please hyperlink the name of the Ministry for Cities, Environment, Regions and Transport or Stats NZ to the MCERT or Stats NZ web page that contains, or links to, the source data.

Disclaimer

While all care and diligence has been used in processing, analysing and extracting data and information for this publication, the Ministry for Cities, Environment, Regions and Transport, Stats NZ and the data providers give no warranty in relation to the report or data used in the report – including its accuracy, reliability and suitability – and accept no liability whatsoever in relation to any loss, damage, or other costs relating to the use of any part of the report (including any data) or any compilations, derivative works, or modifications of the report (including any data).

Citation

Ministry for Cities, Environment, Regions and Transport & Stats NZ (2026). *New Zealand's Environmental Reporting Series: Our Atmosphere and Climate 2026*. Retrieved from environment.govt.nz.

Published in October 2026 by the Ministry for Cities, Environment, Regions and Transport and Stats NZ

Publication number: MCERT 14

ISSN: 2382-0179

ISBN: 978-1-997358-12-1

Cover image: Broad Bay, Dunedin (Clare Toia-Bailey, Image Central)

Contents

Message to readers	5
Introduction	6
As our climate changes, our way of life will change with it	6
About <i>Our Atmosphere and Climate 2026</i>	6
What has changed since <i>Our atmosphere and climate 2023</i>	8
1. The climate we have known is entering uncharted territory	11
Long-term change	11
Extreme weather	15
2. The impacts of climate change on the natural environment and human health	20
The natural environment	20
People's connections to the environment	23
Human health	26
3. The impacts of climate change on the economy and infrastructure	29
The economy	29
Property, infrastructure and services	33
4. The choices that shape New Zealand's climate future	41
Our place globally	41
Our emissions story	42
Carbon storage and land-use change	45
5. Towards a better understanding	47
Understanding future climate change and its impacts	47
Understanding system complexity	48
Improving access to information	49
Additional information	50
References	53

Figures

Figure 1:	New Zealand annual average temperature anomaly, 1909–2025	13
Figure 2:	Annual total rainfall and maximum daily rainfall trends, 1960–2025	16
Figure 3:	Percentage of people whose homes are currently exposed to a 1 percent annual likelihood inland flood event	35
Figure 4:	New Zealand’s gross greenhouse gas emissions, 2024	43

Message to readers

Tēnā koutou katoa

For most of Aotearoa New Zealand's history, the environmental conditions that underpin our society have changed only gradually. Increasingly, this is no longer the case.

Climate change is affecting many aspects of our natural and built environments. Some changes occur gradually over decades. Others emerge through changes in the frequency, intensity, or location of events and hazards. Together, they are altering the conditions within which communities, businesses, infrastructure and ecosystems operate.

As these conditions change, trustworthy information becomes increasingly important. Understanding what is changing, how quickly it is changing, and what those changes may mean is essential for informed discussion and decision-making.

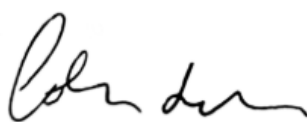
This is the purpose of environmental reporting. Under the Environmental Reporting Act 2015, the Secretary for the Environment and the Government Statistician jointly produce reports that provide an independent, evidence-based assessment of New Zealand's environment. By bringing together information on environmental pressures, state and impacts, environmental reporting helps build a shared understanding of the changes occurring around us.

Our Atmosphere and Climate 2026 is the first environmental report released by the Ministry for Cities, Environment, Regions and Transport alongside Stats NZ. It reflects the contributions of many organisations, experts and communities across New Zealand's environmental information system. It also highlights the connections between climate change, communities, infrastructure, economic activity and the natural environment, demonstrating the value of understanding these issues as part of a wider system.

No single report can answer every question. However, bringing credible evidence together in one place provides a stronger foundation for informed decisions about the places and environments on which New Zealand's future depends.



Jeremy Lightfoot
Secretary for the Environment



Colin Lynch
Government Statistician

Introduction

As our climate changes, our way of life will change with it

Aotearoa New Zealand is shaped by its climate. The weather patterns here have shaped the physical form of our land and influenced the development of species and ecosystems found nowhere else. When humans arrived, these environments along with temperatures and precipitation patterns were crucial to where we built settlements, grew crops and placed infrastructure. But now New Zealand's climate, largely stable for the past ten millennia, is changing and we are increasingly seeing the impacts of these changes unfold.

Human activities are increasing the concentration of greenhouse gases in the atmosphere, trapping more heat. That additional heat is showing up in rising temperatures, warming oceans, rising seas, shifting rainfall patterns and more intense extremes. The impacts of our past choices are already playing out. The effects extend through ecosystems, and people's health and wellbeing to livelihoods, property and infrastructure. The extent of further change and future impacts depends strongly on future global greenhouse gas emissions.

About Our Atmosphere and Climate 2026

Our Atmosphere and Climate 2026 is the latest in a series of environmental reports produced by the Ministry for Cities, Environment, Regions and Transport and Stats NZ under the Environmental Reporting Act 2015 (the Act). It is the fourth report in the series dedicated to New Zealand's atmosphere and climate, following reports in 2017, 2020 and 2023, and the first report released following the transfer of the statutory functions of the Ministry for the Environment. This report brings together the latest data and evidence to explain how New Zealand's climate is changing, what those changes mean for our environment and lives, and the pressures contributing to them.

Report structure

This report is structured around four key questions:

- **What is changing?** [Section 1](#) describes the current state of our atmosphere and climate, including possible outlooks for the future. Long-term trends show warming air and sea temperatures, changes in weather patterns and rising seas. These changes result in an increase in extreme events. Droughts, floods, severe storms, wildfires and heatwaves are all expected to become more common with climate change.
- **Why does it matter?** [Section 2](#) and [Section 3](#) focus on why these changes matter. Climate change is not unfolding evenly. Changes and impacts vary across regions, seasons, ecosystems and communities, and they arrive both as gradual long-term shifts and as sudden, disruptive events. Climate change is now impacting our ecosystems, health, economy and infrastructure. The certainty of how these impacts will develop becomes less clear the further we look ahead; however, we do know that if greenhouse gas emissions continue to increase, so will the impacts of climate change.

- **Why is it happening?** How much the climate continues to change depends on the pressures we and others place on it moving forward, which is the focus of [Section 4](#). While New Zealand is responsible for a small portion of global emissions, our emissions per person are high. Greenhouse gas emissions arise from activities such as food production, energy generation, transport and housing. Our emissions are reducing in some areas, but stable or increasing in others. Changes in land use affect our overall emissions.
- **What do we still need to know?** Although we have a large amount of evidence on climate change and its likely impacts, there are areas where we can improve our understanding. [Section 5](#) outlines priority areas for building our knowledge, understanding links between impacts, and strengthening climate information systems.

Data and evidence in the report

The Act requires us to report on environmental pressures, state and impacts, as well as on specific topics set out in the Act. We do this through a set of environmental indicators. Where indicators are not available or do not fully describe an issue, we use a broader body of evidence to ensure the report provides a comprehensive and authoritative picture of the state of New Zealand's atmosphere and climate.

The indicator data in this report draw on many sources, including public research organisations and central government. The body of evidence brings together peer-reviewed scientific literature, government reports and other grey literature, mātauranga Māori (Māori knowledge), and observational information on ecosystem changes.

All data and evidence used in this report were corroborated and checked for consistency with their original sources, and a panel of independent scientists reviewed the report. This approach brings together multiple lines of evidence, helping to ensure the report provides a comprehensive and reliable picture of New Zealand's atmosphere and climate, including in areas where indicators alone do not fully describe the issue. Indicator definitions and update dates are available on the Stats NZ indicators web pages. Evaluating specific policies and providing advice on responses is out of scope for reports prepared under the Act. Reports under the Act are produced independently of ministers.

Outlooks

This report contains outlooks assessments which are a description of how the environment may change in the future. They are assessed based on current data and trends and likely future impacts on the environment and the things we value.

The future will always be uncertain. For this reason, the assessments in this report should not be read as statements of fact but as assessments of what may occur based on what we know now about the range of possible futures. To support this, we have used expressions of likelihood and confidence to help in interpretation. This ensures we can make assessments about current and emerging issues even when our confidence in them may be low due to the limitations of the evidence base.

Expressions of likelihood are italicised in the text. Expressions of confidence, which give an indication of the reliability and level of corroboration of evidence used in an assessment, are presented in brackets and italicised at the end of each assessment. The approach used in this report closely follows guidance from the Intergovernmental Panel on Climate Change around

uncertainty assessments. These assessments reflect the amount, quality and consistency of the evidence available, together with the level of agreement among experts.

Higher confidence indicates stronger supporting evidence and greater agreement among lines of evidence. Lower confidence indicates that greater uncertainty remains. This report synthesises evidence on projected future changes (outlooks) from a range of published studies and reports. Where appropriate, it aligns with the climate scenario framework used by the Climate Change Commission (He Pou a Rangi Climate Change Commission, 2026b: appendix 1).

The underlying studies use a range of approaches, including different climate scenarios and sea-level rise assumptions, to assess how New Zealand's climate and environment may change under plausible future conditions.

What has changed since *Our atmosphere and climate 2023*

Of the 18 indicators included in this report, 13 are atmosphere and climate indicators that have been updated since *Our atmosphere and climate 2023* (see [Stats NZ environment indicators](#)). Overall, the continued global pressures placed on our atmosphere and climate mean the updates show a continuation of the broad trends reported previously.

The highest recorded atmospheric concentrations of carbon dioxide, methane and nitrous oxide in New Zealand were recorded in 2025, with 7 of the 10 warmest years on record occurring in the last decade since 2016. This follows a similar pattern to global trends, with global temperatures passing 1.5 degrees Celsius above pre-industrial levels for the first time in 2024.

Since *Our atmosphere and climate 2023*, the strongest advances in the evidence have been in understanding impacts and risk. Research has strengthened evidence that climate change is affecting ecosystems and species across land, freshwater and marine environments, increasing risks to human health and wellbeing. Climate change is also creating growing challenges for sectors such as agriculture, fisheries, tourism and insurance, but evidence is increasingly showing that our choices could create new opportunities. The evidence base has also expanded considerably for Māori cultural values, knowledge systems and connections to the environment.

New national-scale assessments now provide a more comprehensive picture of climate risk across New Zealand, including the exposure of homes, infrastructure, businesses and communities to flooding, landslides and coastal hazards. These studies, together with a growing body of research on adaptation and resilience, provide a clearer understanding of where risks are emerging, who is most exposed, and where the opportunities exist to reduce future impacts.

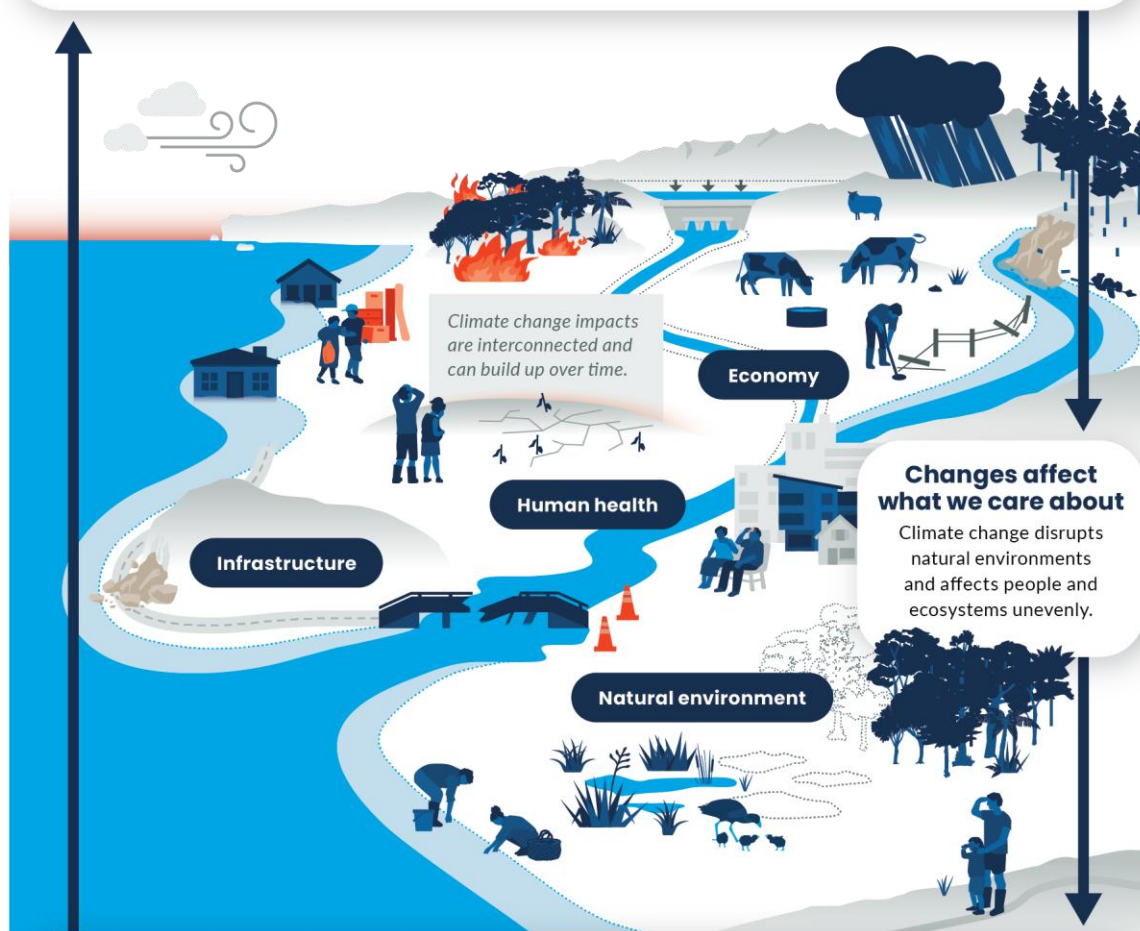
Our changing climate

Understanding what is changing, how fast, and where, can help communities anticipate and respond to future change.



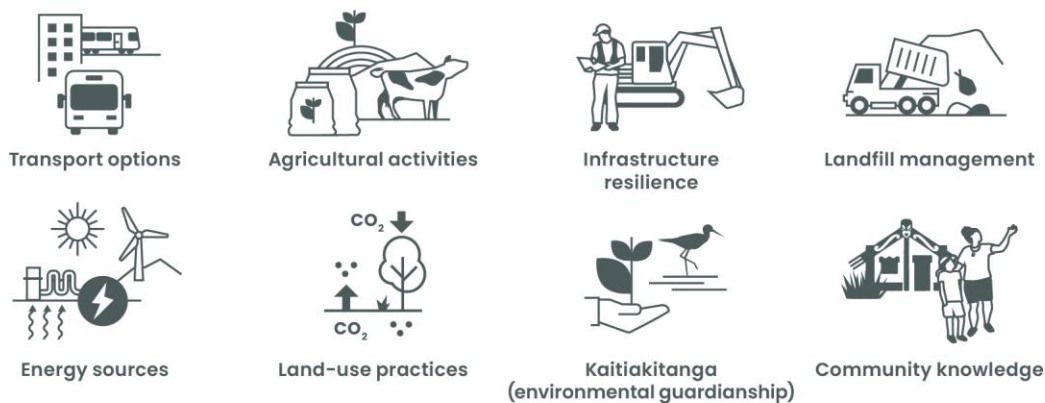
How our climate is changing

The effects of climate change can be widespread or localised, gradual or sudden, and affect many things at once.



Our choices matter

Our choices affect emissions, land use and the condition of the environment. These choices can increase or reduce pressures on the climate, shaping future change.



1. The climate we have known is entering uncharted territory

Section themes

- Greenhouse gases continue to accumulate, contributing to long-term warming.
- Multiple climate indicators show that New Zealand's climate is continuing to change.
- Changes in temperature, rainfall and climate extremes vary across regions and seasons.
- Natural climate variability continues to influence year-to-year conditions, against a backdrop of long-term climate change.



1. The climate we have known is entering uncharted territory

The climate we have known is becoming increasingly unreliable. Human activities are continuing to increase the concentration of greenhouse gases in the atmosphere. As these gases build up, they trap more heat and drive changes that affect temperatures, rainfall, sea levels and extreme weather. Carbon dioxide levels in the atmosphere are the highest they have been in around 4.1 to 4.5 million years (Lindsey, 2025), and global temperatures exceeded 1.5 degrees Celsius above pre-industrial (1850 to 1900) levels in 2024, with a 75 percent chance of mean global temperatures remaining above 1.5 degrees Celsius over the threshold between 2026 to 2030 (UN, n.d.; WMO, 2026).

These global changes are affecting Aotearoa New Zealand's climate. They are being experienced through both gradual shifts, such as steadily rising temperatures and sea levels, and changes in the frequency and intensity of some extreme events. These changes vary across regions and seasons and interact with natural climate variability. As temperatures continue to rise, climate-related risks and impacts are expected to increase further. This section examines how New Zealand's climate is changing, how those changes vary across the country, and what current evidence indicates about future change.

While the climate has been like this before, it is the ability of ecosystems and our society to adapt to the speed of this change that matters. It is crucial to understand what is changing, how fast, and where. This can help people and communities anticipate and respond to future change in our environment, society and economy.

Long-term change

Human activities, including emissions and land-use change, are continuing to increase concentrations of carbon dioxide and other heat-trapping greenhouse gases in the atmosphere. These changes are driving increases in temperatures across New Zealand.

Increased temperatures change weather patterns and rainfall. Some areas are expected to experience more rainfall and others less. Warming also interacts with global weather patterns such as the El Niño Southern Oscillation.

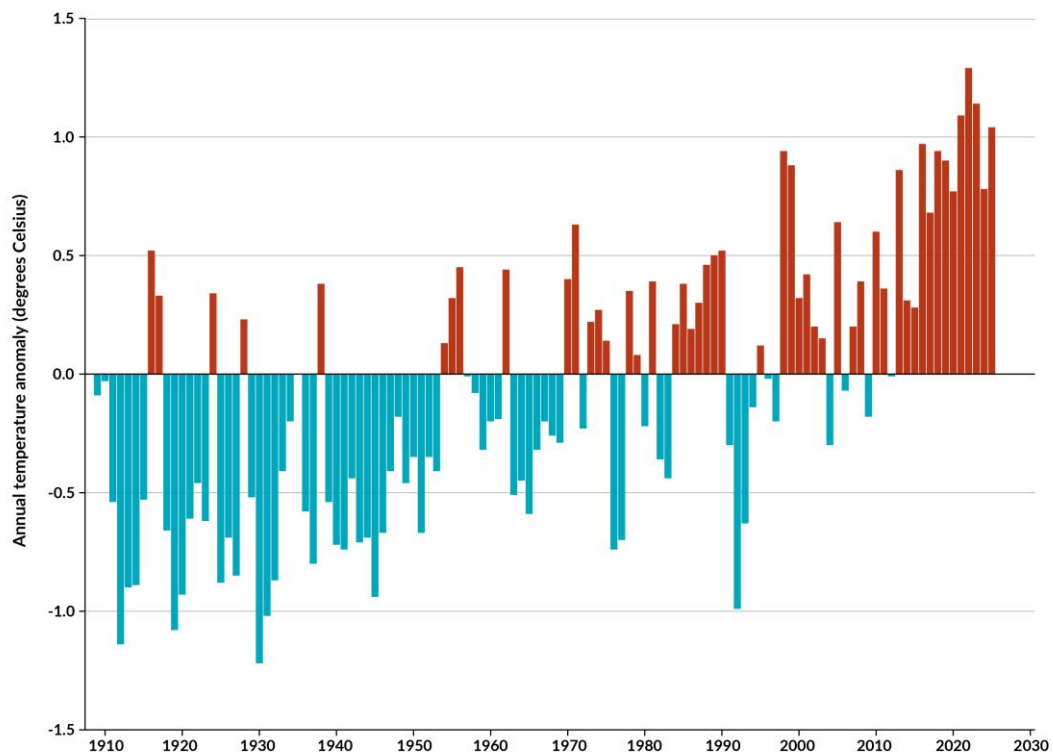
The atmosphere is warming

- Concentrations of carbon dioxide at Baring Head (Wellington) were 423.1 parts per million in December 2025, up 5.5 percent since December 2016 (see indicator: [Greenhouse gas concentrations: Data to 2025](#)). This is around 51 percent higher than pre-industrial levels of 280 parts per million (Ciais et al., 2013). This reflects a longer-term global trend, with carbon dioxide growth rates accelerating significantly since the 1960s, when the average growth rate was 0.8 parts per million a year, to 2.4 parts per million a year during the period 2011 to 2020 (WMO, 2025).

- The highest concentrations of methane on record at Baring Head were 1,901.7 parts per billion in September 2025 (see indicator: [Greenhouse gas concentrations: Data to 2025](#)). This is around 163 percent higher than pre-industrial levels of 722 parts per billion (Ciais et al., 2013).
- The highest concentration of nitrous oxide measured at Baring Head was 338.3 parts per billion, recorded in December 2025 (see indicator: [Greenhouse gas concentrations: Data to 2025](#)). This is around 25 percent higher than pre-industrial levels of 271 parts per billion (Ciais et al., 2013).
- New Zealand's annual average temperature has risen by 1.36 degrees Celsius since measurement began in 1909, with 7 of the 10 warmest years on record occurring in the last decade (2016 to 2025) (see indicator: [Temperature: Data to 2025](#); see [figure 1](#)). Between 1972 and 2025, average temperatures were very likely increasing at 26 of 30 sites in spring, 25 sites in summer, 25 sites in autumn, and all 30 sites in winter (see indicator: [Temperature: Data to 2025](#)).
- **Outlook:** Warming by the end of the century depends strongly on future greenhouse gas emissions (*high confidence*). However, continued warming by about 0.2 degrees Celsius a decade is projected to occur regardless of near-term emissions pathways (*high confidence*). New Zealand's air temperature is *very likely* to warm by between 0.75 degrees Celsius and 1.2 degrees Celsius¹ above the average temperature between 1995 and 2014 by the middle of the century (*high confidence*) under low and high climate scenarios respectively. By the end of the century, warming will reach between 0.8 degrees Celsius and 3.2 degrees Celsius above the same baseline (*high confidence*) (Bodeker et al., 2022; Broadbent et al., 2024; MfE, 2018). The greatest increases will *likely* be seen in summer, with warming projected to be greatest at higher elevations (*high confidence*) (Gibson et al., 2025a; MfE, 2018).
- **Outlook:** Heatwaves will *very likely* increase in frequency, length and intensity across the country, with particularly strong effects across the northern half of the North Island (*high confidence*) (Broadbent et al., 2024; Gibson et al., 2025a; Lewis et al., 2025a).

¹ Note that the Paris Agreement target of limiting warming to 1.5 degrees Celsius is relative to pre-industrial conditions, rather than the 1995–2014 baseline used for New Zealand projections discussed here.

Figure 1: New Zealand annual average temperature anomaly, 1909–2025



Data source: Stats NZ, using data from Earth Sciences New Zealand

Note: The baseline for temperature anomalies is the average annual temperature for the 30 years from 1991 to 2020.

Seas are rising and oceans are warming

- Global ice losses from glaciers, the Greenland ice sheet and the Antarctic ice sheet are the second largest contributors to rising sea levels, after ocean-warming-related thermal expansion. As temperatures rise, ice melts and drains into the ocean, adding large volumes. Between 2000 and 2023, an estimated average of 273 billion tonnes of glacial ice a year has been lost (The GlaMBIE Team, 2025). New Zealand's glacier ice volumes peaked in 1997 at 56 cubic kilometres, and have since decreased to 30 cubic kilometres in 2023. Total ice volume decreased 6.5 percent between April 2022 and March 2023 (see indicator: [Annual glacier ice volumes: Data to 2023](#)).
- **Outlook:** Models of glacier retreat estimate New Zealand glaciers will *very likely* lose between 14 and 86 percent of their volume by 2100 under the low climate scenario, and between 69 and 100 percent under the high climate scenario, compared with 2015 glacier volumes (*high confidence*) (Carrivick et al., 2022; Rounce et al., 2023; Zekollari et al., 2024).
- Relative sea-level rise (the change in sea level relative to the land) is rising more slowly in parts of New Zealand where the land is rising (uplift) but is rising more quickly in areas where the land is sinking (subsidence), even though absolute sea-level rise is no different at the local level (MfE, 2024b; NZ SeaRise, n.d.).
- At four longer-term monitoring sites around New Zealand, annual mean coastal sea levels rose faster between 1961 and 2020 than during the period between 1901 and 1960 (see indicator: [Coastal sea-level rise](#)).

- **Outlook:** Absolute sea-level rise (the change in sea level independent of land movement), is projected to exceed 20 centimetres above the average of 1995 to 2014 levels between 2045 and 2050, depending on the climate change scenario (*high confidence*). Sea-level rise relative to land will continue to be highly variable in New Zealand, as there are many areas experiencing either land subsidence or uplift (*high confidence*) (MfE, 2024b).
- Between 1982 and 2023, sea-surface temperature in the country's four oceanic regions increased, on average, 0.16 to 0.26 degrees Celsius each decade (see indicator: [Sea-surface temperature: Data to 2023](#)). The rate of warming in ocean waters around New Zealand is increasing and is now 34 percent faster than the global average warming rate (Pinkerton et al., 2024). New Zealand's oceans are warming faster than the global average, due to changes in atmospheric circulation and corresponding changes in ocean currents (Trenberth et al., 2025; see [Our Marine Environment 2025](#)).
- Coastal waters around New Zealand are warming faster than the global average, with rates of increase in the country's nine coastal regions ranging from 0.19 to 0.34 degrees Celsius each decade (Pinkerton et al., 2024; see indicator: [Sea-surface temperature: Data to 2023](#); see [Our Marine Environment 2025](#)).
- **Outlook:** Sea-surface temperatures around New Zealand are projected to increase 1 to 1.5 degrees Celsius above the average 1982 to 2022 temperatures by mid-century, with increasing marine heatwave intensity. This increase is projected with little difference between low and high climate scenarios (*high confidence*). By the end of the century, temperatures are projected to increase by about 1 degree Celsius (low climate scenario) to up to 3 degrees Celsius (high climate scenario) (*high confidence*). Coastal bottom waters are also projected to increase about 0.5 to 1.0 degrees Celsius by mid-century (*medium confidence*) (Behrens et al., 2025).

Rainfall patterns are changing across New Zealand

- The atmosphere around and over New Zealand has become more humid over the past decade. Warmer surrounding seas contribute to warmer, more humid air, and weather patterns over the surrounding oceans influence how moisture is transported over the country (Krishna et al., 2024; Kropač et al., 2025). In addition, New Zealand's mountainous terrain and location in the Roaring Forties² mean rainfall varies across the country (see indicator: [Rainfall: Data to 2025](#)).
- Annual rainfall between 1960 and 2025 increased at many sites in the southern South Island. Of the sites where rainfall decreased, many were in the northern half of the North Island (see indicator: [Rainfall: Data to 2025](#); see [figure 2](#)).
- **Outlook:** By 2090, annual rainfall is projected to decrease across much of the North Island, particularly in the north and east, and in the north and east of the South Island. Rainfall is projected to increase in the west and south of the South Island (*medium confidence*) (Broadbent et al., 2024; Gibson et al., 2025a; MfE, 2024a, for more information see [Aotearoa New Zealand climate projections map](#)).
- **Outlook:** Going forward, the number of wet days (those with more than 1 millimetre of rain) and consecutive wet days annually will *likely* decrease across the North Island and

² The 'Roaring Forties' is a belt of strong westerly winds in the Southern Hemisphere which generally occur between the latitudes of 40 and 49 degrees. As these winds are forced upwards by the Southern Alps and North Island ranges, heavy rainfall is dropped on the western coast of New Zealand, leaving the east coast typically drier (see indicator: [Rainfall: Data to 2025](#)).

eastern slope of the Southern Alps by the end of the century (*medium confidence*). However, the average rainfall on wet days will *likely* increase in most areas, occurring across fewer days (*medium confidence*), while extreme rainfall will *very likely* increase (*high confidence*) (Broadbent et al., 2024, Gibson et al., 2025a, Harrington et al., 2024).

Extreme weather

The extra heat in the atmosphere is driving an increase in the likelihood of extreme weather events. Extreme rainfall, drought and wildfires have affected many parts of New Zealand in recent years. Future changes in extreme weather will vary between regions, with some areas projected to see more extreme events.

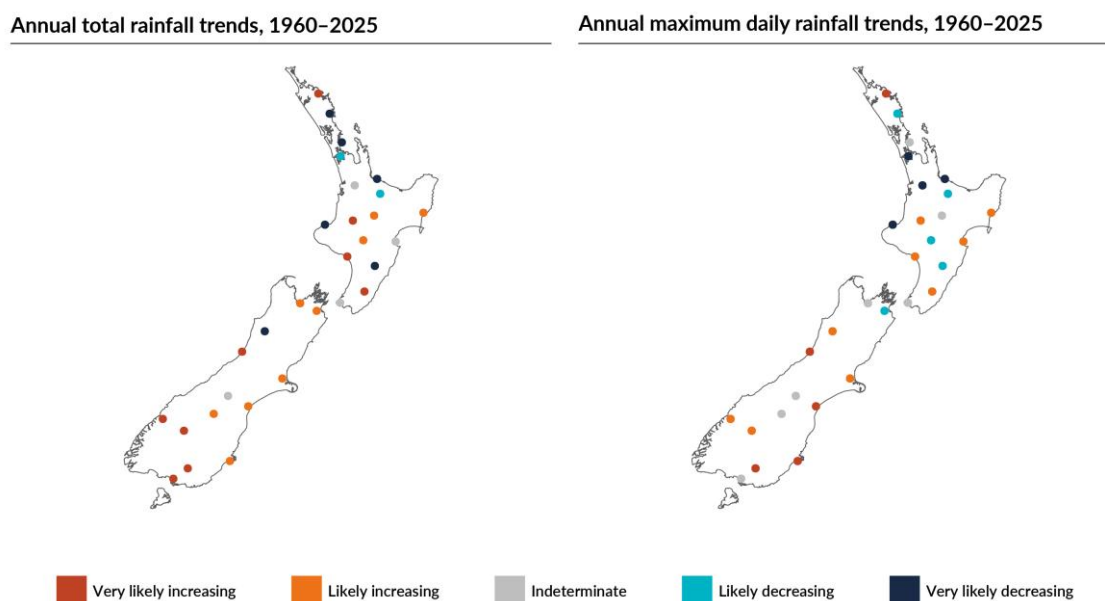
Heavy rainfall is becoming more intense in some areas

- Recent years have seen a series of significant extreme rainfall and flooding events across New Zealand, including the Auckland Anniversary Weekend floods and Cyclone Gabrielle in 2023, flooding in Otago in 2024, flooding in Nelson, Tasman and Marlborough in 2025, and the severe Wellington flooding in April 2026 when some locations received more than 70 millimetres of rain in one hour (Earth Sciences New Zealand, 2026a; NIWA, 2024, 2025; Renwick, 2026).
- Observed changes in extreme rainfall varies across the country, with some areas experiencing an increase in annual maximum daily rainfall and others a decrease (see [figure 2](#)). Most sites that experienced a decrease were in the upper half of the North Island. Further, most sites with an increase in annual rainfall also experienced an increase in annual maximum one-day rainfall amounts, and vice versa for sites experiencing decreases (see indicator: [Extreme rainfall: Data to 2025](#)).
- Despite several high-profile extreme rainfall and flooding events between 2023 and 2025, changes in total rainfall across the country have been largely within the near normal range (80 to 119 percent of average), although some regions experienced much wetter or drier than normal conditions (Earth Sciences New Zealand 2026a; NIWA 2024, 2025). There is still uncertainty about long-term changes in extreme daily rainfall (Bird et al., 2023; Sigid et al., 2025).
- Human-induced warming increases the amount of rain that falls in extreme daily rainfall events about 5 to 8 percent for each degree Celsius of warming, with larger increases for shorter-duration extremes such as hourly rainfall (Rosier et al., 2024, 2025; Thomas et al., 2024).
- **Outlook:** Models for rainfall intensity project an 8 to 28 percent increase in average annual maximum one-day rainfall compared to 1985 to 2014 levels by the end of the century, under a high climate scenario. The frequency of extreme rainfall events is also projected to increase for much of New Zealand, with 40 to 50 percent of locations projected to experience 1-in-10-year rainfall events twice as frequently by the end of the century. The most extreme projected events would resemble major historic storms such as Cyclone Bola (1988) and the May 1923 Canterbury storm, with potentially greater intensity as the climate warms (Sigid et al., 2026).
- **Outlook:** Atmospheric rivers are *likely* to increase in frequency (*medium confidence*). The most extreme events may nearly double in frequency over the South Island within decades (*low confidence*). Under the high climate scenario, moisture delivery by

atmospheric rivers is expected to increase up to 20 percent by the end of the century (*medium confidence*) (Gibson et al., 2026; Goddard et al., 2025).

- **Outlook:** Storms originating as tropical cyclones are expected to occur at similar frequency to current observations (*low confidence*). However, the intensity of rainfall associated with these cyclones is *likely* to increase 15 to 55 percent by the end of the century under a high climate scenario, depending on the region (*medium confidence*) (Gibson et al., 2025b; Stone et al., 2024).

Figure 2: Annual total rainfall and maximum daily rainfall trends, 1960–2025



Data source: Stats NZ, using data from Earth Sciences New Zealand

Note: Annual total rainfall trends refer to information from the indicator: [Rainfall: Data to 2025](#). Annual maximum daily rainfall trends refer to information from the indicator: [Extreme rainfall: Data to 2025](#).

Changing climate extremes will bring hotter and drier conditions

- Reduced soil moisture is associated with higher temperatures during hot periods. Dry soil conditions contributed to higher temperatures in some recent hot summer months in New Zealand (Debsharma et al., 2026).
- Trends in frequency of agricultural drought³ events between 1972 and 2025 were varied, with one-third of total sites showing a decrease, and 23 percent showing an increase. In recent years, between 2016 and 2025, Dannevirke spent the most time in a drought event (55 percent), and Reefton had six separate events, the most of any site (see indicator: [Drought and wet periods: Data to 2025](#)).

³ Agricultural drought is a medium-term event (6 months) that may impact crop production or livestock due to lack of soil moisture (NOAA, n.d.).

- **Outlook:** Modelling⁴ shows that by 2050, approximately 38,000 to 55,000 square kilometres of New Zealand's productive land is projected to experience an increased potential evapotranspiration deficit of at least 50 millimetres, depending on the climate scenario (*medium confidence*). By 2090, the projected area decreases to approximately 31,000 square kilometres under a low climate scenario, reflecting lower climate impacts under continued emissions reductions, but increases to approximately 95,000 square kilometres under a high climate scenario (*medium confidence*) (Paulik et al., 2026).
- The extreme wind indicator measures the annual average of the daily maximum wind gust (a measure of windiness) and annual maximum wind gust (a measure of wind strength). In general, most of the 17 sites⁵ showed a decrease in annual average of the daily maximum wind gust and annual maximum wind gust, with the exception of Gisborne, New Plymouth and Queenstown, which all showed an increase (see indicator: [Extreme wind: Data to 2025](#)).
- Wildfire risk⁶ is changing, but whether the risk is increasing or decreasing varies considerably by location. The annual number of days with very high or extreme forest fire danger increased at 13 of 28 sites across New Zealand between 1997 and 2023 (see indicator: [Wildfire risk: Data to 2023](#)).
- Days of very high or extreme fire danger do not necessarily mean a wildfire did, or will, occur. Similarly, wildfires can occur even if the fire danger is not very high or extreme. This is because an ignition source is needed for a wildfire to occur (see indicator: [Wildfire risk: Data to 2023](#)). After ignition, the extent of a wildfire depends on a range of factors, including weather conditions, fuel availability, and how quickly the fire is detected and controlled. Approximately 3 percent of wildfires cause 95 percent of the area burnt, and 97 percent of wildfires in New Zealand are caused by people (FENZ, n.d.).
- **Outlook:** Under both the low and high climate scenarios, wildfire weather conditions are projected to be more severe across many parts of New Zealand by 2100, with longer wildfire seasons and more days with conditions suitable for more severe fires (*medium confidence*) (Melia et al., 2022).

Natural climate variability continues to influence extremes

- The El Niño Southern Oscillation is a natural climate cycle, not climate change itself. However, phases of this cycle influence the conditions for rainfall in different parts of the country. During El Niño conditions, westerly winds strengthen in summer, leading to drier conditions in the east and wetter conditions in the west of the country. Colder southerly winds become more common in winter, and south-westerly winds in spring and autumn often bring a mix of the summer and winter effects. During La Niña events, more north-easterly winds bring more rainfall to the north and east of the North Island, with less rain in the south and west of the South Island (Earth Sciences New Zealand, n.d.).

⁴ Uncertainty exists in modelling for future drought, since climate models cannot confidently determine whether New Zealand's warm season will be wetter, which could offset drying, or drier, which could extend and intensify drought events (Gibson et al., 2024; Lewis et al., 2025b).

⁵ Around the country, 17 of 30 sites had sufficient data between 1980 and 2025 to allow maximum wind gust trends to be determined (see indicator: [Extreme wind: Data to 2025](#)).

⁶ Wildfire risk is reported as the average number of very high or extreme fire danger class days per year, using the New Zealand Fire Danger Rating System (see indicator: [Wildfire risk: Data to 2023](#)).

- The El Niño Southern Oscillation can also influence the occurrence and severity of extreme rainfall events by altering the large-scale atmospheric circulation patterns (or atmospheric rivers)⁷ that drive heavy rainfall (Griffiths, 2011). Between 1960 and 2023, during El Niño years, there have been generally fewer atmospheric rivers north of New Zealand and more over southern New Zealand and the Southern Ocean, south of the country, compared with La Niña years (Gibson et al., 2023, 2026).
- The most recent El Niño phase of the Southern Oscillation Index was from July 2015 to April 2016, and the most recent La Niña phase was from April 2022 to February 2023 (see indicator: [El Niño Southern Oscillation: Data to 2025](#)). In July 2026, El Niño conditions were confirmed in the tropical Pacific, and this phase is expected to become one of the strongest on record (Earth Sciences New Zealand, 2026b).

⁷ Atmospheric rivers are long, narrow regions in the atmosphere that transport significant quantities of water vapour, which often leads to substantial rainfall when they interact with the land (Waliser & Guan, 2017).

2. The impacts of climate change on the natural environment and human health

Section themes

- Climate change is changing the natural systems that sustain life across land, freshwater and marine environments. Native ecosystems and species are facing increasing pressure from changing climate conditions and extreme events.
- The effects are being felt not only in nature, but also in the ways people connect with places, ecosystems and the outdoors.
- Changes to the environment affect Māori relationships with ecosystems and places, impacting important cultural values, practices and knowledge transmission.
- Climate-related hazards are creating growing risks to human health and wellbeing.
- Increasing exposure to climate effects like flooding and extreme heat impacts human health, including through physical illnesses and diseases, and psychological distress.



2. The impacts of climate change on the natural environment and human health

The changes to Aotearoa New Zealand's climate described in section 1 are already affecting the natural environment and people's health and wellbeing. The impacts are far-reaching and increasing, affecting communities in diverse ways. Some impacts emerge gradually as temperatures rise, rainfall patterns shift and sea levels increase. Others occur more abruptly through extreme events such as floods, droughts, wildfires and marine heatwaves. Together, these changes can alter ecosystems, affect species and increase risks to communities.

New Zealand's unique ecosystems and native species are particularly vulnerable to changing climatic conditions and are facing increasing disruption. Climate change is already altering habitats and ecosystems across land, freshwater and marine environments, while extreme events can cause immediate damage and intensify existing pressures. This is projected to increase if global greenhouse gas emissions and temperatures continue to rise. Because the natural environment also supports much of our economy and wellbeing, these impacts can extend well beyond the ecosystems and species directly affected.

Degradation and loss of ecosystems and species are felt widely in our communities as we lose the benefits they provide us. New Zealanders have a close affinity with the environment and outdoor recreation, and climate change is affecting our ability to connect with nature. For many Māori, the transmission of mātauranga (Māori knowledge) and maintenance of reo (language), tikanga (customs and protocols) and identity are closely linked to te taiao (the environment), and these processes are being put at risk by environmental change.

Climate change affects human health both directly and indirectly. Higher temperatures can increase heat-related illness and mortality, while floods and other extreme events can increase risks of disease, psychological distress and disruption to the places and services that support wellbeing. These impacts are not distributed evenly, and people's exposure and vulnerability vary across communities and locations.

This section looks at how climate change is impacting the natural environment, people's connections with nature, and human health and wellbeing. Section 3 then discusses the related impacts to our economy, infrastructure, homes and livelihoods.

The natural environment

New Zealand has a large variety of native species that are found nowhere else, and the ecosystems they inhabit are vulnerable to disruption. Climate change is increasing risks to ecosystems, species and ecological processes across New Zealand, with impacts already being observed for some ecosystems and species. Environmental change is also reflected in changing ecological signals recognised through mātauranga Māori.

Warming temperatures affect where species can live and can make it easier for invasive species to thrive. Changes to weather patterns and the timing of seasons alter the life cycles of

plants and animals, while more frequent extreme events such as storms and wildfires pose more immediate threats. The rate of climate change is also important, with some species and ecosystems less able than others to adapt to accelerating changes.

Climate change is altering ecosystems and ecological processes

- Climate change is bringing about large-scale physical changes to ecosystems on land, and in the freshwater and marine environments. This affects their condition and ability to support life (IPCC, 2022).
- Changing rainfall patterns are already affecting river flows. Lower flows are contributing to warmer waters, poorer water quality and shifts in suitable habitat for indigenous and introduced species (Booker & Whitehead, 2022; Canning et al., 2025; Mouton et al., 2022; Queen et al., 2023; see [Our Freshwater 2026](#)).
- Climate change and associated changes in rainfall patterns are expected to exacerbate land degradation processes, such as landslides and erosion, increasing sediment movement from land to rivers, estuaries and coastal environments (Neverman et al., et al., 2023; Smith et al., 2023).
- **Outlook:** River flows are projected to continue shifting, with increases in the west and south of the South Island and decreases in the east and north of the North Island (*low confidence*) (Collins, 2020, 2021).
- In the marine environment, warming seas and ocean acidification, combined with sedimentation, are reducing the quality of habitat. This impacts species such as pāua and affects their ability to survive and reproduce (Short et al., 2023).
- **Outlook:** Seaweed ecosystems are expected to face increasing pressure from warming seas and other climate-driven changes (*low confidence*) (Cornwall et al., 2025). These ecosystems provide habitat for economically and culturally important species such as pāua and kina (Cornwall et al., 2025).
- Native coastal ecosystems that help buffer coastlines from flooding and erosion are at risk from sea-level rise. In some locations, habitats may be squeezed between rising seas and natural barriers or existing development, reducing the space available for coastal plants and animals (Allen et al., 2023; Davis-Jones, 2025; Douglas et al., 2022; Rullens et al., 2022; Stewart et. al, 2023; see [Our Marine Environment 2025](#)).
- Droughts are affecting native ecosystems and are expected to become a more significant pressure in some regions. Droughts can reduce the survival of drought-sensitive tree species and influence how forests function and store carbon (Boffa Miskell, 2020; Macinnis-Ng & Schwendenmann, 2015; Wyse et al., 2013; see [Our atmosphere and climate 2023](#)).
- Shifts in the timing and severity of frosts, along with a reduction in snowfall and general increase in temperature, are expected to affect the timing of some indigenous species' seasonal lifecycle stages, such as flowering and growth. These changes may disrupt interactions between species and potentially shift the composition and distribution of plant and animal communities (Awatere et al., 2021a; McGlone & Walker, 2011; Renwick et al., 2016; see [Our atmosphere and climate 2023](#)).

Native species are responding to changes in ecosystems

- Over the past 50 years, sightings of tropical and subtropical fish within New Zealand's waters have increased. These changes are consistent with warming ocean temperatures and more frequent marine heatwaves, which are altering the distribution of some marine species (Middleton et al., 2023; Montie & Thomsen, 2023).
- Marine heatwaves are already affecting some native marine species and the habitats they support. Recent studies have linked extreme marine heatwaves to widespread sponge bleaching and die-offs in Fiordland (Bell et al., 2024), and to the local loss of southern bull kelp and long-term shifts in intertidal communities in parts of Canterbury (Montie & Thomsen, 2023).
- **Outlook:** Climate change is expected to further increase pressure on marine species and the ecosystems they depend on (*high confidence*) (Bas et al., 2024; Datta et al., 2024; Roach et al., 2025).
- Native species in New Zealand's freshwater environments are already being affected by climate change. For example, changing flows and droughts have been observed to impact freshwater fish through strandings and worsened water quality (Keegan et al., 2022).
- **Outlook:** Climate change is projected to further increase impacts on freshwater fish. At least 14 native freshwater fish species are projected to experience declines in population and changes to where they can live by the end of the century, with the ranges of at least three species reducing by 50 percent or more (*low confidence*) (Canning et al., 2025).
- Native terrestrial species are already being affected by climate change. For example, warmer alpine temperatures have allowed mammalian predators to increasingly invade alpine habitat that was previously safe for native birds to nest. Small, isolated populations of rare and threatened species may be particularly vulnerable to extreme events such as fires (Keegan et al., 2022).
- **Outlook:** Climate change is expected to change where many native species can live, and some native species may lose large areas of suitable habitat. Suitable habitat for most native bird species is projected to shift and contract, while many introduced species are projected to expand their ranges (*low confidence*). Most vulnerable will be alpine species, colder-dwelling species in the South Island, species with restricted ranges and endangered species (*medium confidence*) (Weinhäupl & Devenish-Nelson, 2024).
- **Outlook:** Climate change is expected to increase the spread and impacts of invasive species and pathogens, placing additional pressure on indigenous biodiversity (*medium confidence*) (Campbell et al., 2025; Canning et al., 2025; Lee et al., 2025; Weihäupl & Devenish-Nelson, 2024).
- Members of Tuawhenua and Ngāti Whare have observed a significant decline in native fruit abundance, in particular tawa, and the frequency of fruiting events across a variety of species in both the Te Urewera and Whirinaki forests over the past 30 years (Lyver et al., 2025; Yukich Clendon et al., 2023). Mātauranga Māori observations provide additional evidence of ecological change and can complement other forms of environmental monitoring.

Extreme events are accelerating pressures on ecosystems and species

- Storm surges and strong winds are posing problems for shorebirds and seabirds, affecting breeding habitat and breeding seasons. These events also create challenging conditions for visual foragers such as penguins, gannets and shags (Crockett & Kearns, 1975; Powlesland, 1998 as cited in Whitehead et al., 2019; see [Our atmosphere and climate 2023](#)).
- Some coastal and river bird species are vulnerable to extreme weather and sea-level rise. Cyclone Gabrielle was associated with declines in several braided-river bird populations, while higher spring tides and increased storm surges are expected to affect the beach breeding grounds of tara iti (fairy terns) (Allen et al., 2024; Brumby et al., 2025; see [Our Marine Environment 2025](#)).
- Flooding is posing challenges for both terrestrial and freshwater plant and animal species. Floods directly impact population numbers and affect breeding sites. They also cause a range of problems from increased erosion and landslides in hill country, leading to increased sedimentation on coastal plains (Goodman, 2018; Keegan et al., 2022; Lettink & Monks, 2019; Neverman et al., 2023; Smith et al., 2023; see [Our atmosphere and climate 2023](#)).
- Following Cyclone Gabrielle, native forests, wetlands, braided rivers, freshwater ecosystems and threatened species experienced a range of impacts. These included excess sediment deposition, vegetation damage, tree dieback and declines in some bird populations (Allen et al., 2024).
- Prolonged drought and extreme heat can have significant impacts on ecosystems and species. Increasing drought occurrence can affect forest regeneration, disease susceptibility and tree mortality, and can contribute to wildfire risk by increasing dry vegetation (He Pou a Rangi Climate Change Commission, 2026b). The Climate Change Adaptation Action Plan developed by the Department of Conservation (DOC) highlights drought and wildfire as climate-related pressures on biodiversity that are expected to intensify over the coming decades (DOC, 2025a).
- Most terrestrial ecosystems in New Zealand are not adapted to fire (Kitzberger et al., 2016; Tepley et al., 2018). Recovery from fire events is slow, and fires can disrupt the natural succession of ecosystems and favour non-native plant species over native ones. Non-native vegetation is often more flammable, increasing potential fire frequency and intensity (Case et al., 2023; Perry et al., 2014; Richardson et al., 2018; see [Our atmosphere and climate 2023](#)).

People's connections to the environment

Climate change is driving changes to ecosystems that could increasingly affect our connections with the natural environment. For many Māori, the transmission of mātauranga and maintenance of reo, tikanga and identity are closely linked to te taiao. The loss of species and reduced access to places can disrupt cultural practices and wider systems of knowledge, relationships and culture. More broadly, the changes to natural spaces and loss of outdoor recreation opportunities result in a reduction of the benefits these places provide.

Climate change affects Māori relationships with ecosystems and places

- Environmental transformation due to the changing climate can reduce access to culturally important places, and can reduce the ability of Māori to uphold values, tikanga, mātauranga, and cultural practices and protection (Mahuta et al., 2025).
- Where coastal erosion, relocation or retreat affects whenua (land) to which Māori have whakapapa-based relationships (relationships based on ancestral ties), the impacts on identity can extend beyond individual values, interests or legal ownership, disrupting collective and intergenerational connections and responsibilities held through whānau, hapū (sub-tribes) and iwi (Johnson et al., 2023a).
- A study of the environmental values of Ngātiwai iwi found that the loss of even a single important species can have impacts on culture. Connections between value systems and the environment mean that environmental change can influence cultural values and practices associated with whakapapa, manaakitanga (showing of hospitality), stewardship, and connections to people, place and ancestors (Yletyinen et al., 2022).
- The disruption of access to specific species and places can have wider impacts. For many Māori communities, relationships with whenua, wai (water) and taonga species underpin cultural practices, responsibilities and the intergenerational transmission of mātauranga. For example, disconnection from harvesting tuna (eel) in Waikato has disrupted poukai⁸ gatherings and the mātauranga about kai and ceremony that those events carry (Mahuta & van Schravendijk-Goodman, 2024). Similarly, wāhine Māori (Māori women) in Te Tai Tokerau describe degraded access to kūtai (mussels) and tuna harvest sites as reducing their capacity to mentor rangatahi (young people) through tikanga-based hīkoi and place-based environmental learning (Johnson et al., 2024).
- **Outlook:** As species and habitats continue to change, ecosystems that support tikanga and identity may also be affected (*medium confidence*). The mātauranga and practices connected with them could be affected, including access to kai, rongoā (Māori healing practices), pūrākau (ancient narratives) and the intergenerational knowledge embedded in these practices (Awatere et al., 2026; Campbell et al., 2025; Canning et al., 2025; Datta et al., 2024; Lee et al., 2025; Mahuta & van Schravendijk-Goodman, 2024; Paul-Burke et al., 2022).
- **Outlook:** Changes to river systems due to climate change, such as those projected for the Lower Waikato River, are expected to lead to changes in river behaviour, erosion and ecology (*medium confidence*). This may disrupt mātauranga and cultural practices connected to place (*medium confidence*) (Mahuta et al., 2025).
- At the same time, Māori communities are drawing on mātauranga Māori, local environmental knowledge and long-standing relationships with place to understand and respond to climate-related change. These knowledge systems can inform adaptation and support resilience while maintaining connections between people, ecosystems and future generations (Awatere et al., 2021a; Mahuta et al., 2025).
- **Outlook:** Systems based on the maramataka (Māori lunar calendar), used to understand the environment and guide cultural practices, are inherently adaptive and may evolve in response to environmental change. However, projected changes in rainfall patterns, drought frequency, seasonal rhythms and other climate-driven environmental changes

⁸ Hui held on marae where people who support the Kīngitanga (Māori King movement) demonstrate their loyalty, contribute to funds and discuss movement affairs.

may make some *tohu* (environmental signs) less predictable or harder to recognise, particularly where they are linked to seasonal rhythms, species behaviours or lunar cycles. This may limit the effectiveness of maramataka-based planning and practices that rely on these *tohu* (*medium confidence*) (Awatere et al., 2026).

Climate change reduces opportunities to connect with nature

- Our ecosystems, and the wildlife they support, provide opportunities for connecting with nature through outdoor recreation. Access to nature is considered one of the key benefits of living in New Zealand (DOC, 2021). However, many of the natural destinations and visitor assets that support these experiences are at increasing risk from the effects of climate change, which could see popular attractions become increasingly degraded, costly or inaccessible in the future (PwC, n.d.).
- Nature-based recreation is an important part of life for many New Zealanders. Around one-third of New Zealanders surveyed in 2025 said enjoying and exploring nature was their main reason for considering a day trip (MBIE, 2025), and 40 percent visited protected natural areas each month during the 2024/25 summer. Coastal destinations were popular for New Zealanders to visit in summer, with half of the 10 most visited protected natural areas located on the coast (DOC, 2025b).
- Reduced access to natural destinations may limit opportunities for outdoor education and experiences such as school camps. These experiences give young people opportunities to learn outside the classroom and engage with natural environments. More broadly, connection with nature among young people has been associated with improved wellbeing and stronger environmental values and behaviours (Hill et al., 2020; Madera et al., 2025).
- Extreme weather is already affecting the natural areas New Zealanders visit. Cyclones Hale and Gabrielle in 2023 led to the closure of more than 500 DOC sites and the cancellation of more than 1,600 accommodation bookings. Many buildings, tracks and other visitor assets were damaged, with 42 percent of sites in the affected regions requiring repairs or replacements (Bose & Becken, 2024).
- Coastal natural areas are at increasing risk of damage and degradation from sea-level rise. Many DOC campgrounds, buildings and walking tracks are located in areas vulnerable to coastal flooding (Tait, 2019; see [Our Marine Environment 2025](#)). Intertidal habitats are likely to be lost and degraded as they are squeezed between rising seas, natural barriers and coastal protection structures such as seawalls, reducing opportunities for recreational and cultural activities such as observing wildlife and collecting shellfish (Rullens et al., 2022).
- International studies suggest that coastal erosion and retreat can have significant social impacts, including effects on wellbeing, recreation, sense of place and community connections. Adaptation responses, such as coastal protection works, can also have social impacts and may not always align with community preferences. These findings have implications for adaptation, as they highlight the importance of managing the potential loss or displacement of the social networks and amenity values that are supported by coastal living (Buck, 2025; Bukvic et al., 2022; Phillips & Murphy, 2021; Phillips et al., 2022).

Human health

Climate change has both direct and indirect impacts on people's health. Rising temperatures result in more heat-related illnesses and can affect wellbeing through heat stress and overheating. Extreme weather events increase the incidence of infectious diseases and respiratory issues and have been linked with mental health impacts. Health impacts are not distributed evenly. Children are particularly vulnerable to heat stress. Māori communities can have higher baseline vulnerabilities and face a higher burden, particularly in rural and coastal areas.

Extreme events and high temperatures increase mortality and illness

- Extreme heat affects human health. In New Zealand, the mortality risk during the summer was estimated to have increased 0.5 percent for every 1 degree Celsius increase in mean temperature between 1999 and 2025 (Lu et al., 2026). In a study of Wellington public housing tenants, indoor overheating was linked to sleep disruption, stress and reduced wellbeing (Chen et al., 2025).
- **Outlook:** Under both low and high climate scenarios, the number of days above 25 degrees Celsius is *very likely* to increase by 2050 (*high confidence*), increasing exposure to heat-related health risks (*low confidence*) (Broadbent et al., 2024; He Pou a Rangi Climate Change Commission, 2026b; Lai et al., 2024; Lu et al., 2026).
- Floods and tropical cyclones can have lasting effects on health. Multi-country studies, which include New Zealand data, have linked these events to elevated mortality risk in the weeks and months following exposure (Huang et al., 2024a; Yang et al., 2023). Flood exposure has also been associated with increased hospitalisation risks across a range of diseases, including respiratory, infectious and digestive diseases (Yang et al., 2025). Infectious disease hospitalisation risks have been found to remain elevated for up to 26 weeks after flood exposure (Yang et al., 2026).
- For New Zealand between 2000 and 2019, each additional day of modelled tropical cyclone exposure was associated with an estimated 14 percent increase in hospitalisations for infectious diseases over the following two months. For intestinal infectious diseases specifically, there was an estimated 21 percent increase in hospitalisations associated with each day of exposure (Huang et al., 2024b).
- Flooding and extreme weather events increase human health risks via contamination of drinking water, particularly for untreated supplies (Awatere et al., 2021a; MOH, 2024; Teen, 2024; see [Our Freshwater 2026](#)). For example, reported cases of leptospirosis spiked between February and April 2023, suggesting increased exposure following Cyclone Gabrielle. Leptospirosis is a bacterial infection that can be passed from animals to humans through contaminated water, including floodwaters (EHINZ, 2025).

Severe weather events carry a mental health burden for people and communities

- Exposure to climate-related hazards, including extreme rainfall, heat, drought, wildfires and floods, has been linked to psychological distress and worsened mental health. Severe weather events can also disrupt homes, livelihoods, infrastructure and community

connections, placing an ongoing burden on affected individuals and communities (Charlson et al., 2021, Grout et al., 2022; Jones et al., 2023; Ministerial Inquiry into Land Uses in Tairāwhiti and Wairoa, 2023).

- People in Hawke's Bay and Te Tairāwhiti who experienced Cyclone Gabrielle in 2023 – as well as civil defence personnel in Westport who dealt with three major floods in 2022 to 2023 – reported high levels of stress, anxiety, grief and symptoms of PTSD following the event (Johnson et al., 2025; McClutchie et al., 2026; Thorpe et al., 2025).
- The impact of the 2023 Auckland severe weather events continued to affect people well after the immediate event. Many Aucklanders, especially affected homeowners, faced a long recovery process while enduring stress, anxiety, uncertainty, financial pressure and emotional impacts. Those supporting the recovery work also experienced stress while navigating complex issues and managing expectations from people in distress (Tāmaki Makaurau Recovery Office, 2026).
- When climate events disrupt access to mahinga kai (traditional food gathering), wāhi tapu (sites of significance), or places where tikanga is practised, the harm includes losing the capacity to maintain and fulfil the relationships associated with these practices, not only losing the physical environments themselves (Mahuta et al., 2025).
- Marae hold cultural, spiritual and ancestral significance for Māori. Cyclone Gabrielle's passage in February 2023 damaged many marae, with some destroyed. The storm also damaged urupā (burial grounds), culturally significant objects such as waka, and the natural environment, while restricting access to places of cultural significance through damaged roads. These losses and disruptions caused grief among Māori in Te Tairāwhiti and Hawke's Bay (McClutchie et al., 2026; Thorpe et al., 2025).
- People, homes and culturally important sites are becoming increasingly exposed to extreme weather events (see [section 3](#)).

Climate-related health risks are not distributed evenly

- Māori communities face the same health risks from climate change as the general public, and may experience greater vulnerability due to pre-existing inequities in health outcomes, socioeconomic conditions, and uneven access to key determinants of health, including housing and healthcare services. Vulnerability is further elevated in rural and coastal areas where access to health services may be more limited, and exposure to climate-related hazards is greater (Jones et al., 2014; Masters-Awatere et al., 2022).
- Children are also particularly vulnerable to heat-related illness, with New Zealand research finding greater sensitivity to high temperatures among Māori, Pacific and Asian children than European children (Lai et al., 2024).
- Between 2000 and 2019, New Zealand hospital admissions for children under five years old were estimated to be 33 percent higher with daily maximum temperatures of 30 degrees Celsius (compared to 24 degrees Celsius), and more than twice as high when daily temperatures reached 35 degrees Celsius. Between 2013 and 2019, heat-related admissions represented approximately 0.3 to 1.1 percent of total annual hospital admissions for children under five (Lai et al., 2024).
- **Outlook:** Heat-related hospital admissions for children under five are projected to increase with future warming. Modelling estimates that these admissions would increase 76 percent under 1 degree Celsius of warming, compared with admissions between 2013 and 2019 (*low confidence*) (Lai et al., 2024).

3. The impacts of climate change on the economy and infrastructure

Section themes

- Climate changes such as drought, extreme heat and warming seas are already impacting the production of some agricultural crops like kiwifruit and farmed seafood like mussels.
- Projected future changes are expected to challenge dairy and fruit production and commercial fishing, but may expand suitable areas and conditions for some crops and species.
- Extreme weather events are causing widespread damage to homes, property and culturally important sites, endangering lives and carrying significant economic costs.
- Many of our homes, and much of our power, water and transport infrastructure, are already exposed to flooding or landslides, and are projected to become even more exposed over time.
- Damage to roads and infrastructure can cut people and businesses off from essential services like power, water and hospitals, and disrupt food production and distribution.



3. The impacts of climate change on the economy and infrastructure

The climate changes described in section 1, and their effects on natural systems and people, as described in section 2, are also affecting Aotearoa New Zealand's economy, infrastructure, property and livelihoods. Some impacts develop gradually as temperatures rise, rainfall patterns shift, seas warm and sea levels increase. Others arise through sudden events such as floods, droughts, storms and landslides. These impacts can compound over time and spread across connected economic and infrastructure systems.

Major sectors of New Zealand's economy, including agriculture, fisheries and tourism, depend on relatively stable environmental and climatic conditions. Rising temperatures, and changes to water availability, growing conditions and marine environments are already affecting some activities and are expected to create further risks. Not all changes will have the same effect in every place or sector, and some may create opportunities. However, working with changing and extreme conditions can involve uncertainty, disruption and costs.

Homes, businesses and essential infrastructure are also increasingly exposed to climate-related hazards. Damage to transport routes, electricity networks, water services and community facilities can have consequences beyond the assets directly affected. It can interrupt access to essential services, disrupt supply chains and livelihoods, and make it harder for communities to respond to and recover from ongoing extreme events. These effects are interconnected and can persist long after an event has passed.

The costs of climate impacts are not limited to disaster response and recovery. As risks increase, insurers are expected to respond through higher premiums and, in some cases, reduced availability of cover in high-risk locations. Evidence is increasingly showing that investing in risk reduction and adaptation before disasters occur is often less costly than repeated recovery afterwards.

This section will examine the impacts of climate change on our major economic sectors before considering the growing costs of climate-related hazards and the exposure of property, infrastructure and essential services.

The economy

Much of New Zealand's economy is dependent on the environment. As the environment changes with a changing climate, many sectors face increasing risks. The agricultural sector could feel increased impacts from more droughts and storms. Temperature changes will affect where certain crops can be grown, and could expand the range of pests. Commercial fisheries are also being impacted, with projected increases for some fish stocks and declines for many others. Changes to ecosystems and damage to infrastructure is affecting the tourism industry, while insurance and financial services are under increasing pressure from repeated extreme events.

Climate change is having direct economic impacts on agriculture and horticulture

- Nationally, drought is associated with increased short- and long-term debt, lower profitability and greater financial strain for dairy farms (Kamal & Noy, 2023). There is some evidence that drought can increase the profitability of dairy farming within New Zealand's largest dairying regions (Waikato and Taranaki), as the lower production from these regions during droughts is significant enough to drive up the market price for milk (Pourzand, 2023).
- **Outlook:** More frequent droughts and greater variability in freshwater availability are expected to increase the need for investment in irrigation, water storage and other water management measures. This potentially adds to costs for farmers (*low confidence*) (Cameron & Peer, 2025).
- **Outlook:** Climate change is projected to reduce dairy production in New Zealand. However, the overall impact on farm profitability is uncertain, as it will also depend on how climate change affects global milk supply and market prices (*low confidence*) (Wreford et al., 2026).
- **Outlook:** Climate change is expected to affect the health and wellbeing of livestock by increasing heat stress in dairy cattle (*medium confidence*) (Woodward et al., 2025) and creating conditions that favour some animal diseases and parasites (*low confidence*) (Lilburne et al., 2025; Wada et al., 2026).
- Kiwifruit production is already being affected by changes in temperature and rainfall, as well as more frequent extreme weather events. Drought, flooding and heat stress can reduce fruit quality and yields, affecting grower incomes and communities that depend on the industry (Rajan et al., 2024).
- **Outlook:** Climate change is expected to shift where crops can be grown in New Zealand. Suitable growing areas are *very likely* to expand or move southward for some crops, creating new opportunities in some regions while reducing suitability in others. For example, viable growing areas are projected to expand for avocados and shift for crops such as blueberries (*high confidence*) (Lilburne et al., 2025; Vetharanim et al., 2024).

Warmer waters are impacting commercial fisheries and aquaculture

- Marine heatwaves can affect the abundance and distribution of commercially important fish species. Moderate marine heatwaves lead to an increased abundance of commercial fish species around New Zealand, and therefore larger catches. However, more severe events are associated with declines in fish populations and reduced catches (Lacheheb et al., 2024; Mediodia et al., 2024).
- Marine heatwaves have caused large losses in farmed salmon and mussels (Cook et al., 2025; Ericson et al., 2023; Muznebin et al., 2022). Green-lipped mussels have poorer health at warmer temperatures (Azizan et al., 2023; Ericson et al., 2023; Kozal et al., 2024), and they have come under increasing pressure from increases in harmful algal blooms due to more frequent and intense marine heatwaves (Greenhough et al., 2025).
- **Outlook:** Increases of around 1 degree Celsius in sea-surface temperature and 0.5 to 1 degrees Celsius in coastal bottom water temperature are expected by mid-century (*high confidence*). This projected warming means populations of some commercially important

inshore finfish, such as snapper and tarakihi, could benefit, while others, such as blue cod and red cod, could be harmed (*low confidence*) (Behrens et al., 2025).

- **Outlook:** Even under the low climate scenario, the projected effects of climate change on the ocean around New Zealand, particularly increasing sea-surface temperatures, are predicted to reduce the extent of suitable habitat for the commercially important offshore finfish species hake, hoki and barracouta by the end of the century (*low confidence*) (Bas et al., 2024).
- **Outlook:** Models for the shallow coastal ecosystem of Tasman and Golden Bays project reductions in the productivity of about half of its fisheries, and increases for the others, if water temperatures warm by 1.9 degrees Celsius by 2060 (*medium confidence*). For the deep offshore ecosystem of the Chatham Rise, productivity is projected to decrease for about 85 percent of fisheries in response to this rate of warming (*medium confidence*) (Datta et al., 2024).

The Māori economy is facing climate impacts across different sectors

- **Outlook:** Climate change is expected to affect Māori primary industries through warming, more frequent droughts, changing rainfall patterns and shifts in seasonal conditions. These changes may affect agricultural and aquaculture productivity and disrupt maramataka-based planning (planning based on the Māori lunar calendar), food production and tikanga-aligned practices (practices aligned with customs and protocols) that rely on seasonal rhythms and environmental signals (*medium confidence*) (Awatere et al., 2021b, 2026; Cummings et al., 2021; King et al., 2010).
- Māori-led tourism businesses around Westland Tai Poutini National Park are being challenged by the retreat of the glacier tourist attractions (Hamilton et al., 2025).
- Māori horticulture enterprises in Hawke's Bay were significantly affected by Cyclone Gabrielle, which caused extensive crop losses and substantial recovery costs (Schulze et al., 2025).
- Warmer ocean conditions have been linked to impacts on commercial fisheries (Cook et al., 2025; Lacheheb et al., 2024) and have coincided with lower landed volumes of some fish stocks. Māori own the rights to nearly one-third of New Zealand's commercial fishing quota, and, for many Māori, fisheries are their most significant economic assets. These revenue streams could be affected if temperature changes impact fish stocks in specific quota management areas (Hudson, 2022).

Extreme weather and a changing climate are affecting tourism

- The flooding in early 2023 from Cyclones Hale and Gabrielle is estimated to have cost local economies and the Department of Conservation (DOC) at least \$56 million through cancellations, lost revenue and asset damage to public conservation lands and water (Bose & Becken, 2024).
- **Outlook:** Even under the low climate scenario, by 2050, the tourism sector could face pressure due to reductions in international visitors, particularly from long-haul journeys that may become prohibitively expensive for many. Tourism operators with high emissions could struggle to remain viable, as the world shifts to a lower-emission economy.

However, there are opportunities to adapt, reposition and even grow the tourism sector under these changing conditions (PwC, n.d.).

- **Outlook:** If the transition to global net zero is delayed from 2050 to 2060 or later, by 2050 visitor experience providers could be more severely affected by widespread extreme weather damage to tourist destinations and transport infrastructure. Operators could face considerable costs to adapt, and without support many businesses could struggle to remain viable (PwC, n.d.).

Insurers face increased costs, leading to higher premiums and reduction of coverage in some areas

- Profits for businesses in financial and insurance services are impacted when severe extratropical cyclones hit New Zealand, especially when this happens in back-to-back years or multiple times in the same year. For example, four severe extratropical cyclones made landfall during the April 2017 to March 2018 financial year, corresponding to an estimated \$110 million reduction in annual profits across affected financial and insurance services firms (Roy & Noy, 2023).
- Extreme weather events carry significant costs to insurers. There were \$3.8 billion in insured losses associated with Cyclone Gabrielle and the Auckland Anniversary Weekend floods, both in 2023. This figure was dominated by home and contents losses, comprising \$2.1 billion, followed by business losses, comprising \$1.45 billion (ICNZ, n.d.).
- The 11 severe weather events since the Cyclone Gabrielle, Auckland Anniversary Weekend and North Island severe weather events in early 2023 have resulted in \$638 million in insured losses – approximately \$401 million for domestic claims (such as home and contents), \$184 million for business and commercial claims, and \$46 million for motor vehicle claims (ICNZ, n.d.).
- Research indicates a sound insurance sector contributes to the financial security of property and business owners. Disaster insurance protects investments, and, by transferring financial risk from individuals to markets, it encourages investment and economic growth (Storey et al., 2024).
- The increasing risk of disasters under climate change is expected to result in insurers increasing premiums and reducing or fully withdrawing coverage in high-risk areas, transferring significant financial risks to property owners. This has major implications for the residential property market, as mortgage lending is contingent on securing insurance (Storey et al., 2024).
- More insurers are adopting 'risk-based' pricing, where properties in areas at high risk of disasters are subject to higher premiums. In 2024, for the approximately 120,000 properties assessed as being at a high risk of flooding, around 20 percent were already paying an average of \$250 more a year in risk-based premiums (RBNZ, 2024).
- Some marae face challenges accessing adequate insurance, retrofitting capacity, or access to recovery funding, particularly where there are multiple landowners, or where they are collectively governed in ways that do not meet standard eligibility criteria. These factors can limit the ability of marae to restore function following damage from extreme weather events. Evidence on the scale of this challenge remains regional rather than being nationally quantified (Awatere et al., 2021a, 2026; Berghan, 2021).

Up-front investment in adaptation can reduce rising recovery costs

- Loss and damage to infrastructure and property from flooding under climate change carries significant economic costs (New Zealand Infrastructure Commission, 2026).
Outlook: These costs are projected to rise. Climate change is *very likely* to increase the financial costs of inland and coastal flooding damage across existing homes, public buildings, transport networks and water and electricity infrastructure, under the moderate⁹ and high climate scenarios (*high confidence*) (Horspool et al., 2026).
- **Outlook:** Modelling suggests annual flood damage costs could increase around 55 to 70 percent by 2075 (in 2022 dollars), under the moderate and high climate scenarios. For example, flood damage costs for current private buildings are projected to rise between 45 to 60 percent, from \$270 million up to \$390 to \$430 million a year. Costs from damaged water and electricity networks could increase between 65 to 80 percent, from \$250 million up to \$420 to \$460 million a year, depending on future emissions (*low confidence*) (Horspool et al., 2026).
- Investing in flood risk reduction is more effective and cost efficient than spending on post-disaster recovery. Every \$1 invested in flood management infrastructure is estimated to avoid between \$5 and \$8 in direct losses. For example, for Westport it was estimated that a \$10 to \$20 million investment in flood protection prior to major flooding events in July 2021 and February 2022 could have largely prevented the approximately \$200 million in estimated recovery and indirect costs following the events (Te Uru Kahika, 2023).
- Other costly climate-related hazards, such as landslides, are projected to occur more frequently and with greater intensity (He Pou a Rangi Climate Change Commission, 2026b).
- Investing in landslide resilience can also avoid the far greater costs associated with recovering from landslides. In an example from Auckland, it is estimated that preventative measures targeting drainage and slope stability could have significantly reduced the extent and cost of landslide damage from the 2023 Auckland Anniversary Weekend and Cyclone Gabrielle events (Auckland Transport, 2025).

Property, infrastructure and services

Much of our infrastructure was not designed for the level of natural hazard impacts we are already experiencing due to climate change. These impacts are projected to increase. Increasing numbers of homes and properties are exposed to flooding and landslides, putting people more at risk. The critical infrastructure – such as transport routes and marae – needed to respond to more frequent extreme events are also more vulnerable. Water supplies are often under pressure from drought, flooding and salt-water intrusion, and changes to agricultural production – both in New Zealand and globally – put our food security at risk.

⁹ The moderate climate scenario used here is defined in Horspool et al., 2026. It equates to SSP2-4.5.

People and property are becoming increasingly vulnerable to flooding and landslides

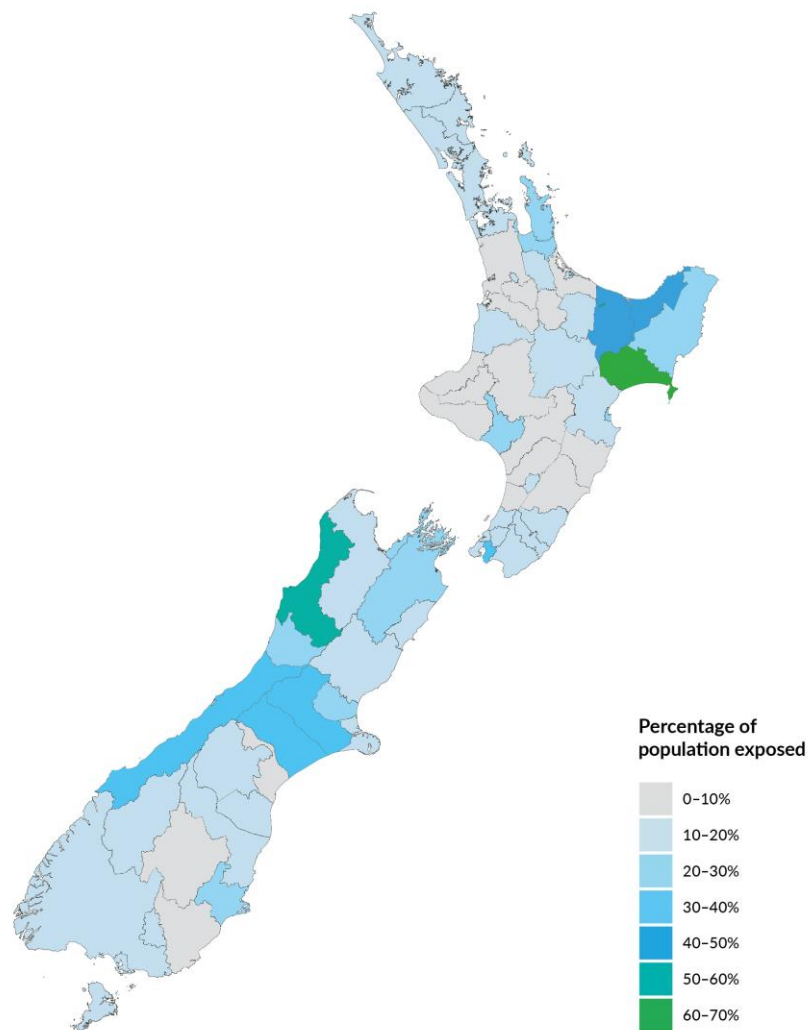
- Since the 28-day national state of emergency declared for Cyclone Gabrielle in 2023, every region except Taranaki has been affected by at least one local state of emergency due to extreme weather or flooding. Region-level states of emergency for extreme weather have affected ten regions, with these declarations lasting two to three weeks for events affecting the Bay of Plenty, Tairāwhiti, Nelson, Tasman and Southland regions (NEMA, n.d.).
- The effects of extreme weather can pose direct risks to safety. In 2023, Cyclone Gabrielle caused 11 deaths due to flooding and rainfall-induced landslides (Brook & Nicoll, 2024; Kerr et al., 2023), and there were nearly 2,000 ACC injury claims linked to the event. Although most injuries were minor soft tissue injuries, there were several hundred more serious injuries, including lacerations, fractures and concussions (Wilson et al., 2023). In January 2026, eight people died in Tauranga as a result of landslides following a series of severe storms (New Zealand Gazette, 2026).
- Extreme weather events in recent years have caused widespread damage and disruption to homes. Properties have been ‘red-stickered’ (prohibited from access until repairs have made them safe to occupy) following flood events in each of the past three years (Earth Sciences New Zealand, 2026a; NIWA, 2024, 2025).
- Flooding of inland areas presents the most widespread risk to people and property. Modelling estimates that the homes of about 750,000 people are already exposed to inland flooding under a 1 percent annual likelihood flooding event.¹⁰ Communities in some parts of the country are particularly exposed. The homes of approximately 55 percent of the population of both the Kawerau (eastern Bay of Plenty) and Buller Districts, and of 63 percent of the Wairoa District, are exposed (He Pou a Rangi Climate Change Commission, 2026a; Paulik et al., 2026; see [figure 3](#)).
- **Outlook:** Exposure of existing homes to inland flooding is projected to increase nationally, with between 815,000 and 839,000 residents exposed by 2050 under a 1 percent annual likelihood flooding event, under the low and high climate scenarios respectively (*low confidence*) (Paulik et al., 2026).
- For rainfall-induced landslides, modelling estimates that the homes of about 80,000 people are already exposed under a 1 percent annual likelihood rain event. **Outlook:** Exposure of existing homes is projected to increase, with between 111,000 and 127,000 residents exposed by 2050, under the low and high climate scenarios respectively (*low confidence*) (Paulik et al., 2026).
- For coastal flooding, modelling estimates that the homes of about 32,000 people are already exposed under a 1 percent annual likelihood flooding event.¹¹ **Outlook:** Exposure of existing homes is projected to increase, with between 48,000 and 52,000 residents exposed by 2050, under the low and high climate scenarios respectively (*high confidence*) (Paulik et al., 2026).

¹⁰ Current exposure estimates for inland flooding and rainfall-induced landslides are based on 1 degree Celsius of warming above pre-industrial (1850 to 1900) levels, which current warming has already surpassed (He Pou a Rangi Climate Change Commission, 2026c).

¹¹ Current exposure estimates for coastal flooding are based the 2005 midpoint of New Zealand sea-level rise relative to land for 1995 to 2024 (He Pou a Rangi Climate Change Commission, 2026c).

- The increasing risks of disasters under climate change will result in homes in high-risk areas becoming uninsurable. Without insurance, these homes are ineligible for mortgage lending, making them more difficult to sell and reducing their market value (Nyce et al., 2015; Storey et al., 2024). Those who wish to sell may have to do so at a considerable loss, reducing their options to purchase homes elsewhere.
- **Outlook:** As coastal flooding becomes more frequent, around 10,000 properties in Auckland, Christchurch, Wellington and Dunedin may become increasingly difficult or expensive to insure as soon as 2035, with modelling estimating that it is *likely* they will be uninsurable by mid-century (*low confidence*) (Storey et al., 2024).

Figure 3: Percentage of people whose homes are currently exposed to a 1 percent annual likelihood inland flood event



Data source: He Pou a Rangi Climate Change Commission

Climate change increases risks of disruption to power, water, wastewater and stormwater services

- Extreme weather events in recent years have caused widespread disruption to homes and properties. In 2023, Cyclone Gabrielle cut power to 225,000 homes as a result of wind, flooding or landslides. In 2025, more than 25,000 properties lost power from a single storm (Earth Sciences New Zealand 2026a; NIWA 2024).
- Modelling estimates that 11 percent of electricity transmission structures are already exposed to inland flooding and 4 percent are already exposed to rainfall-induced landslides, under a 1 percent annual likelihood inland flooding or rainfall event.¹² **Outlook:** Exposure is projected to increase. By 2050 under the low, moderate¹³ and high climate scenarios, about 11 percent of existing structures are projected to be exposed to inland flooding (*low confidence*), with 5 to 6 percent exposed to rainfall-induced landslides (*low confidence*), under a 1 percent annual likelihood event (Paulik et al., 2026).
- Climate change is already affecting water infrastructure and is expected to increase risks to drinking water, wastewater and stormwater systems. Climate-related hazards can affect drinking water supply, water quality and the performance of water infrastructure (He Pou a Rangi Climate Change Commission, 2026b).
- Stormwater and wastewater systems are already under pressure from heavy rainfall and flooding, with many networks under stress. More frequent and intense rainfall is expected to place further pressure on these systems and may exceed the design capacity of existing networks. This increases the risk of wastewater overflows, reduced system performance and contamination of waterways (He Pou a Rangi Climate Change Commission, 2026b).
- Flooding of inland areas presents the most widespread risk to water infrastructure. Modelling estimates that 35 percent of wastewater and stormwater pipes and 27 percent of water supply pipes are already exposed to inland flooding, under a 1 percent annual likelihood event. **Outlook:** Exposure of existing networks is projected to increase under the low, moderate and high climate scenarios, with 39 to 40 percent of wastewater and stormwater pipes and 30 to 31 percent of water supply pipes exposed by 2050 (*low confidence*) (He Pou a Rangi Climate Change Commission, 2026a; Paulik et al., 2026).
- At present, shallow coastal groundwater already causes flooding and leaks into urban stormwater and drainage systems. Rising sea levels are making these problems worse by raising coastal groundwater tables. These issues could limit residential water use through outages, restrictions or water quality problems. The risks of polluted water and sewage overflows also increase (Bosserelle & Hughes, 2024; see [Our Freshwater 2026](#)).
- For water infrastructure near the coast, shallow groundwater presents the most widespread exposure risk stemming from rising seas. Modelling estimates that 7 percent of wastewater and stormwater pipes and 5 percent of water supply pipes are already exposed to shallow (less than 1 metre below the ground surface) coastal groundwater.¹⁴ **Outlook:** Exposure of existing networks is projected to increase, with 8 percent of

¹² Current exposure estimates for inland flooding and rainfall-induced landslides are based on 1 degree Celsius warming above pre-industrial (1850 to 1900) levels, which current warming has already surpassed (He Pou a Rangi Climate Change Commission, 2026c).

¹³ The moderate climate scenario used here and in the remainder of this section is defined in Paulik et al., 2026. It equates to SSP2-4.5.

¹⁴ Current exposure estimates for shallow coastal groundwater are based the 2005 midpoint of New Zealand sea-level rise relative to land for 1995 to 2024 (He Pou a Rangi Climate Change Commission, 2026c).

wastewater and stormwater pipes and 6 percent of water supply pipes exposed by 2050, under the low, moderate and high climate scenarios (*medium confidence*) (He Pou a Rangi Climate Change Commission, 2026a; Paulik et al., 2026).

- Drought poses a risk to drinking water supply, particularly when reduced water availability coincides with periods of high demand. **Outlook:** Drought frequency is likely to increase in some regions (*high confidence*), which may further reduce drinking water supply (Broadbent et al., 2024; He Pou a Rangi Climate Change Commission, 2026b; Lewis et al., 2025b).
- Such impacts can also be costly. For example, emergency upgrades to drinking water supplies for Auckland during the region's 2020 drought cost more than \$220 million (Orsman, 2020).

Transport routes and critical services are increasingly exposed to climate impacts

- Extreme weather events have already damaged and disrupted transport infrastructure in New Zealand, causing road and airport closures and affecting the movement of people and goods (Earth Sciences New Zealand, 2026a; NIWA, 2024, 2025).
- Modelling estimates that 1 percent of New Zealand's road network is already exposed to coastal flooding under a 1 percent annual likelihood event,¹⁵ which could isolate around 140,000 people and more than 15,000 businesses from essential services such as hospitals. **Outlook:** Isolation risk is projected to rise due to increased coastal flooding of roads with sea-level rise. With the projected 20 centimetres of relative coastal sea-level rise by mid-century,¹⁶ it is likely that more than 183,000 people (*high confidence*) and 23,000 businesses (*medium confidence*) could become isolated, under both the low and high climate scenarios (Paulik et al., 2026; Urban Intelligence, 2025, 2026).
- People can also lose access to essential services when these are directly damaged by coastal flooding. Modelling estimates that 77 schools, 6 fire stations and 6 hospitals are already directly exposed to coastal flooding under a 1 percent likelihood annual event.¹⁷ **Outlook:** With 20 centimetres of relative coastal sea-level rise by mid-century, a further 29 schools and 9 fire stations are projected to be exposed (*medium confidence*) (Urban Intelligence, 2024).
- Damage to water, wastewater and power infrastructure after coastal flooding events can render essential service providers such as hospitals and schools inoperable, even when they do not become isolated physically (Anderson et al., 2025a).
- Modelling estimates that 19 percent of the road network is already exposed to inland flooding, and 7 percent is already exposed to rainfall-induced landslides, under a 1 percent

¹⁵ Current exposure estimates for coastal flooding are based the 2005 midpoint of New Zealand sea-level rise relative to land for 1995 to 2024 (He Pou a Rangi Climate Change Commission, 2026c).

¹⁶ The projected 20 centimetres of relative coastal sea-level rise is above 2020 levels. This is projected to occur by 2045 (high climate scenario) to 2050 (low climate scenario), in places where it is not slowed by uplift or accelerated by subsidence (MfE, 2024b).

¹⁷ Current exposure estimates for essential services are based on a benchmark of 0 metres sea-level rise, which may not be directly comparable to the sea-level rise benchmark used for homes, water and transport infrastructure.

annual likelihood inland flooding or rainfall event.¹⁸ **Outlook:** Exposure is projected to increase. By 2050, under the low, moderate and high climate scenarios, about 20 percent of the existing network is projected to be exposed to inland flooding (*low confidence*), with 9 to 12 percent exposed to rainfall-induced landslides (*low confidence*), under a 1 percent annual likelihood event (Paulik et al., 2026).

- Although inland flooding and rainfall-induced landslides are estimated to affect significantly more of our road network than coastal flooding, comprehensive national estimates for the associated risks of population and business isolation are not currently available for these hazards (He Pou a Rangi Climate Change Commission, 2026c).
- Damage to transport infrastructure can also disrupt supply chains, businesses and access to employment. This affects the availability of goods and services and people's ability to earn income, and creates economic costs for communities. It can take years to repair the damage from major storms, prolonging disruption and leaving communities more vulnerable to recurrent events (He Pou a Rangi Climate Change Commission, 2026b).

Marae and culturally important sites can face infrastructure restraints and are vulnerable

- Marae serve critical roles as community emergency hubs during extreme weather events, providing shelter, welfare coordination and logistical support (Cram, 2021). Māori communities and cultural infrastructure, including marae, face specific challenges in responding to climate change because adaptation and recovery can be constrained by governance, funding and land-ownership arrangements (Awatere et al., 2021b).
- Some marae have begun retrofitting for climate resilience. The Living Pā project at Te Herenga Waka, Victoria University of Wellington, demonstrates how tikanga-grounded design principles can be applied to the construction and retrofit of wharehau (meeting houses) for climate resilience (Hall et al., 2024).
- Many marae are vulnerable to coastal flooding and rainfall-induced landslides. Modelling estimates that 12 marae (1.1 percent) are already directly exposed to coastal flooding and 2 marae (0.2 percent) are already exposed to rainfall-induced landslides, under a 1 percent annual likelihood coastal flooding¹⁹ or rainfall event.²⁰ A total of 100 marae (9 percent) are at risk of becoming isolated by this level of flooding, and a total of 88 marae (8 percent) are at risk of isolation by this extent of landslides, due to transport infrastructure exposure. This isolation could prevent marae from fulfilling their roles as cultural centres and emergency hubs during disasters, potentially compromising both cultural continuity and community resilience (MfE, 2024b; Urban Intelligence, 2024).
- **Outlook:** Sea-level rise will *very likely* increase coastal flooding exposure affecting settlements, marae and heritage sites (*high confidence*) (Bailey-Winiata et al., 2025; Jones et al., 2024a, 2024b; Lan et al., 2023; Paulik et al., 2023; Urban Intelligence 2024). Models

¹⁸ Current exposure estimates for inland flooding and rainfall-induced landslides are based on 1 degree Celsius warming above pre-industrial (1850 to 1900) levels, which current warming has already surpassed (He Pou a Rangi Climate Change Commission, 2026c).

¹⁹ Current coastal flooding exposure estimates for marae are based on a benchmark of 0 metres sea-level rise, which may not be directly comparable to the sea-level rise benchmark used for homes, power, water and transport infrastructure.

²⁰ The benchmark used for current rainfall-induced landslide exposure estimates for marae may not be directly comparable to the benchmark used for homes, power, water and transport infrastructure.

estimate that 20 centimetres of relative coastal sea-level rise by mid-century would directly expose a further 2 marae (14 total) to coastal flooding under a 1 percent annual likelihood event and could isolate a further 16 marae (116 total) (*high confidence*) (Urban Intelligence, 2024).

- Many culturally important sites and infrastructure, including marae, urupā (burial grounds) and kāinga (settlements), are vulnerable to damage from flooding, erosion, wildfires and other extreme weather events. Damage to these sites can affect the mātauranga Māori (Māori knowledge) associated with them (Awatere et al., 2021b; King et al., 2007).
- About one-fifth of known coastal archaeological sites are located on landforms sensitive to erosion driven by sea-level rise. Erosion of coastal sites is of particular concern, as it poses a risk of permanent loss of these culturally significant sites (Jones et al., 2024a, 2024b; Williams et al., 2025).

Climate change disrupts supply chains and food security

- Climate change is expected to change where and when some foods can be produced in New Zealand, which in turn could limit our access to them at a seasonal or local level (Lilburne et al., 2025).
- New Zealand's food security can also be affected by disruptions outside the country. Some staple foods, such as sugar, wheat, maize, rice and coffee, are imported from a small number of places, so climate-related droughts, floods or other disruptions to overseas production and trade-flows affect New Zealand's access to these foods (Soliman & Greenhalgh, 2020).
- New Zealand's people and communities are vulnerable to periods of food insecurity following disasters that disrupt domestic food production and supply chains (such as food delivered by road). These disruptions can be exacerbated by remoteness and geography (Resilience to Nature's Challenges, 2024).
- A case study of Christchurch shows that coastal flooding events could reduce or prevent access to supermarkets. In addition to the supermarkets that could not operate due to damage, many more would be made functionally inoperable due to interrupted services, such as power and water. Disruption or damage to transport infrastructure could prevent access or require travelling longer distances, adding to burdens on households (Anderson et al., 2025b).
- Lost income following extreme weather events can also reduce people's ability to afford food (Resilience to Nature's Challenges, 2024). This is particularly significant for rural and lower socioeconomic communities, where many people are already struggling to feed their families under increasing food prices (Strom et al., 2025; Vatsa & Renwick, 2025).

4. As communities change, so do the pressures they place on the environment

Section themes

- Changes to New Zealand's livestock composition and how we manage farms has shifted our agricultural emissions profile.
- Transport is the second biggest contributor to New Zealand's emissions, reflecting the way people and freight move around the country, and our continued reliance on road transport.
- Renewable energy sources can reduce our emissions, but these sources are heavily dependent on the climate and environmental conditions.
- How we use land and manage ecosystems can affect emissions, while also creating opportunities to reduce emissions and increase carbon storage.



4. The choices that shape New Zealand's climate future

As discussed in section 1, climate change is driven by the accumulation of greenhouse gases in the atmosphere. Section 2 and section 3 described how a changing climate is affecting Aotearoa New Zealand's environment, communities and economy, and how future impacts are influenced by decisions we make about how and where we live, build and invest. This section focuses on another part of that story: New Zealand's contribution to climate change through our greenhouse gas emissions, and the factors that influence the balance between emissions and removals.

While New Zealand's contribution to global greenhouse gas emissions is small, our emissions per person are high. Greenhouse gas emissions arise from activities such as food production, energy generation, transport, housing and land management. At the same time, forests, wetlands and other ecosystems remove and store carbon from the atmosphere. Our emissions are reducing in some areas, but are stable or increasing in others.

The balance between greenhouse gas emissions and removals is shaped by the way New Zealand generates energy, produces food, develops settlements and manages land. These same decisions can also influence environmental conditions and future exposure to climate-related hazards. Changes in land use, for example, can affect carbon storage, ecosystem condition and the vulnerability of people, infrastructure and natural systems to a changing climate. This balance between emissions and removals is changing across different sectors of the economy.

Within te ao Māori (the Māori worldview), people and the environment are often understood as existing in relationship with one another across places and generations. This perspective recognises that the environmental pressures created today can affect the choices, opportunities and wellbeing of future generations. It highlights the importance of considering the long-term balance between human activities and the capacity of natural systems to sustain environmental and human wellbeing over time (Awatere et al., 2021a; 2026).

Our place globally

Greenhouse gas emissions generated in one country contribute to atmospheric concentrations, regardless of where they occur. Although New Zealand's contribution to global emissions is small, our emissions per person are high, and reducing the impacts of climate change requires collective effort to reduce emissions. There is therefore opportunity for us to contribute to global efforts to reduce emissions. Understanding New Zealand's contribution requires considering both our emissions and their place within the cumulative global emissions that are driving climate change.

Emissions generated locally accumulate globally

- New Zealand makes up 0.06 percent of the world's population but emits 0.17 percent of all global emissions. Modelling by the Climate Change Commission suggests that if global

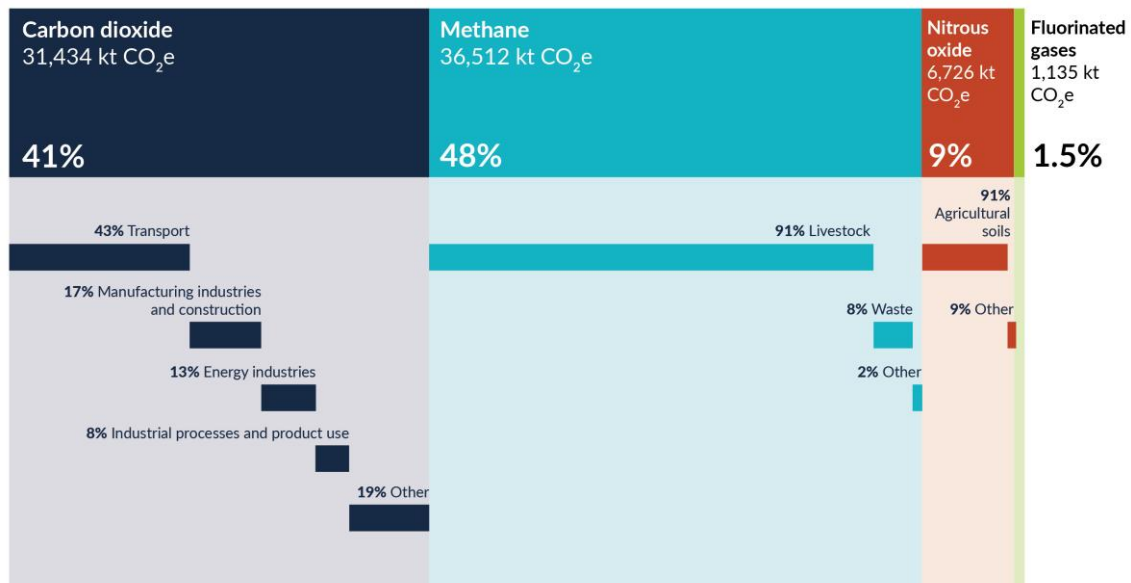
per person emissions were maintained at levels similar to New Zealand's, warming would be projected to peak at 5 degrees Celsius and decline to approximately 4.3 degrees by the year 2100 (He Pou a Rangi Climate Change Commission, n.d.).

- Our small share of global emissions, alongside that of many other countries, has global implications. In 2025, New Zealand and the other countries that each contribute less than 1 percent of global emissions collectively accounted for around a quarter of global emissions (EDGAR, 2026).
- Under the Paris Agreement, the global goal is to limit global warming to 1.5 degrees Celsius above pre-industrial levels and achieve net zero greenhouse gas emissions in the second half of this century. However, projections are indicating that sustained warming may reach, and even exceed, 1.5 degrees Celsius by the end of this decade (United Nations Environment Programme, 2026).
- It is considered that 1.5 degrees Celsius of global warming is a critical threshold, where several major climate tipping points, such as ice sheet and permafrost melt, or ecosystem collapse, become more likely to be triggered (Armstrong McKay et al., 2022). The maximum temperature reached, and the amount of time we spend above 1.5 degrees Celsius of warming, will have long-lasting implications for the impacts we experience (United Nations Environment Programme, 2026). As discussed in section 2 and section 3, some of the climate impacts of a world exceeding 1.5 degrees Celsius of warming are already starting to emerge in New Zealand – for example, ecosystem and biodiversity loss, intensifying extreme weather, and increasing harm to vulnerable populations.

Our emissions story

New Zealand's greenhouse gas emissions are changing across different sectors of the economy. Emissions have reduced in some areas as energy sources, livestock numbers, landfill management and forestry patterns have changed. In other areas, emissions remain stable or are increasing – particularly where transport demand, agricultural production, land-use change, and how and where people live continue to shape emissions and environmental conditions. Agriculture and energy (including transport) have dominated New Zealand's gross emissions over the long term, producing more than 90 percent of our gross emissions in 2024 (MfE, 2026; see [figure 4](#)). This reflects the significant role that both sectors hold in New Zealand's economy through export, employment and connectivity, and how the choices we make within these sectors can shape our emissions future.

Figure 4: New Zealand's gross greenhouse gas emissions, 2024



Note: Emissions presented here exclude emissions from Tokelau.

Changes in agricultural emissions largely reflect changes in livestock populations

- A major component of New Zealand's export economy, the agriculture sector, is the largest source of emissions. In 2024, agriculture made up 53 percent (40,148 kilotonnes of carbon dioxide equivalent emissions (kt CO₂e) of the country's gross emissions, of which 79 percent (31,588 kt CO₂e) was methane (MfE, 2026). Methane is a short-lived but potent greenhouse gas that, when emitted, causes additional warming compared to carbon dioxide (MfE, 2021).
- Between 2005 and 2023, sheep numbers decreased 39 percent. Although their population numbers have fluctuated since 2005, dairy cattle numbers have increased 16 percent, and the number of beef cattle decreased 17 percent (see indicator: [Livestock numbers: Data to 2023](#)).
- These changes to livestock populations contributed the most to reductions in methane emissions between 2005 and 2024. Methane emissions from enteric fermentation – a digestive process in ruminant animals such as sheep and cows – decreased due to declining sheep and non-dairy cattle populations. This was partially offset by growth in dairy cattle numbers, resulting in a net reduction of 1,781 kt CO₂e – that is, 44 percent of New Zealand's total reduction in methane (MfE, n.d., 2026).
- The net effects of changes in the overall numbers of different livestock types drove a 24 percent (478 kt CO₂e) increase in agricultural soil emissions between 2005 and 2024 (MfE, 2026).

Most of our transport emissions, New Zealand's second largest contributor, come from road transport

- New Zealand's domestic transport emissions per capita are high compared with many other Annex I countries²¹ (MfE, 2026), reflecting the structure of New Zealand's transport system and the way people and freight move around the country.
- Transport accounted for 18 percent of overall gross emissions (13,745 kt CO₂e) in 2024 and have increased 69 percent since 1990 (MfE, 2026). Of these emissions, 91 percent (12,556 kt CO₂e) were from road transport (MfE, 2026).
- Road transport was the only carbon dioxide emissions source that increased between 2005 and 2024 (13 percent, or 1,451 kt CO₂e). This was due to traffic growth and reflects the dominant role of roads in our transportation sector. With a dispersed population, rural-based economy and limited public transport infrastructure, New Zealand has one of the highest rates of car ownership in the world and predominantly moves freight by truck (MfE, n.d., 2026).
- The majority of New Zealanders live in urban areas, with city populations increasing and urban land cover expanding (EHINZ, n.d.). This drives demand for transport infrastructure and development (New Zealand Infrastructure Commission, n.d.). The area of land covered by transport infrastructure increased 15 percent (774 hectares) between 1996 and 2018, and 16 percent (988 hectares) between 2018 and 2023 (see indicator: [Urban land cover: Data to 2023](#)).

Emissions from energy generation fluctuate with climate conditions

- In 2024, New Zealand's energy industries (which includes public electricity and heat production, and manufacture of solid fuels) produced 14 percent of energy sector emissions (3,952 kt CO₂e) – a 34 percent decrease since 1990 (MfE, 2026).
- Between 2005 and 2024, the greatest decrease in emissions across sectors was from the energy sector. The largest reduction in emissions from within the energy sector during this time was in public electricity and heat production, where emissions decreased 59 percent, primarily due to an increase in renewable electricity generation. While total electricity generation grew 6 percent during this period, the share from renewable sources increased significantly – from 66 percent to 85 percent – driven by expanded geothermal and wind capacity (MfE, 2026). As a comparison, 32 percent of total electricity generation globally came from renewable sources (IEA, 2025).
- Large year-to-year fluctuations in emissions from public electricity and heat production occurred between 1990 and 2024. More than half of New Zealand's electricity comes from hydroelectric power generation, with electricity emissions sensitive to rainfall in key catchment areas. In a 'dry' hydro year (such as 2024), low rainfall reduces most of New Zealand's hydro lake levels, requiring greater use of natural gas and coal as back-up generation, increasing emissions (MfE, 2026).

²¹ Annex I Parties include the industrialised countries that were members of the Organisation for Economic Co-operation and Development in 1992, plus countries with economies in transition, including the Russian Federation, the Baltic States, and several Central and Eastern European States (UNFCCC, n.d.).

Emissions are reducing in the industrial and waste sectors

- In 2024, New Zealand's industrial processes and product use sector generated 5.1 percent (3,897 kt CO₂e) of New Zealand's gross greenhouse gas emissions. This represents a 12 percent increase since 1990 and a 4 percent decrease since 2005 (MfE, 2026).
- The decrease since 2005 has been driven primarily by COVID-19 pandemic disruptions to economic activity in the mineral and chemical industries, improved management in aluminium production, and the shortage of natural gas supply and energy security disrupting methanol production (MfE, 2026).
- In 2024, the waste sector produced 4 percent (3,009 kt CO₂e) of New Zealand's gross greenhouse gas emissions – mainly methane from solid waste disposal sites. This is a 10 percent decrease since 1990 (MfE, 2026).
- Improved landfill management contributed significantly to the reductions in methane emissions between 2005 and 2024, with a reduction of 27 percent (852 kt CO₂e) (MfE, 2026).

Carbon storage and land-use change

Although agriculture, transport, energy, industry and waste are the main sources of greenhouse gas emissions, land use also influences the amount of greenhouse gases removed from the atmosphere. Together, emissions and removals determine New Zealand's greenhouse gas balance. Many of these same land-use decisions can also influence exposure and vulnerability to climate-related hazards.

Land uses, such as forests, cropland, grassland, wetlands and settlements, either emit greenhouse gases into the atmosphere or remove it by acting as carbon sinks. When calculating greenhouse gas emissions this is referred to as the 'land use, land-use change and forestry' (LULUCF) sector. Land-use management and the impacts of human activities influence the potential of different land uses to be either a carbon sink or carbon source. Forest growth can offset emissions, but these benefits can be reduced depending on harvest rates and management practices. Wetlands are effective carbon stores, and this carbon is released to the atmosphere when they are drained (usually as carbon dioxide or methane).

Land-use and forest management decisions influence the balance between emissions and removals

- The LULUCF sector offset 28 percent (20,977 kt CO₂e) of New Zealand's gross emissions (75,812 kt CO₂e) in 2024 – a net removal increase compared to 2023, due to less deforestation and conversion to grassland. On balance, this meant our net emissions were 54,834 kt CO₂e (MfE, 2026).
- Emissions removals are mainly due to the carbon captured during the growth of the trees in indigenous and exotic forests, and the locking up of carbon in wood products produced from New Zealand-grown timber. National conversion of non-forest land to forested land is calculated to have removed 3,875 kt CO₂e from the atmosphere in 2024, equal to 26 percent of the carbon sink from New Zealand's existing forests (MfE, 2026). Fewer conversions of forest land to grassland occurred in 2024 compared with 2005, and this

offset 78 percent of the sector's increase in gross emissions between 2005 and 2024 (MfE, 2026).

- Forests can also be a source of emissions through harvesting, deforestation and decomposition of the resulting organic material. Greenhouse gases are also emitted through the burning of slash generated by these forestry activities (MfE, 2026). Current harvest rates are at near historically high levels, as many of the forests planted during significant land-use changes in the 1980s and early 1990s are now reaching maturity (MfE, 2026). High harvest rates in 2024 relative to 2005 has increased net emissions from the LULUCF sector 9 percent, which means it offset fewer of our overall gross emissions.

Healthy wetlands can store carbon, but wetland drainage can release it

- Land-use change, such as conversion to grazing grassland, has reduced the extent of pre-European historical wetland area, with estimates that only around 10 percent of this area remains (Dymond et al., 2021).
- New Zealand's freshwater wetland area decreased 6,641 hectares between 1996 and 2023. It decreased 537 hectares between 2018 and 2023 – the smallest decrease in a measurement period since 1996 (see indicator: [Wetland area: Data to 2023](#)).
- Peat wetlands specifically have stored large amounts of carbon (Ausseil et al., 2015), absorbed over long periods. However, emissions from peat wetlands can fluctuate. When peat wetlands are drained, they can release carbon into the atmosphere as carbon dioxide. It is estimated that drained peatlands used for farming emit 3.9 million tonnes of CO₂e every year (Goodrich et al., 2025) – equivalent to 5 percent of New Zealand's gross emissions in 2024 (MfE, 2026). However, when they are re-wetted, they can absorb and store carbon. For example, 1 hectare of drained organic soil used for grassland in New Zealand can produce about 24 tonnes of CO₂e per hectare each year. If rewetted, total CO₂e emissions would fall to 3.4 tonnes of CO₂e per hectare each year (Goodrich et al., 2025).
- New Zealand's saline wetland area decreased 356 hectares between 1996 and 2023. It decreased 113 hectares between 2018 and 2023 (see indicator: [Wetland area: Data to 2023](#)). Coastal wetlands are particularly effective at sequestering carbon and can store carbon at rates comparable to native forests (Ross et al., 2024).

5. Towards a better understanding

Global scale pressures on the atmosphere and climate are driving the changes in Aotearoa New Zealand's climate. This report described the current changes being observed and their impacts on people, communities, ecosystems and places. As the climate continues to change, understanding how these impacts may unfold over coming decades becomes increasingly important for adaptation planning and investment.

A better understanding of changing climate patterns, their consequences, and the ways people and natural systems may be affected can inform decision-making across a range of sectors. This section highlights where additional knowledge, data and evidence could improve our understanding of future climate risks and their implications for New Zealand. Three important areas of focus are strengthening our knowledge of future impacts, enhancing understanding of complex interactions across natural and social systems, and improving the quality and availability of decision-ready information about current and future changes.

Understanding future climate change and its impacts

While our understanding of climate change continues to improve, part of planning for future climate change includes making decisions despite inherent uncertainty. The following six knowledge gaps highlight important areas to improve our understanding of future impacts to New Zealand's environment, communities and economy.

- **Future climate conditions:** Our knowledge of the climate system has improved significantly in recent decades, but uncertainties remain around some aspects. For some issues, such as extreme rainfall, sea-level rise and the timing of impacts, continued research, monitoring and climate projections may improve understanding. For others, such as landslides and wildfire, climate is only one of several interacting drivers, and a range of future outcomes will need to be considered.
- **Uneven distribution of climate impacts:** The impacts of climate change are not distributed evenly across communities and places (Anderson et al., 2025a). While differences in exposure, vulnerability and adaptive capacity are increasingly recognised, how to address these inequities remains a knowledge gap (Jayawardena, 2024; Johnson et al., 2023b).
- **How climate impacts unfold:** While it is unlikely that we will be able to project precisely when and where future impacts will occur, understanding the direction and pace of change remains important. Some of the most consequential impacts may arise not from individual events, but from how events interact across time and place. This includes multiple hazards occurring together (eg, ex-tropical cyclones causing both river and coastal flooding, or extreme wind and heat resulting in wildfires), impacts affecting several locations simultaneously and repeated events occurring before recovery from earlier events is complete. There is currently little systematic information on how often communities, infrastructure and ecosystems are still recovering when the next event arrives. Better information on recovery, cumulative impacts and approaching thresholds

would improve our understanding of future climate risks, and support adaptation planning and emergency preparedness.

- **Changes to the natural environment:** Ecosystems, species and productive landscapes are already responding to climate change, but important knowledge gaps remain about what is changing, how quickly it is changing and what the consequences may be. Better understanding of these changes would improve our awareness of climate-related risks to biodiversity, ecosystem services and the benefits people derive from the natural environment.
- **Impacts across te ao Māori (the Māori worldview):** Important knowledge gaps remain about how climate change may affect Māori communities, cultural practices, mātauranga Māori (Māori knowledge) and the Māori economy. This includes understanding impacts on customary activities, relationships with place and transmission of intergenerational knowledge. Māori-led monitoring and mātauranga Māori provide important evidence for understanding these impacts.
- **Economic consequences:** There is limited understanding of the costs associated with climate impacts, recovery and adaptation to long-term environmental change in New Zealand. Evidence indicates that reducing risk from climate-related hazards is more cost-efficient than spending on recovery (He Pou a Rangi Climate Change Commission, 2026d). However, the true costs of recovery are not well established and there is limited centralised information on what it costs to repair or replace affected infrastructure and other assets. In addition, the benefits of anticipatory adaptation are difficult to quantify due to the inherent uncertainty regarding the timing and magnitude of the avoided impacts (Wilby et al., 2021). Acute events are relatively visible; while the cumulative costs of these events and slower, gradual changes – including effects on the cost of goods, employment and productivity – are harder to detect and less well understood.

Understanding system complexity

Climate impacts do not occur in isolation. The risks experienced by people and places are often shaped by interactions between environmental, cultural, social and economic systems. More research is needed on the connections and interactions between different areas of knowledge.

- **Thresholds and cascading risks:** Some environmental systems may respond gradually to climate change, while others may experience more rapid or difficult-to-reverse changes once certain thresholds are crossed. Climate impacts interact across environmental, social, cultural and economic systems, meaning disruption in one place can create consequences elsewhere. Understanding where thresholds exist for New Zealand's environment, and how impacts may cascade across systems would improve our understanding of future climate risks.
- **Co-benefits, trade-offs and climate resilience:** Resilience to climate change is supported by our environmental systems, and those same systems also provide other benefits. Many perform several of these functions concurrently: forests influence carbon storage, biodiversity and erosion processes; while wetlands influence carbon storage, biodiversity, water quality and flood management. This means our choices about how we use land and resources shape all of these outcomes. We need a greater understanding of how these outcomes interact, reinforce each another, or create trade-offs.

Improving access to information

Improving our understanding of climate change depends not only on new research, but also on access to trusted, relevant and decision-ready information. Many of the questions identified in this section cannot be answered by a single dataset, model or research project.

Improving understanding of future climate change requires more than filling individual knowledge gaps. It also requires an environmental information system capable of connecting evidence across disciplines, scales and sectors, so that climate risks can be understood within the broader environmental, social and economic systems in which they occur. This will allow relationships between climate hazards, ecosystem condition, infrastructure, communities and places to be understood together.

A recent report by the Parliamentary Commissioner for the Environment highlights challenges associated with New Zealand's fragmented environmental information landscape (PCE, 2026). Information is often collected by different organisations, for different purposes, using different approaches. This can make it difficult to access, combine and apply evidence consistently when assessing future risks and opportunities.

As climate change continues, decision-makers will increasingly need access to information that is:

- trusted – underpinned by robust science, monitoring and transparent methods
- accessible – available when and where it is needed, without barriers that may lead to less suitable information being used instead
- connected – able to bring together information across hazards, ecosystems, infrastructure, communities and places
- decision-ready – presented in forms that support planning, investment and risk management decisions, and matched to the scale and significance of the decision being made
- maintained over time – supported by ongoing monitoring, investment and updates so it remains relevant as environmental conditions change.

Climate projections, hazard maps, environmental monitoring, impact assessments and mātauranga Māori all contribute to understanding future climate risks. However, their value depends not only on their quality, but also on the ability to bring them together in ways that support interpretation and action.

Additional information

Environmental indicators

Listed below are the environmental indicators incorporated in this report, including 13 updated indicators in bold:

- **Annual glacier ice volumes: Data to 2023**
- **Atmospheric ozone: Data to 2025**
- Coastal sea-level rise
- **Drought and wet periods: Data to 2025**
- **El Niño Southern Oscillation: Data to 2025**
- **Extreme rainfall: Data to 2025**
- **Extreme wind: Data to 2025**
- **Frost and growing degree days: Data to 2025**
- **Greenhouse gas concentrations: Data to 2025**
- Livestock numbers: Data to 2023
- **Rainfall: Data to 2025**
- Sea-surface temperature: Data to 2023
- **Sunshine hours: Data to 2025**
- **Temperature: Data to 2025**
- Urban land cover: Data to 2023
- **UV intensity: Data to 2023**
- Wetland area: Data to 2023
- **Wildfire risk: Data to 2023**

The table below presents a summary of site data available from atmosphere and climate indicators supporting this release.

Indicator	Site data
Atmospheric ozone: Data to 2025	The annual average thickness of the ozone layer above Lauder in 2025 was 316 Dobson units – thicker than the average across the full measurement series from 1979–2025, which was 308 Dobson units. Upper-atmospheric ozone absorbs ultraviolet (UV) radiation from the sun, influencing the amount that reaches the Earth’s surface (see indicator: Atmospheric ozone: Data to 2025).
Drought and wet periods: Data to 2025	Of 30 sites, 20 had extreme dryness from 2016 to 2025, and 16 sites spent at least 25 percent of the time in medium-term drought. 25 sites had extreme wetness from 2016 to 2025, and 19 sites spent at least 25 percent of the time in a wet period (see indicator: Drought and wet periods: Data to 2025).
Extreme rainfall: Data to 2025	Extreme rainfall measures the highest amount of rainfall recorded in a single day each year and the percentage of annual rainfall from very wet days (days where daily rainfall exceeds a 95th percentile threshold). Between 1960 and 2025, annual maximum one-day rainfall amounts decreased at 9 sites, 8 of which were in the upper half of the North Island. Annual maximum one-day rainfall increased at 14 sites, and 7 sites had indeterminate trends. Between 1960 and 2025, the percentage of annual rainfall from very wet days decreased at 10 sites and increased at 17. Three sites had indeterminate trends (see indicator: Extreme rainfall: Data to 2025).
Extreme wind: Data to 2025	For the 17 sites where trends could be assessed between 1980 and 2025, both the annual average of the daily maximum wind gust and annual maximum wind gust decreased at 13 sites, increased at 3 sites (Gisborne, New Plymouth and Queenstown), and were indeterminate at 1 site (see indicator: Extreme wind: Data to 2025).
Frost and growing degree days: Data to 2025	Trends in the number of growing degree days ²² increased at 29 of 30 sites, and decreased at one site (Lake Tekapo) between 1972 and 2025. Trends in the number of frost days ²³ between 1972 and 2025 decreased at 20 of 27 sites, increased at 5 sites and were indeterminate at 2 sites, (see indicator: Frost and growing degree days: Data to 2025).
Rainfall: Data to 2025	Average annual rainfall at 30 sites increased at 18 sites and decreased at 8 between 1960 and 2025. Four sites had indeterminate trends (see indicator: Rainfall: Data to 2025).
Sunshine hours: Data to 2025	Between 2016 and 2025, Richmond (Tasman) received an average of 2,682 hours of bright sunshine each year – the highest among the 30 sites with sufficient data. Balclutha (Otago) received the lowest, with 1,686 hours each year on average. 22 of 30 sites received more than 2,000 average annual hours of bright sunshine (see indicator: Sunshine hours: Data to 2025).
UV intensity: Data to 2023	Between 2004 and 2023, the average number of days each year with peak UV intensity at very high or extreme levels at the 5 sites being monitored were 137 in Leigh, 112 in Paraparaumu, 104 in Lauder, 94 in Christchurch, and 71 in Invercargill (see indicator: UV intensity: Data to 2023).

²² Growing degree days estimate the length of the growing season for agriculture and horticulture. The measure counts the total number of degrees Celsius that the average temperature is above a base temperature (commonly 10 degrees Celsius) each day (see indicator: [Frost and growing degree days: Data to 2025](#)).

²³ A frost day is when the minimum air temperature recorded is below 0 degrees Celsius. It refers to a temperature measured in an instrument screen 1.2 metres above the ground rather than a ‘ground frost’ (see indicator: [Frost and growing degree days: Data to 2025](#)).

Acknowledgements

This report was compiled by the Ministry for Cities, Environment, Regions and Transport and Stats NZ's Environmental Reporting team.

Data providers

We would like to thank the following for providing data and advice in the development of indicators used in this report:

- Bioeconomy Science Institute (BSI)
- Earth Sciences New Zealand (ESNZ)
- Fire and Emergency New Zealand (FENZ)
- Land Information New Zealand (New Zealand Hydrographic Authority)
- Manaaki Whenua – Landcare Research
- National Aeronautics and Space Administration (NASA)
- National Oceanic and Atmospheric Administration (NOAA)
- National Institute of Water and Atmospheric Research (NIWA)
- Stats NZ

Senior science and mātauranga advisors

We would like to thank the following people and organisations for providing advice and helping to shape this report:

- Luke Harrington
- Tom FitzGerald (Water Technology)
- Shaun Awatere (Bioeconomy Science Institute)

External peer reviewers

We would like to thank the following people and organisations for providing advice and critical review of this report:

- Drew Bingham (Department of Conservation)
- Petra Pearce (Auckland Council)
- Sandy Morrison (University of Waikato)

Infographic

The infographic on page 9 was created by Dumpark Information Design.

References

- Allen, S., Bell, R., & Forkink, A. (2023). Coastal realignment: Another coastal challenge. *Policy Quarterly*, 19(1), 50–57. <https://doi.org/10.26686/pq.v19i1.8105>
- Allen, W., McCarthy, J., Jolly, B., Planzer, S., Sprague, R., Richardson, S., Baker, C., Graham, E., Mahlum, S., Hickford, M., Smith, B., Crawford, R., McArthur, N., & Beattie, A. (2024). *Ecological impacts of Cyclone Gabrielle*. Prepared for the Ministry of Business, Innovation and Employment by Manaaki Whenua – Landcare Research. https://www.landcareresearch.co.nz/assets/researchpubs/Cyclone_Gabrielle_Integrated_ecological_assessment_Full_report.pdf
- Anderson, M. J., Conrow, L., Hobbs, M., Paulik, R., Blackett, P., & Logan, T. (2025a). Distributional justice and climate risk assessment: An analysis of disparities within direct and indirect risk. *Risk Analysis*, 45(11), 3354–3374. <https://doi.org/10.1111/risa.17664>
- Anderson, M. J., Brunner, L., & Logan, T. (2025b). Functional isolation: The compounding burden on community capacity from cascading infrastructure failures and access disruption. *International Journal of Disaster Risk Reduction*, 118, 105190. <https://doi.org/10.1016/j.ijdrr.2025.105190>
- Armstrong McKay, D. I., Staal, A., Abrams, J. F., Winkelmann, R., Sakschewski, B., Loriani, S., Fetzer, I., Cornell, S. E., Rockström, J., & Lenton, T. M. (2022). Exceeding 1.5°C global warming could trigger multiple climate tipping points. *Science*, 377(6611), eabn7950. <https://doi.org/10.1126/science.abn7950>
- Auckland Transport. (2025). *Climate Adaptation Framework and Action Plan 2025*. Auckland Transport. <https://at.govt.nz/media/iqebfs0r/at-climate-adaption-framework-and-action-plan.pdf>
- Ausseil, A.-G. E., Jamali, H., Clarkson, B.R., & Golubiewski, N.E. (2015). Soil carbon stocks in wetlands of New Zealand and impact of land conversion since European settlement. *Wetlands Ecology and Management*, 23, 947–961. <https://doi.org/10.1007/s11273-015-9432-4>
- Awatere, S., King, D. N., Reid, J., Williams, L., Masters-Awatere, B., Harris, P., Tassell-Matamua, N., Jones, R., Eastwood, K., Pirker, J., & Jackson, A.-M. (2021a). He huringa āhuarangi, he huringa ao: A changing climate, a changing world. *Te Arotahi*, 7. Ngā Pae o te Māramatanga. <https://www.maramatanga.ac.nz/te-arotahi-07>
- Awatere, S., Reid, J., Masters-Awatere, B., Tassell-Matamua, N., Eastwood, K., Jackson, A.-M., King, D. N., Williams, L., Harris, P., Jones, R., & Pirker, J. (2021b). *He huringa āhuarangi, he huringa ao: a changing climate, a changing world*. Manaaki Whenua – Landcare Research. <https://www.landcareresearch.co.nz/assets/researchpubs/He-huringa-ahuarangi-he-huringa-ao-a-changing-climate-a-changing-world.pdf>
- Awatere, S., Harcourt, N., Kainamu, A., Forster, M., & Masters-Awatere, B. (2026). *Ngā mea hirahira o te ao Māori: Climate change risks to the Māori domain, National Climate Change Risk Assessment (NCCRA) 2026*. (Original work published 2025). Prepared for He Pou a Rangi Climate Change Commission by the New Zealand Institute for Bioeconomy Science Ltd. <https://www.climatecommission.govt.nz/assets/Uploads/NCCRA/finals/2026-NCCRA-Climate-change-risks-to-Maori.pdf>
- Azizan, A., Venter, L., Jansen van Rensburg, P. J., Ericson, J. A., Ragg, N. L. C., & Alfaro, A. C. (2023). Metabolite changes of *Perna canaliculus* following a laboratory marine heatwave exposure: Insights from metabolomic analyses. *Metabolites*, 13(7), 815. <https://doi.org/10.3390/metabo13070815>
- Bailey-Winiata, A. P., Gallop, S. L., Wotherspoon, L., Paulik, R., Winder-Murray, H., Billing, A., Conroy, E., Bennett, R., White, I., Ellis, J., & Fa’au, T. (2025). Increased exposure of marae to coastal flooding with sea level rise and adaptation learnings of Ngāi Tamawhariua and Maketū Iwi Collective. In C. A. Hendtlass, T. Fitzgerald, & A. Serrano (Eds.), *Shoreline strategies: Embracing coastal transformation*

- in *Aotearoa New Zealand* (pp. 29–36). New Zealand Coastal Society.
<https://www.coastalsociety.org.nz/assets/Uploads/files/SP6-reading-version.pdf>
- Bas, M., Ouled-Cheikh, J., Julià, L., Fuster-Alonso, A., March, D., Ramírez, F., Cardona, L., & Coll, M. (2024). Fish and tips: Historical and projected changes in commercial fish species' habitat suitability in the Southern Hemisphere. *Science of the Total Environment*, 948, 174752.
<https://doi.org/10.1016/j.scitotenv.2024.174752>
- Behrens, E., Dunn, M. R., Holmes, S. J., & Cummings, V. J. (2025). Marine heatwaves and fisheries in Aotearoa New Zealand: Observed and projected temperature anomalies and potential impacts by fisheries management area. *New Zealand Aquatic Environment and Biodiversity Report No. 351*. Fisheries New Zealand. <https://fs.fish.govt.nz/Doc/25860/AEBR-351-2025-Marine-heatwaves-and-fisheries-in-Aotearoa-New-Zealand.pdf.ashx>
- Bell, J. J., Micaroni, V., Strano, F., Ryan, K. G., Mitchell, K., Mitchell, P., Wilkinson, S., Thomas, T., Bachtar, R., & Smith, R. O. (2024). Marine heatwave-driven mass mortality and microbial community reorganisation in an ecologically important temperate sponge. *Global Change Biology*, 30, e17417. <https://doi.org/10.1111/gcb.17417>
- Berghan, J. (2021). *Kaupapakāinga: The potential for Māori cohousing*. Prepared for Building Better Homes, Towns and Cities: Affordable Housing for Generations. Building Better Homes.
https://www.buildingbetter.nz/wp-content/uploads/2023/08/Berghan_2021_kaupapakainga_potential_for_maori_cohousing.pdf
- Bird, L. J., Bodeker, G. E., & Clem, K. R. (2023). Sensitivity of extreme precipitation to climate change inferred using artificial intelligence shows high spatial variability. *Communications Earth & Environment*, 4(1), 469. <https://doi.org/10.1038/s43247-023-01142-4>
- Bodeker, G., Cullen, N., Katurji, M., McDonald, A., Morgenstern, O., Noone, D., Renwick, J., Revell, L. & Tait, A. (2022). *Aotearoa New Zealand climate change projections guidance: Interpreting the latest IPCC WG1 report findings*. Report number CR 501. Prepared for the Ministry for the Environment.
<https://environment.govt.nz/assets/publications/Climate-Change-Projections-Guidance-FINAL.pdf>
- Boffa Miskell. (2020, May 5). *The Big Dry: what drought means for our indigenous biodiversity*. Boffa Miskell. <https://www.boffamiskell.co.nz/news-insights/the-big-dry-what-drought-means-for-our-indigenous-biodiversity>
- Booker, D. J., & Whitehead, A. L. (2022). River water temperatures are higher during lower flows after accounting for meteorological variability. *River Research and Applications*, 38(1), 3–22.
<https://doi.org/10.1002/RRA.3870>
- Bose, D., & Becken, S. (2024). Tourism-related economic loss and damage from the North Island weather events on New Zealand conservation land and waters. *Journal of Outdoor Recreation and Tourism*, 46, 100767. <https://doi.org/10.1016/j.jort.2024.100767>
- Bosserelle, A. L., & Hughes, M. W. (2024). Practitioner perspectives on sea-level rise impacts on shallow groundwater: Implications for infrastructure asset management and climate adaptation. *Urban Climate*, 58, 102195. <https://doi.org/10.1016/J.UCLIM.2024.102195>
- Broadbent, A. M., Gibson, P. B., Sood, A., Rampal, N., & Stuart, S. J. (2024). How do New Zealand's downscaled CMIP6 climate projections compare with CMIP5? *Weather and Climate*, 44(1), 2–24.
<https://doi.org/10.2307/27384325>
- Brook, M. S., & Nicoll, C. (2024). Brief report of fatal rainfall-triggered landslides from record-breaking 2023 storms in Auckland, New Zealand. *Landslides*, 21(7), 1581–1589.
<https://doi.org/10.1007/s10346-024-02258-0>
- Brumby, A., Marshall, J., Murray, T., O'Donnell, C., & Richards, R. (2025). *Trait-based climate change vulnerability assessments of terrestrial taxa in Aotearoa New Zealand*. Science for Conservation 343. Department of Conservation. <https://www.doc.govt.nz/globalassets/documents/science-and-technical/science-for-conservation/343-climate-change-taxa/sfc343.pdf>

- Buck, M. (2025). Living on the edge: How do perceptions of coastal erosion risk affect residential mobility decisions? *Local Environment*, 30(10), 1279–1293.
<https://doi.org/10.1080/13549839.2025.2467868>
- Bukvic, A., Whittemore, A., Gonzales, J., & Wilhelmi, O. (2022). Understanding relocation in flood-prone coastal communities through the lens of place attachment. *Applied Geography*, 146, 102758.
<https://doi.org/10.1016/j.APGEOG.2022.102758>
- Cameron, N. A., & Peer, R. A. M. (2025). Quantifying water use in New Zealand's dairy food system: A baseline for future sustainability. *Agricultural Systems*, 225, 104272.
<https://doi.org/10.1016/j.agsy.2025.104272>
- Campbell, R., Beresford, R., Turner, R., Carey-Smith, T., & FitzHerbert, S. (2025). Potential climate change impacts on myrtle rust risk in Aotearoa/New Zealand. *Plant Pathology*, 74(5), 1426–1441.
<https://doi.org/10.1111/ppa.14104>
- Canning, A. D., Zammit, C., & Death, R. G. (2025). The implications of climate change for New Zealand's freshwater fish. *Canadian Journal of Fisheries and Aquatic Sciences*, 82, 1–15.
<https://doi.org/10.1139/cjfas-2024-0127>
- Carrivick, J. L., Sutherland, J. L., Huss, M., Purdie, H., Stringer, C. D., Grimes, M., James, W. H. M., & Lorrey, A. M. (2022). Coincident evolution of glaciers and ice-marginal proglacial lakes across the Southern Alps, New Zealand: Past, present and future. *Global and Planetary Change*, 211, 103792.
<https://doi.org/10.1016/j.gloplacha.2022.103792>
- Case, B., Hall, D., Day, N., Hermans, S., & Buckley, H. (2023). What is the role of biodiversity in mediating the effects of climate change on New Zealand's future agroecosystems? *New Zealand Economic Papers*, 57(2), 139–143. <https://doi.org/10.1080/00779954.2023.2191613>
- Charlson, F., Ali, S., Benmarhnia, T., Pearl, M., Massazza, A., Augustinavicius, J., & Scott, J. G. (2021). Climate change and mental health: A scoping review. *International Journal of Environmental Research and Public Health*, 18(9), 4486. <https://www.mdpi.com/1660-4601/18/9/4486>
- Chen, Z., O'Sullivan, K. C., Pierse, N., Ericson, E., & Stephenson, K. (2025). Exploring health and wellbeing impacts of summer indoor overheating on public housing tenants: A mixed-methods study in Wellington, New Zealand. *Energy and Buildings*, 347, Part B, 116296.
<https://doi.org/10.1016/j.enbuild.2025.116296>
- Ciais, P., Sabine, C., Bala, G., Bopp, L., Brovkin, V., Canadell, J., Chhabra, A., DeFries, R., Galloway, J., Heimann, M., Jones, C., Le Quéré, C., Myneni, R., Piao, S., & Thornton, P. (2013). Carbon and other biogeochemical cycles. In T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, & P. M. Midgley (Eds.), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter06_FINAL.pdf
- Collins, D. B. G. (2020). New Zealand river hydrology under late 21st century climate change. *Water*, 12(8), 2175. <https://doi.org/10.3390/W12082175>
- Collins, D. B. G. (2021). Hydrological sentinels and the relative emergence of climate change signals in New Zealand river flows. *Hydrological Sciences Journal*, 66(15), 2146–2154.
<https://doi.org/10.1080/02626667.2021.1987439>
- Cook, K. M., Dunn, M. R., Behrens, E., Pinkerton, M. H., Law, C. S., & Cummings, V. J. (2025). The impacts of marine heatwaves on ecosystems and fisheries in Aotearoa New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 59(5), 1530–1560.
<https://doi.org/10.1080/00288330.2024.2436661>
- Cornwall, C. E., Nelson, W. A., Aguirre, J. D., Blain, C. O., Coyle, L., D'Archino, R., Desmond, M. J., Hepburn, C. D., Liggins, L., Shears, N. T., & Thomsen, M. S. (2025). Predicting the impacts of climate change on New Zealand's seaweed-based ecosystems. *New Zealand Journal of Botany*, 63(1), 1–27.
<https://doi.org/10.1080/0028825X.2023.2245786>

- Cram, F. (2021). Mahi aroha: Māori work in times of trouble and disaster as an expression of a love for the people. *Kōtuitui: New Zealand Journal of Social Sciences Online*, 16(2), 356–370. <https://doi.org/10.1080/1177083X.2021.1879181>
- Crockett D.E., & Kearns, M.P. (1975). Northern little blue penguin mortality in Northland. *Notornis*, 22(1), 69–72. <https://doi.org/10.63172/415892ygifvc>
- Cummings, V. J., Lundquist, C. J., Dunn, M. R., Francis, M., Horn, P., Law, C., Pinkerton, M. H., Sutton, P., Tracey, D., Hansen, L., & Mielbrecht, E. (2021). *Assessment of potential effects of climate-related changes in coastal and offshore waters on New Zealand's seafood sector*. New Zealand Aquatic Environment and Biodiversity Report No. 261. Fisheries New Zealand. <https://fs.fish.govt.nz/Doc/24891/AEBR-261-Assessment-Of-Potential-Effects-Of-Climate-Change-On-Seafood-Sector-3389.pdf.ashx>
- Datta, S., Beran, H., & Rogers, A. (2024). The impacts of warming on shallow and deep-water fisheries in New Zealand. *Earth's Future*, 12(12), e2024EF004857. <https://doi.org/10.1029/2024ef004857>
- Davis-Jones, C. (2025). *Climate change effects on marine habitats: Literature review and guidance document*. SLR Project No.: 810.031203.00001. Prepared for the Bay of Plenty Regional Council by SLR Consulting New Zealand. <https://atlas.boprc.govt.nz/api/v1/edms/document/BOPRC-1864443702-56484/content>
- Debsharma, N., Gibson, P. B., Harrington, L. J., & Lewis, H. (2026). Quantifying the influence of soil moisture on recently observed heat extremes in a maritime climate: A New Zealand case study. *Climate Dynamics*, 64, 241. <https://doi.org/10.1007/s00382-026-08175-3>
- DOC (Department of Conservation). (2021). *New Zealanders and the environment. Domestic customer segmentation research: New Zealanders engaging with the environment, biodiversity and conservation*. Department of Conservation. <https://www.doc.govt.nz/globalassets/documents/about-doc/role/visitor-research/nzers-and-the-environment.pdf>
- DOC (Department of Conservation). (2025a). *Climate change adaptation action plan 2025–28*. Department of Conservation. <https://www.doc.govt.nz/globalassets/documents/our-work/climate-change/climate-change-adaptation-action-plan-2025-28.pdf>
- DOC (Department of Conservation). (2025b). *DOC visitor insights: Summer 2024/2025. A look at visitor activity and experiences outdoors over peak summer 2024/2025*. Department of Conservation. <https://www.doc.govt.nz/globalassets/documents/about-doc/role/visitor-research/understanding-2024-2025-summer-activity.pdf>
- Douglas, E. J., Bulmer, R. H., MacDonald, I. T., & Lohrer, A. M. (2022). Estuaries as coastal reactors: Importance of shallow seafloor habitats for primary productivity and nutrient transformation, and impacts of sea level rise. *New Zealand Journal of Marine and Freshwater Research*, 56(3), 553–569. <https://doi.org/10.1080/00288330.2022.2107027>
- Dymond, J. R., Sabetizade, M., Newsome, P. F., Harmsworth, G. R., & Ausseil, A. -G. (2021). Revised extent of wetlands in New Zealand. *New Zealand Journal of Ecology*, 45(2), 3444. <https://doi.org/10.20417/nzjecol.45.32>
- Earth Sciences New Zealand. (n.d.). *The impact of El Niño and La Niña on New Zealand's climate*. Retrieved August 26, 2026, from <https://niwa.co.nz/climate-and-weather/el-nino-and-la-nina/impact-el-nino-and-la-nina-new-zealands-climate>
- Earth Sciences New Zealand. (2026a, January 8). *Annual climate summary: 2025: New Zealand's 4th-warmest year on record*. Earth Sciences New Zealand. <https://niwa.co.nz/climate-and-weather/annual/annual-climate-summary-2025>
- Earth Sciences New Zealand. (2026b, July 2). *El Niño declared, expected to intensify into one of the strongest on record*. <https://niwa.co.nz/news/el-nino-declared-expected-intensify-one-strongest-record>

- EDGAR (The Emissions Database for Global Atmospheric Research). (2026). *EDGAR GHG emissions [Dataset]* available from *GHG emissions of all world countries*.
https://edgar.jrc.ec.europa.eu/report_2026
- EHINZ (Environmental Health Intelligence New Zealand). (2025). *Leptospirosis notifications*. [Surveillance Report]. Environmental Health Intelligence NZ, Massey University.
https://ehinz.ac.nz/assets/Surveillance-reports/Released_2025/Lepto_2025final.pdf
- EHINZ (Environmental Health Intelligence New Zealand). (n.d.). *Urban–rural profile*. Retrieved September 16, 2026, from <https://www.ehinz.ac.nz/indicators/population-vulnerability/urbanrural-profile/>
- Ericson, J. A., Venter, L., Copedo, J. S., Nguyen, V. T., Alfaro, A. C., & Ragg, N. L. C. (2023). Chronic heat stress as a predisposing factor in summer mortality of mussels, *Perna canaliculus*. *Aquaculture*, 564, 738986. <https://doi.org/10.1016/j.aquaculture.2022.738986>
- FENZ (Fire and Emergency New Zealand). (n.d.). *Wildfire readiness and prevention: Spot the signs, stop wildfire*. Retrieved September 16, 2026, from <https://www.fireandemergency.nz/fire-safety-campaign-resources/wildfire-readiness-and-prevention/>
- Gibson, P. B., Broadbent, A. M., Stuart, S. J., Lewis, H., Campbell, I., Rampal, N., Harrington, L. J., & Williams, J. (2025a). Downscaled CMIP6 future climate projections for New Zealand: Climatology and extremes. *Weather and Climate Extremes*, 49, 100784.
<https://doi.org/10.1016/j.wace.2025.100784>
- Gibson, P. B., Lewis, H., Campbell, I., Rampal, N., Fauchereau, N., & Harrington, L. J. (2025b). Downscaled climate projections of tropical and ex-tropical cyclones over the southwest Pacific. *Journal of Geophysical Research: Atmospheres*, 130(14), e2025JD043833.
<https://doi.org/10.1029/2025jd043833>
- Gibson, P. B., Rampal, N., Dean, S. M., & Morgenstern, O. (2024). Storylines for future projections of precipitation over New Zealand in CMIP6 models. *Journal of Geophysical Research: Atmospheres*, 129(5), e2023JD039664. <https://doi.org/10.1029/2023JD039664>
- Gibson, P. B., Rampal, N., Goddard, F. W., Guan, B., DeFlorio, M. J., & Prince, H. D. (2026). Emerging trends in landfalling atmospheric rivers over the South Pacific. *npj Climate and Atmospheric Science*, 9, 63. <https://doi.org/10.1038/s41612-026-01338-3>
- Gibson, P. B., Stone, D., Thatcher, M., Broadbent, A., Dean, S., Rosier, S. M., Stuart, S., & Sood, A. (2023). High-resolution CCAM simulations over New Zealand and the South Pacific for the detection and attribution of weather extremes. *Journal of Geophysical Research: Atmospheres*, 128(14), e2023JD038530. <https://doi.org/10.1029/2023jd038530>
- The GlaMBIE Team. (2025). Community estimate of global glacier mass changes from 2000 to 2023. *Nature*, 639, 382–388. <https://doi.org/10.1038/s41586-024-08545-z>
- Goddard, F. W., Gibson, P. B., & Rampal, N. (2025). High-resolution climate change projections of atmospheric rivers over the South Pacific. *Journal of Geophysical Research: Atmospheres*, 130(6), e2024JD041572. <https://doi.org/10.1029/2024jd041572>
- Goodman, J.M. (2018). *Conservation, ecology and management of migratory galaxiids and the whitebait fishery: A summary of current knowledge and information gaps*. Department of Conservation.
<https://www.doc.govt.nz/globalassets/documents/conservation/land-and-freshwater/freshwater/conservation-ecology-and-management-of-migratory-galaxiids.pdf>
- Goodrich, J. P., Pronger, J., Campbell, D. I., Glover-Clark, G. L., Price, R., Mudge, P., Wyatt, J., Robertson, H., Wall, A. M., Wheatley-Wilson, A., & Schipper, L. A. (2025). Large greenhouse gas emissions from drained peatlands in New Zealand, and the climate mitigation potential of rewetting. *Mires and Peat*, 32, 29. <https://doi.org/10.19189/001c.147886>
- Greenhough, H., Vignier, J., Smith, K. F., Brown, C. M., Kenny, N. J., & Rolton, A. (2025). Multi-stressor dynamics: Effects of marine heatwave stress and harmful algal blooms on juvenile mussel (*Perna*

- canaliculus*) survival and physiology. *Science of the Total Environment*, 964, 178590.
<https://doi.org/10.1016/j.scitotenv.2025.178590>
- Griffiths, G. (2011). Drivers of extreme daily rainfalls in New Zealand. *Weather and Climate*, 31, 24–49.
<https://doi.org/10.2307/26169716>
- Grout, L., Hales, S., Thornley, L., & Wilson, N. (2022). *An exploration of the human health impacts associated with seven decades of severe weather events in Aotearoa New Zealand: The need for better data*. University of Otago Wellington.
https://www.otago.ac.nz/__data/assets/pdf_file/0027/332865/an-exploration-of-the-human-health-impacts-associated-with-seven-decades-of-severe-weather-events-in-aotearoa-new-zealand-the-need-for-better-data-report-841638.pdf
- Hall, M., Bargh, M., Tēmara, T., Ross, M., Skerrett, M., Shedlock, K., McRae, H., Thomson, R., Potangaroa, R., Mulligan, R., & North, L. (2024). *He Pā Mataora – learning to live with the Living Pā: final report*. Report to the National Science Challenge Deep South. Te Herenga Waka | Victoria University of Wellington. <https://deepsouthchallenge.co.nz/wp-content/uploads/2024/09/He-Pa-Mataora-Learning-to-live-with-the-Living-Pa-Final-Report.pdf>
- Hamilton, A., Fountain, J., Stewart, E., & Espiner, S. (2025). Māori-led tourism and climate change impacts and adaptation: Perspectives from Westland Tai Poutini National Park, New Zealand. *Australian Journal of Emergency Management*, 40(2), 30–38. <https://doi.org/10.47389/40.2.39>
- Harrington, L. J., Rosier, S. M., Marsh, T. I., & Frame, D. J. (2024). Robust changes to the wettest and driest days of the year are hidden within annual rainfall projections: A New Zealand case study. *Environmental Research Letters*, 19(7), 074057. <https://doi.org/10.1088/1748-9326/ad585a>
- He Pou a Rangi Climate Change Commission. (n.d.). *FAQs: The context for Aotearoa New Zealand*. Retrieved September 16, 2026, from <https://www.climatecommission.govt.nz/exploring-the-issues/aotearoa-context/>
- He Pou a Rangi Climate Change Commission. (2026a). *Exposure to climate-related hazards workbook* [Worksheet]. Earth Sciences New Zealand: National Climate Hazard Exposure Census. <https://www.climatecommission.govt.nz/assets/Monitoring-and-reporting/NAPPA-2026/Exposure-to-climate-related-hazards-workbook.xlsx>
- He Pou a Rangi Climate Change Commission. (2026b). *Full assessment: 2026 national climate change risk assessment for Aotearoa New Zealand*. He Pou a Rangi Climate Change Commission. <https://www.climatecommission.govt.nz/assets/Uploads/NCCRA/finals/2026-NCCRA-Full-assessment.pdf>
- He Pou a Rangi Climate Change Commission. (2026c). *National insights relevant for adaptation planning: Metrics on exposure and vulnerability to climate-related hazards*. He Pou a Rangi Climate Change Commission. <https://www.climatecommission.govt.nz/assets/Monitoring-and-reporting/NAPPA-2026/National-insights-relevant-for-adaptation-planning.pdf>
- He Pou a Rangi Climate Change Commission. (2026d). *Progress report: national adaptation plan. Assessing progress on the implementation and effectiveness of the Government's first national adaptation plan. Second Progress Report*. He Pou a Rangi Climate Change Commission. https://www.climatecommission.govt.nz/assets/Uploads/CCC-6270-NAPPA-2026_FA_WEB-2807.pdf
- Hill, A., North, C., Cosgriff, M., Irwin, D., Boyes, M., & Watson, S. (2020). *Education outside the classroom in Aotearoa New Zealand. A comprehensive national study: Final report*. Ara Institute of Canterbury Ltd. https://eonzpublic.blob.core.windows.net/online/EOTC_in_Aotearoa_New_Zealand_Final_Report-2020.pdf
- Horspool, N.A., Paulik, R., & Griffiths, N. (2026). *Estimating national-scale losses to infrastructure from natural hazards: Phase 2 – future climate scenarios, regional disaggregation and flooding impacts on buildings*. GNS Science Consultancy Report 2026/07. Prepared for the New Zealand Infrastructure Commission Te Waihanga by Earth Sciences New Zealand.

<https://media.umbraco.io/te-waihangā-30-year-strategy/Obweckkr/cr2026-07-national-scale-loss-estimates-to-infrastructure-phase-2-final.pdf>

- Huang, W., Yang, Z., Zhang, Y., Vogt, T., Armstrong, B., Yu, W., Xu, R., Yu, P., Liu, Y., Gasparrini, A., Hundessa, S., Lavigne, E., Molina, T., Geiger, T., Guo, Y. L., Otto, C., Hales, S., Pourzand, F., Pan, S. - C., ... Collaborators, M. C. C. (2024a). Tropical cyclone-specific mortality risks and the periods of concern: A multicountry time-series study. *PLoS Medicine*, 21(1), e1004341. <https://doi.org/10.1371/journal.pmed.1004341>
- Huang, W., Vogt, T., Park, J., Yang, Z., Ritchie, E. A., Xu, R., Zhang, Y., Hales, S., Yu, W., Hundessa, S., Otto, C., Yu, P., Liu, Y., Ju, K., Lavigne, E., Ye, T., Wen, B., Wu, Y., Kliengchuay, W., ... Guo, Y. (2024b). Risks of infectious disease hospitalisations in the aftermath of tropical cyclones: A multi-country time-series study. *The Lancet Planetary Health*, 8(9), e629–e639. [https://doi.org/10.1016/s2542-5196\(24\)00158-x](https://doi.org/10.1016/s2542-5196(24)00158-x)
- Hudson, M. (2022, July 7). Māori hold a third of NZ's fishing interests, but as the ocean warms and fish migrate, these rights don't move with them. *The Conversation*. <https://theconversation.com/maori-hold-a-third-of-nzs-fishing-interests-but-as-the-ocean-warms-and-fish-migrate-these-rights-dont-move-with-them-186284>
- ICNZ (Insurance Council of New Zealand). (n.d.). *Cost of natural disasters*. Retrieved 16 September, 2026, from <https://www.icnz.org.nz/industry/cost-of-natural-disasters/>
- IEA (International Energy Agency). (2025). *Renewables 2025: Analysis and forecasts to 2030*. International Energy Agency. <https://iea.blob.core.windows.net/assets/76ad6eac-2aa6-4c55-9a55-b8dc0dba9f9e/Renewables2025.pdf>
- IPCC (Intergovernmental Panel on Climate Change). (2022). *Chapter 11: Australasia. Climate change 2022: Impacts, adaptation and vulnerability. Working Group II contribution to the sixth assessment report of the Intergovernmental Panel on Climate Change*. Intergovernmental Panel on Climate Change. <https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-11/>
- Jayawardena, I. (2024). Indigenous, ethnic, and racial diversity and climate justice: New Zealand's climate adaptation policies and policy approaches. *Environmental Research: Climate*, 3, 035004. <https://doi.org/10.1088/2752-5295/ad50fd>
- Johnson, D., Fisher, K., & Parsons, M. (2024). Resistance, resurgence, and wellbeing: Climate change loss and damages from the perspective of Māori women. *Environment and Planning E: Nature and Space*, 7(3), 1318–1364. <https://doi.org/10.1177/25148486231217891>
- Johnson, D., Harrison, S., Cattoën, C., Luttrell, J., & Blackett, P. (2025). 'That still haunts me a little bit': Decision-makers and information providers' experiences of recurring flood events. *International Journal of Disaster Risk Reduction*, 118, 105216. <https://doi.org/10.1016/j.ijdr.2025.105216>
- Johnson, D., Parsons, M., & Fisher, K. (2023a). Adaptation at whose expense? Explicating the maladaptive potential of water storage and climate-resilient growth for Māori women in northern Aotearoa. *Global Environmental Change*, 82, 102733. <https://doi.org/10.1016/j.gloenvcha.2023.102733>
- Johnson, D., Blackett, P., Allison, A. E. F., & Broadbent, A. M. (2023b). Measuring social vulnerability to climate change at the coast: Embracing complexity and context for more accurate and equitable analysis. *Water*, 15(19), 3408. <https://doi.org/10.3390/w15193408>
- Jones, R. G., Bennett, H., Keating, G., & Blaiklock, A. (2014). Climate change and the right to health for Māori in Aotearoa/New Zealand. *Health and Human Rights Journal*, 16(1), 54–68. <https://researchspace.auckland.ac.nz/server/api/core/bitstreams/b3e09a9e-4b88-48c1-8594-d04a8ff58703/content>
- Jones, B. D., Collings, B., Dickson, M. E., Ford, M., Hikuroa, D., Bickler, S. H., & Ryan, E. (2024a). Regional implementation of coastal erosion hazard zones for archaeological applications. *Journal of Cultural Heritage*, 67, 430–442. <https://doi.org/10.1016/j.culher.2024.04.007>

- Jones, B. D., Dickson, M. E., Ford, M., Hikuroa, D., & Ryan, E. J. (2024b). Aotearoa New Zealand's coastal archaeological heritage: A geostatistical overview of threatened sites. *Journal of Island & Coastal Archaeology*, 19(4), 657–677. <https://doi.org/10.1080/15564894.2023.2207493>
- Jones, R., Macmillan, A., & Woodward, A. (2023). Superheated storms: Climate drivers, health effects and responses. *New Zealand Medical Journal*, 136(1573), 8–11. <https://doi.org/10.26635/6965.e1573>
- Kamal, S., & Noy, I. (2023). Impact of droughts on farms' financing choices: Empirical evidence from New Zealand. *Weather, Climate, and Society*, 15(1), 121–132. <https://doi.org/10.1175/wcas-d-21-0193.1>
- Keegan, L. J., White, R. S. A., & Macinnis-Ng, C. (2022). Current knowledge and potential impacts of climate change on New Zealand's biological heritage. *New Zealand Journal of Ecology*, 46(1), 3467. <https://doi.org/10.20417/nzj ecol.46.10>
- Kerr, J., Thomson, G., & Wilson, N. (2023). *Cyclone Gabrielle joins list of Aotearoa NZ's 'sudden mass fatality events'*. PHCC (Public Health Communication Centre Aotearoa). <https://www.phcc.org.nz/briefing/cyclone-gabrielle-joins-list-aotearoa-nzs-sudden-mass-fatality-events>
- King, D. N. T., Goff, J., & Skipper, A. (2007). Māori environmental knowledge and natural hazards in Aotearoa-New Zealand. *Journal of the Royal Society of New Zealand*, 37(2), 59–73. <https://doi.org/10.1080/03014220709510536>
- King, D., Penny, G., & Severne, C. (2010). The climate change matrix facing Māori society. In R.A.C. Nottage, D. S. Wratt, J. F. Bornman, & K. Jones (Eds.), *Climate Change Adaptation in New Zealand: Future Scenarios and Some Sectoral Perspectives* (pp. 100–111). New Zealand Climate Change Centre. https://www.researchgate.net/publication/273737386_The_climate_change_matrix_facing_Maori_society
- Kitzberger, T., Perry, G. L. W., Paritsis, J., Gowda, J. H., Tepley, A. J., Holz, A., & Veblen, T. T. (2016). Fire–vegetation feedbacks and alternative states: Common mechanisms of temperate forest vulnerability to fire in southern South America and New Zealand. *New Zealand Journal of Botany*, 54(2), 247–272. <https://doi.org/10.1080/0028825X.2016.1151903>
- Kozal, L. C., Hofmann, G. E., Hawes, N. A., & Ragg, N. L. C. (2024). Paternal heat exposure affects progeny larval development in green-lipped mussels *Perna canaliculus*. *Aquaculture Environment Interactions*, 16, 43–57. <https://doi.org/10.3354/AEI00472>
- Krishna, N., Kingston, D. G., & Mager, S. M. (2024). Climatology and trends of atmospheric water vapour transport in New Zealand. *Theoretical and Applied Climatology*, 155, 7757–7772. <https://doi.org/10.1007/s00704-024-05072-9>
- Kropač, E., Mölg, T., & Cullen, N. J. (2025). From sea to summit: Investigating the explicit role of SST increase for regional and high-altitude climates in New Zealand. *Journal of Geophysical Research: Atmospheres*, 130(15), e2025JD043572. <https://doi.org/10.1029/2025jd043572>
- Lacheheb, M., Noy, I., & Kahui, V. (2024). Marine heatwaves and commercial fishing in New Zealand. *Science of the Total Environment*, 954, 176558. <https://doi.org/10.1016/j.scitotenv.2024.176558>
- Lai, H., Lee, J. E., Harrington, L. J., Ahuriri-Driscoll, A., Newport, C., Bolton, A., Salter, C., Morton, S., Woodward, A., & Hales, S. (2024). Daily temperatures and child hospital admissions in Aotearoa New Zealand: Case time series analysis. *International Journal of Environmental Research and Public Health*, 21(9), 1236. <https://doi.org/10.3390/ijerph21091236>
- Lan, C., Wild, A., Paulik, R., Wotherspoon, L., & Zorn, C. (2023). Assessing indirect impacts of extreme sea level flooding on critical infrastructure. *Journal of Marine Science and Engineering*, 11(7), 1420. <https://doi.org/10.3390/jmse11071420>
- Lee, F., Kusabs, I. A. K., Perry, G. L. W., & MacNeil, C. (2025). Identifying refugia from the synergistic threats of climate change and invasive species. *Web Ecology*, 25(2), 221–239. <https://doi.org/10.5194/we-25-221-2025>

- Lettink, M., & Monks, J. M. (2019). Ecology of scree skinks (*Oligosoma waimatense*) in O Tu Wharekai Wetland, mid-Canterbury high country, New Zealand. *New Zealand Journal of Ecology*, 43(1), 3354. <https://doi.org/10.20417/nzjecol.43.6>
- Lewis, H., Harrington, L. J., Gibson, P. B., & Rampal, N. (2025a). Faster-than-expected intensification of heat extremes in a maritime climate: A New Zealand case study. *Environmental Research Letters*, 20(10), 104017. <https://doi.org/10.1088/1748-9326/adfe80>
- Lewis, H., Harrington, L. J., Gibson, P. B., & Rampal, N. (2025b). Storylines of future drought in the face of uncertain rainfall projections: A New Zealand case study. *Earth System Dynamics*, 16(5), 1557–1568. <https://doi.org/10.5194/esd-16-1557-2025>
- Lilburne, L., Ausseil, A. -G., Sood, A., Guo, J., Teixeira, E., Vetharaniam, I., van der Weerden, T., Smith, H., Neverman, A., Cichota, R., Phillips, C., Johnson, P., Thomas, S., & Dynes, R. (2025). Modelling to identify direct risks for New Zealand agriculture due to climate change. *Journal of the Royal Society of New Zealand*, 55(6), 1683–1700. <https://doi.org/10.1080/03036758.2024.2393295>
- Lindsey, R. (2025, May 21). *Climate change: Atmospheric carbon dioxide*. NOAA Climate.gov. <https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide>
- Lu, S., Noy, I., & Stone, D. (2026). *Heat exposure and mortality in Aotearoa New Zealand: A time-stratified case-crossover study* [Working paper]. Munich Society for the Promotion of Economic Research – CESifo GmbH. <https://doi.org/10.65864/3hbxvskrk8>
- Lyver, P. O'B., Carpenter, J. K., Wardle, D. A., Richardson, S. J., Tahi, B., Carson, D. B., & Timoti, P. (2025). Māori practitioner knowledge indicates a shift in forest fruit biomass and phenology over 75 years. *New Zealand Journal of Ecology*, 49(1), 3622. <https://doi.org/10.20417/nzjecol.49.3622>
- Madera, F., Olcese, M., Cardinali, P., & Migliorini, L. (2025). Nature connectedness in adolescents and young adults: A systematic review. *Journal of Environmental Psychology*, 107, 102761. <https://doi.org/10.1016/j.jenvp.2025.102761>
- Macinnis-Ng, C., & Schwendenmann, L. (2015). Litterfall, carbon and nitrogen cycling in a southern hemisphere conifer forest dominated by kauri (*Agathis australis*) during drought. *Plant Ecology*, 216, 247–262. <http://dx.doi.org/10.1007/s11258-014-0432-x>
- Mahuta, R., & van Schravendijk-Goodman, C. (Eds.). (2024). *Eating with my tuupuna: Practices, kai and haakari of Poukai, Waikato*. Deep South National Science Challenge. Swamp Frog Environmental and Tree Consultants Ltd. https://deepsouthchallenge.co.nz/wp-content/uploads/2024/11/Eating-with-my-Tuupuna_Full-Handbook.pdf
- Mahuta, R., van Schravendijk-Goodman, C., Holland, P., Harrison, S., Rolleston-Gabel, T., Johnson, D., Yang, W., Blackett, P., Connolly, J., Kerridge, D., Manukau, T., Rika-Heke, M., Te Ao, B., Te Ao, P., Flavell, K., & Fear, A. (2025). Measuring climate change impacts on Indigenous sociocultural wellbeing: Case study of Te Puuaha o Waikato. In C. A. Hendtlass, T. Fitzgerald, & A. Serrano (Eds.), *Shoreline strategies: Embracing coastal transformation in Aotearoa New Zealand* (pp. 21–27). New Zealand Coastal Society. <https://www.coastalsociety.org.nz/assets/Uploads/files/SP6-reading-version.pdf>
- Masters-Awatere, B., Young, P., & Graham, R. (2022). State agencies and researchers engaging with Indigenous communities on climate change adaptation planning: A systematic review. *MAI Journal*, 11(1), 3–17. https://www.journal.mai.ac.nz/system/files/Masters-Awatere_0_0.pdf
- MBIE (Ministry of Business, Innovation & Employment) (2025). *Domestic visitor survey (DVS): October 2025 wave topline report*. Ministry of Business, Innovation & Employment. <https://www.mbie.govt.nz/dmsdocument/31751-domestic-visitor-survey-october-2025-wave-report>
- McClutchie, J., Thorpe, H., Raroa, D., Maxwell, H., Barbara, H., Laking, G., & Caddie, M. (2026). Indigenous-led community research in a changing climate: Impacts of Cyclone Gabrielle on the health and wellbeing of Māori in Te Tairāwhiti, Aotearoa New Zealand. *Alternative-an International Journal of Indigenous Peoples*, 22(1), 76–89. <https://doi.org/10.1177/11771801251404025>

- McGlone, M., & Walker, S. (2011). *Potential effects of climate change on New Zealand's terrestrial biodiversity and policy recommendations for mitigation, adaptation and research*. Science for Conservation 312. Department of Conservation. <https://www.doc.govt.nz/documents/science-and-technical/sfc312entire.pdf>
- Mediodia, H. J., Noy, I., & Kahui, V. (2024). The impact of ocean warming on selected commercial fisheries in New Zealand. *Australian Journal of Agricultural and Resource Economics*, 68(3), 587–607. <https://doi.org/10.1111/1467-8489.12564>
- Melia, N., Dean, S., Pearce, H. G., Harrington, L., Frame, D. J., & Strand, T. (2022). Aotearoa New Zealand's 21st-Century Wildfire Climate. *Earth's Future*, 10(6), e2022EF002853. <https://doi.org/10.1029/2022EF002853>
- MfE (Ministry for the Environment). (n.d.). *New Zealand's interactive emissions tracker*. Ministry for the Environment. Retrieved September 16, 2026, from <https://emissionstracker.environment.govt.nz/#NrAMBoEYF12TwCIByBTALo2wBM4eg4As2AzPoSXAjXJbRA>
- MfE (Ministry for the Environment). (2018). *Climate change projections for New Zealand: Atmospheric projections based on simulations undertaken from the IPCC 5th Assessment, 2nd Edition*. Ministry for the Environment. <https://environment.govt.nz/assets/Publications/Files/Climate-change-projections-2nd-edition-final.pdf?v=ee05f63ea287d390662906c6bf39ed7061b30df6>
- MfE (Ministry for the Environment). (2021). *Methane and other major greenhouse gases*. Ministry for the Environment. <https://environment.govt.nz/guides/methane-and-other-major-greenhouse-gases/>
- MfE (Ministry for the Environment). (2024a). *Climate projections insights*. Ministry for the Environment. <https://environment.govt.nz/facts-and-science/climate-change/climate-change-projections/climate-projections-insights-and-publications/>
- MfE (Ministry for the Environment). (2024b). *Coastal hazards and climate change guidance*. Ministry for the Environment. <https://environment.govt.nz/publications/coastal-hazards-and-climate-change-guidance/>
- MfE (Ministry for the Environment). (2026). *New Zealand's Greenhouse Gas Inventory 1990–2024*. Ministry for the Environment. <https://environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-19902024>
- Middleton, I., Francis, M., Aguirre, J. D., Struthers, C., Trnski, T., Duffy, C., Anderson, J., Carney, M., Cox, N., Hemstall, S., Herbert, B., Johnston, C., Middleton, C., Oldfield, T., Robinson, R., Sheath, C., Skipworth, I., Stancich, J., Whittington, H., & Liggins, L. (2023). Occurrences of tropical, subtropical and rare marine fishes in Aotearoa New Zealand indicate biodiversity change. *Journal of Biogeography*, 50(9), 1490–1504. <https://doi.org/10.1111/jbi.14677>
- Ministerial Inquiry into Land Uses in Tairāwhiti and Wairoa. (2023). *Outrage to optimism: Report of the ministerial inquiry into land uses associated with the mobilisation of woody debris (including forestry slash) and sediment in Tairāwhiti/Gisborne District and Wairoa District*. Ministry for the Environment. <https://environment.govt.nz/assets/Outrage-to-Optimism-CORRECTED-17.05.pdf?v=f5ae78144282d25d9eb270c146e7721f99f8f203>
- MOH (Ministry of Health). (2024). *Health national adaptation plan 2024–2027*. Ministry of Health. https://www.health.govt.nz/system/files/2024-10/Health%20National%20Adaptation%20Plan%202024-2027_0.pdf
- Montie, S., & Thomsen, M. S. (2023). Long-term community shifts driven by local extinction of an iconic foundation species following an extreme marine heatwave. *Ecology and Evolution*, 13(6), e10235. <https://doi.org/10.1002/ece3.10235>
- Mouton, T. L., Leprieur, F., Floury, M., Stephenson, F., Verburg, P., & Tonkin, J. D. (2022). Climate and land-use driven reorganisation of structure and function in river macroinvertebrate communities. *Ecography*, 2022(3), e06148. <https://doi.org/10.1111/ECOG.06148>

- Muznebin, F., Alfaro, A. C., Venter, L., & Young, T. (2022). Acute thermal stress and endotoxin exposure modulate metabolism and immunity in marine mussels (*Perna canaliculus*). *Journal of Thermal Biology*, 110, 103327. <https://doi.org/10.1016/J.JTHERBIO.2022.103327>
- NEMA (National Emergency Management Agency). (n.d.). *Declared states of emergency*. National Emergency Management Agency. Retrieved September 16, 2026, from <https://www.civildefence.govt.nz/emergency-events/previous-emergencies/declared-states-of-emergency>
- Neverman, A. J., Donovan, M., Smith, H. G., Ausseil, A. -G., & Zammit, C. (2023). Climate change impacts on erosion and suspended sediment loads in New Zealand. *Geomorphology*, 427, 108607. <https://doi.org/10.1016/j.geomorph.2023.108607>
- New Zealand Gazette. (2026, March 18). *Government Inquiry into the Fatal Landslides in Tauranga*. Retrieved September 23, 2026, from <https://gazette.govt.nz/notice/id/2026-go1496>
- New Zealand Infrastructure Commission. (n.d.). *Land transport*. Retrieved September 16, 2026, from <https://tewaihang.govt.nz/national-infrastructure-plan-online/sector-summaries/land-transport>
- New Zealand Infrastructure Commission. (2026). *When waters rise: Climate change, regional risk and infrastructure investment*. New Zealand Infrastructure Commission | Te Waihang. <https://media.umbraco.io/te-waihang-30-year-strategy/1gpbqo4v/te-waihang-research-insights-series-flood-protection-cover-report.pdf>
- NIWA (National Institute of Water & Atmospheric Research). (2024, January 10). *Annual New Zealand Climate Summary: 2023*. National Institute of Water & Atmospheric Research. <https://niwa.co.nz/climate-and-weather/annual/annual-climate-summary-2023>
- NIWA (National Institute of Water & Atmospheric Research). (2025, January 2025). *Annual climate summary: 2024*. National Institute of Water & Atmospheric Research. <https://niwa.co.nz/climate-and-weather/annual/annual-climate-summary-2024>
- NOAA (National Oceanic and Atmospheric Administration). (n.d.). *Definition of drought*. National Centers for Environmental Information. Retrieved September 16, 2026, from <https://www.ncei.noaa.gov/access/monitoring/dyk/drought-definition>
- NZ SeaRise. (n.d.). *Vertical land movement*. NZ SeaRise | Our Changing Coast. Retrieved July 15, 2026, from <https://searise.nz/resources/digging-deeper/vertical-land-movement/>
- Nyce, C., Dumm, R., Sirmans, G. S., & Smersh, G. (2015). The capitalization of insurance premiums in house prices. *The Journal of Risk and Insurance*, 82(4), 891–919. <https://doi.org/10.1111/jori.12041>
- Orsman, B. (2020, July 7). *Auckland's drought crisis costed at \$224m for extra water*. NZ Herald. <https://www.nzherald.co.nz/nz/aucklands-drought-crisis-costed-at-224m-for-extra-water/O3VQYRJFECGOGSVIZXNEY6ITOQ/>
- Paul-Burke K., Ngarimu-Cameron R., Burke J., Bulmer R., Cameron K., O'Brien T., Bluett C., Ranapia M. (2022). Taura kuku: Prioritising Māori knowledge and resources to create biodegradable mussel spat settlement lines for shellfish restoration in Ōhiwa Harbour. *New Zealand Journal of Marine and Freshwater Research*, 56(3): 570–584. <https://doi.org/10.1080/00288330.2022.2111447>
- Paulik, R., Wild, A., Stephens, S., Welsh, R., & Wadhwa, S. (2023). National assessment of extreme sea-level driven inundation under rising sea levels. *Frontiers in Environmental Science*, 10, 1045743. <https://doi.org/10.3389/fenvs.2022.1045743>
- Paulik, R., Powell, J., Sturman, J., Broadbent, A., Scheele, F., Horspool, N., Dickson, M., Beale, T., Walbran, G., & Stephens, S. (2026). *National climate hazard exposure census*. Prepared for He Pou a Rangi Climate Change Commission by New Zealand Institute for Earth Science Limited. https://haveyoursay.climatecommission.govt.nz/comms-and-engagement/cc2f075f/user_uploads/national-climate-hazard-exposure-census---16032026---final.pdf
- PCE (Parliamentary Commissioner for the Environment). (2026). *Unlocking New Zealand's environmental information*. Parliamentary Commissioner for the Environment.

https://pce.parliament.nz/media/cwingehl/unlocking-new-zealand-s-environmental-information_july-2026_digital.pdf

- Perry, G. L. W., Wilmshurst, J. M., & McGlone, M. S. (2014). Ecology and long-term history of fire in New Zealand. *New Zealand Journal of Ecology*, 38(2), 157–176.
<https://newzealandecology.org/nzje/3198>
- Phillips, C., & Murphy, C. (2021). Solastalgia, place attachment and disruption: Insights from a coastal community on the front line. *Regional Environmental Change*, 21, 46.
<https://doi.org/10.1007/s10113-021-01778-y>
- Phillips, C., Murphy, C., & Bresnihan, P. (2022). The impacts of and responses to place loss in a coastal community in Ireland. *Local Environment*, 27(7), 879–896.
<https://doi.org/10.1080/13549839.2022.2078294>
- Pinkerton, M. H., Gall, M., Thorat, F., Sutton, P., & Wood, S. (2024). *Monitoring ocean health: Satellite indicators for surface temperature, productivity and suspended solids*. Prepared for Ministry for the Environment by National Institute of Water & Atmospheric Research.
<https://doi.org/10.13140/RG.2.2.29646.27208>
- Pourzand, F. (2023). Regional differences in the effects of drought events on farm profitability in New Zealand. *Environmental Hazards*, 22(3), 285–308. <https://doi.org/10.1080/17477891.2022.2141180>
- Powlesland, R. (1998). Gull and tern survey. *OSNZ News*, 88, 3–9. https://www.birdsnz.org.nz/wp-content/uploads/2021/12/OSNZnews88_Sep1998.pdf
- PwC (PricewaterhouseCoopers). (n.d.). *The Aotearoa Circle tourism sector climate change scenarios*. PwC. Retrieved September 16, 2026, from <https://www.pwc.co.nz/insights-and-publications/2023-publications/aotearoa-circle-tourism-sector-climate-change-scenarios.html>
- Queen, L. E., Dean, S., Stone, D., Henderson, R., & Renwick, J. (2023). Spatiotemporal trends in near-natural New Zealand river flow. *Journal of Hydrometeorology*, 24(2), 241–255.
<https://doi.org/10.1175/jhm-d-22-0037.1>
- Rajan, P., Natraj, P., Kim, M., Lee, M., Jang, Y. J., Lee, Y. J., & Kim, S. C. (2024). Climate change impacts on and response strategies for kiwifruit production: A comprehensive review. *Plants* 13(17), 2354.
<https://doi.org/10.3390/plants13172354>
- RBNZ (Reserve Bank of New Zealand). (2024). *Financial stability report May 2024*. Reserve Bank of New Zealand. <https://www.rbnz.govt.nz/-/media/project/sites/rbnz/files/publications/financial-stability-reports/2024/may-2024/fsr-may-24.pdf>
- Renwick, J. (2026, April 20). An ‘ordinary’ storm with extraordinary impacts: What made Wellington’s deluge so intense?. *The Conversation*. <https://theconversation.com/an-ordinary-storm-with-extraordinary-impacts-what-made-wellingtons-deluge-so-intense-281016>
- Renwick, J., Anderson, B., Greenaway, A., Ngaru King, D., Mikaloff-Fletcher, S., Reisinger, A., & Rouse, H. (2016). *Climate change implications for New Zealand*. The Royal Society of New Zealand.
<https://www.royalsociety.org.nz/assets/documents/Climate-change-implications-for-NZ-2016-report-web3.pdf>
- Resilience to Nature’s Challenges. (2024). *Food Systems Security and Disaster Recovery* [Policy brief]. Resilience to Nature’s Challenges National Science Challenge. <https://resiliencechallenge.nz/wp-content/uploads/Food-Security-and-Disaster-Recovery-Policy-Brief-FINAL.pdf>
- Richardson, S. J., King, S., Rose, A. B., McGlone, M. S., & Holdaway, R. J. (2018). Post-fire recovery of a dryland forest remnant in the Wither Hills, Marlborough. *New Zealand Journal of Ecology*, 42(2), 222–228. <https://doi.org/10.20417/nzjecol.42.16>
- Roach, C. J., Jeffs, A. G., van der Reis, A. L., de Souza, J.M.A.C., & Behrens, E. (2025). Deep-sea lobster shifts in distribution and population connectivity under future climate change. *New Zealand Journal of Marine and Freshwater Research*, 59(5), 1659–1677.
<https://doi.org/10.1080/00288330.2025.2510307>

- Rosier, S. M., Bodeker, G. E., Carey-Smith, T. K., Frame, D. J., Gibson, P. B., Harrington, L. J., & Stone, D. A. (2024). *Changing rainfall extremes with climate change in New Zealand: Guidance for decision-makers*. The Deep South National Science Challenge. https://deepsouthchallenge.co.nz/wp-content/uploads/2024/08/Changing-rainfall-extremes-wiht-climate-change-in-NZ_Guidance-for-Decision-makers.pdf
- Rosier, S., Shah, S., Bodeker, G., Carey-Smith, T., Frame, D., & Stone, D. A. (2025). Statistical modelling of extreme daily rainfall over Aotearoa New Zealand. *Weather and Climate Extremes*, 49, 100799. <https://doi.org/10.1016/j.wace.2025.100799>
- Ross, F., Clark, D. E., Albot, O., Berthelsen, A., Bulmer, R., Crawshaw, J., & Macreadie, P. I. (2024). A preliminary estimate of the contribution of coastal blue carbon to climate change mitigation in New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 58(3), 530–540. <https://doi.org/10.1080/00288330.2023.2245770>
- Rounce, D. R., Hock, R., Maussion, F., Hugonnet, R., Kochtitzky, W., Huss, M., Berthier, E., Brinkerhoff, D., Compagno, L., Copland, L., Farinotti, D., Menounos, B., & McNabb, R. W. (2023). Global glacier change in the 21st century: Every increase in temperature matters. *Science*, 379(6627), 78–83. <https://doi.org/DOI:10.1126/science.abo1324>
- Roy, A., & Noy, I. (2023). Impact of extratropical cyclones, floods, and wildfires on firms' financial performance in New Zealand. *Environmental Economics and Policy Studies*, 25, 493–574. <https://doi.org/10.1007/s10018-023-00369-x>
- Rullens, V., Mangan, S., Stephenson, F., Clark, D. E., Bulmer, R. H., Berthelsen, A., Crawshaw, J., Gladstone-Gallagher, R. V., Thomas, S., Ellis, J. I., & Pilditch, C. A. (2022). Understanding the consequences of sea level rise: The ecological implications of losing intertidal habitat. *New Zealand Journal of Marine and Freshwater Research*, 56(3), 353–370. <https://doi.org/10.1080/00288330.2022.2086587>
- Schulze, H., Hunt, S., McIndoe, C., & Dixon, H. (2025). *Māori in horticulture*. Prepared for Horticulture New Zealand (HortNZ) by Business and Economic Research Limited (BERL). <https://www.hortnz.co.nz/assets/About-Us/Aotearoa-Horticulture-Action-Plan/Maori-in-horticulture-report-2025-final.pdf>
- Short L., Craig D., & McCowan, T. (2023). *Upholding the value of pāua quota: Summary report*. Sustainable Seas National Science Challenge. <https://backend.sustainableseaschallenge.co.nz/assets/dms/Reports/Upholding-the-value-of-paua-quota/Report-Upholding-the-value-of-paua-quota.pdf>
- Sigid, M. F., Harrington, L. J., & Carey-Smith, T. (2025). Understanding past record-shattering rainfall events in New Zealand. *Environmental Research: Climate*, 4(4), 045014. <https://doi.org/10.1088/2752-5295/ae1860>
- Sigid, M. F., Harrington, L. J., & Lewis, H. (2026). On the future of extreme rainfall in New Zealand. *Earth's Future*, 14(4), e2025EF007427. <https://doi.org/10.1029/2025ef007427>
- Smith, H. G., Neverman, A. J., Betts, H., & Spiekermann, R. (2023). The influence of spatial patterns in rainfall on shallow landslides. *Geomorphology*, 437, 108795. <https://doi.org/10.1016/j.geomorph.2023.108795>
- Soliman, T., & Greenhalgh, S. (2020). *Rethinking New Zealand's food security in times of disruption* [Policy brief]. Manaaki Whenua – Landcare Research. https://www.landcareresearch.co.nz/assets/Publications/Policy-Briefing-Guidance-Papers/Policy-brief-27_Rethinking-NZs-food-security.pdf
- Stewart, M., Coe, I., Taylor, L., Watchorn, C., & Simmons, W. (2023). *Quick pass dune vulnerability assessment*. Prepared for Christchurch City Council and Environment Canterbury by the University of Canterbury. <https://www.canterbury.ac.nz/content/dam/uoc-main-site/documents/pdfs/see-2023-geography-engagement-/Quick%20Pass%20Dune%20Vulnerability%20Assessment.pdf>

- Stone, D. A., Noble, C. J., Bodeker, G. E., Dean, S. M., Harrington, L. J., Rosier, S. M., Rye, G. D., & Tradowsky, J. S. (2024). Cyclone Gabrielle as a design storm for northeastern Aotearoa New Zealand under anthropogenic warming. *Earth's Future*, 12(9), e2024EF004772. <https://doi.org/10.1029/2024ef004772>
- Storey, B., Owen, S., Zammit, C., & Noy, I. (2024). Insurance retreat in residential properties from future sea level rise in Aotearoa New Zealand. *Climatic Change*, 177, 44. <https://doi.org/10.1007/s10584-024-03699-1>
- Strom, J., Te Ao, B., Rush, E., & Mackay, S. (2025). How has the cost of feeding New Zealand children well changed from 2018 to 2023? Monthly price changes of a modelled lower-cost healthy diet. *Journal of the Royal Society of New Zealand*, 55(6), 2319–2333. <https://doi.org/10.1080/03036758.2024.2370882>
- Tait, A. (2019). *Risk-exposure assessment of Department of Conservation (DOC) coastal locations to flooding from the sea*. Science for Conservation Report 332. Department of Conservation. <https://www.doc.govt.nz/globalassets/documents/science-and-technical/sfc332entire.pdf>
- Tāmaki Makaurau Recovery Office. (2026). *Auckland together: Recovering from the 2023 storms*. Auckland Council. <https://knowledgeauckland.org.nz/media/44a14rf5/auckland-together-recovering-from-2023-storms-t%C4%81maki-makaurau-auckland-recovery-office-june-2026-updated-aug-2026.pdf>
- Te Uru Kahika. (2023). *Before the deluge 2.0: Updated case for co-investment in flood management infrastructure following Cyclones Hale and Gabrielle*. Te Uru Kahika | Regional and Unitary Councils Aotearoa. <https://teurukahika.govt.nz/media/mera2wa4/before-the-deluge-20.pdf>
- Teen, R. (2024). *Water-borne illnesses in Aotearoa New Zealand – past, present, future* [Intern report]. Office of the Prime Minister's Chief Science Advisor. <https://www.dpmc.govt.nz/sites/default/files/2024-07/PMCSA-24-06-04-V1-OPMCSA-Internship-report-Water-borne-illnesses-in-Aotearoa-R-Teen-20-Jun-2024-V1-wcs.pdf>
- Tepley, A. J., Thomann, E., Veblen, T. T., Perry, G. L. W., Holz, A., Paritsis, J., Kitzberger, T., & Anderson-Teixeira, K. J. (2018). Influences of fire–vegetation feedbacks and post-fire recovery rates on forest landscape vulnerability to altered fire regimes. *Journal of Ecology*, 106(5), 1925–1940. <https://doi.org/10.1111/1365-2745.12950>
- Thomas, A., McDonald, A., Renwick, J., Rosier, S., Tradowsky, J. S., & Bodeker, G. E. (2024). Anthropogenic influence on precipitation in Aotearoa New Zealand with differing circulation types. *Weather and Climate Extremes*, 46, 100727. <https://doi.org/10.1016/j.wace.2024.100727>
- Thorpe, H., Langridge, F., Egli, V., McClutchie, J., Bell, J., Horgan-Heke, E., Caddie, M., McCool, J., & Laking, G. (2025). 'It affected everybody, but affected people differently': The health and wellbeing impacts of Cyclone Gabrielle on East Coast communities of Aotearoa New Zealand. *Kōtuitui: New Zealand Journal of Social Sciences Online*, 20(4), 1271–1291. <https://doi.org/10.1080/1177083x.2025.2523344>
- Trenberth, K. E., Cheng, L., Pan, Y., Fasullo, J., & Mayer, M. (2025). Distinctive pattern of global warming in ocean heat content. *Journal of Climate*, 38(9), 2155–2168. <https://doi.org/10.1175/JCLI-D-24-0609.1>
- UN (United Nations). (n.d.). *1.5°C: what it means and why it matters*. United Nations | Climate Action. Retrieved September 16, 2026, from <https://www.un.org/en/climatechange/science/climate-issues/degrees-matter>
- UNFCCC (United Nations Framework Convention on Climate Change). (n.d.). *Parties & Observers*. Retrieved September 21, 2026, from <https://unfccc.int/parties-observers>
- United Nations Environment Programme. (2026). *Limiting overshoot: Navigating exceedance of 1.5°C and pathways towards return*. United Nations Environment Programme. <https://doi.org/10.59117/20.500.11822/49857>

- Urban Intelligence. (2024). *National infrastructure exposure & property isolation assessment: Contributing to the national adaptation metrics*. Prepared for He Pou a Rangi Climate Change Commission by Urban Intelligence. https://haveyoursay.climatecommission.govt.nz/comms-and-engagement/cc2f075f/user_uploads/2.a-urban-intelligence_national-infrastructure-exposure---property-isolation-report--2-.pdf
- Urban Intelligence. (2025). *Social vulnerability assessment*. Prepared for He Pou a Rangi Climate Change Commission by Urban Intelligence. <https://www.climatecommission.govt.nz/assets/Uploads/NCCRA/finals/Climate-Change-Commission-Social-Vulnerability-Assessment-Coastal-Flooding-Updated.pdf>
- Urban Intelligence. (2026). *Business isolation report*. Prepared for He Pou a Rangi Climate Change Commission by Urban Intelligence. <https://www.climatecommission.govt.nz/assets/Monitoring-and-reporting/NAPPA-2026/CCC-Business-Isolation-Report-April-2026.pdf>
- Vatsa, P., & Renwick, A. (2025). Food prices in New Zealand: Implications for feeding people better. *Journal of the Royal Society of New Zealand*, 55(6), 2305–2318. <https://doi.org/10.1080/03036758.2024.2368788>
- Vetharaniam, I., Stanley, C. J., Cummins, M., van den Dijssel, C., & Müller, K. (2024). Modelling climate change impacts on location suitability for cultivating avocado and blueberry in New Zealand. *Land*, 13(11), 1753. <https://doi.org/10.3390/land13111753>
- Wada, M., Sagarasaerane, O., Cogger, N., Marshall, J., Cuttance, E., Macara, G., Sood, A., & Vallee, E. (2026). Machine learning for predicting climate change impacts on *Pseudopithomyces chartarum* spore counts: A risk indicator of facial eczema. *New Zealand Veterinary Journal*, 74(2), 98–114. <https://doi.org/10.1080/00480169.2025.2579134>
- Waliser, D., & Guan, B. (2017). Extreme winds and precipitation during landfall of atmospheric rivers. *Nature Geoscience*, 10, 179–183. <https://doi.org/10.1038/ngeo2894>
- Weinhäupl, C., & Devenish-Nelson, E. S. (2024). Potential impacts of climate change on terrestrial Aotearoa New Zealand's birds reveal high risk for endemic species. *Biological Conservation*, 296, 110668. <https://doi.org/10.1016/j.biocon.2024.110668>
- Whitehead, E., Adams, N., Baird, K., Bell, B., Borrelle, S., Dunphy, B., Gaskin, C., Landers, T., Rayner, M., & Russell, J. (2019). *Threats to seabirds of northern Aotearoa New Zealand*. Northern New Zealand Seabird Charitable Trust. https://www.nzseabirdtrust.com/_files/ugd/de29ab_de931d3693e64d0dbaeefba453c569dc.pdf
- Wilby, R. L., Lu, X., Watkiss, P., & Rodgers, C. A. (2021). Towards pragmatism in climate risk analysis and adaptation. *Water Policy*, 23(S1), 10–30. <https://doi.org/10.2166/wp.2021.232>
- Williams, S., Meihana, P., Bosserelle, C., Hebberd, C., Battersby, J., Welsh, R., Hepi, J., & McKenzie Sheat, R. (2025). Climate-induced sea level rise: Implications for archaeological taonga at Te Pokohiwi o Kupe | Wairau Bar, Aotearoa New Zealand. *MAI Journal*, 14(1), 5–15. <https://doi.org/10.20507/MAIJournal.2025.14.1.1>
- Wilson, N., Broadbent, A., & Kerr, J. (2023). *Cyclone Gabrielle by the numbers: A review at six months*. Public Health Communication Centre. <https://knowledgeauckland.org.nz/media/2pchtuky/cyclone-gabrielle-by-the-numbers-review-at-six-months-phcc-nick-wilson-et-al-14-aug-2023.pdf>
- WMO (World Meteorological Organization). (2025). *WMO greenhouse gas bulletin. No 21: 16 October 2025*. World Meteorological Organization. https://wmo.int/sites/default/files/2025-10/GHG-21_en.pdf
- WMO (World Meteorological Organization). (2026). *WMO global annual to decadal climate update*. World Meteorological Organization. <https://library.wmo.int/idurl/4/69882>
- Woodward, S. J. R., Beukes, P. C., Edwards, J. P., Verhoek, K. J., Jago, J. G., & Zammit, C. (2025). Regional heat stress maps for grazing dairy cows in New Zealand under climate change. *Animal Production Science*, 65(4), AN24231. <https://doi.org/10.1071/an24231>

- Wreford, A., Guenther, M., & Saunders, J. T. (2026). Evaluating the economic impacts of climate change on Aotearoa–New Zealand’s dairy sector. *The Australian Journal of Agricultural and Resource Economics*, 70(1), 71–86. <https://doi.org/10.1111/1467-8489.70062>
- Wyse, S. V., Macinnis-Ng, C. M. O., Burns, B. R., Clearwater, M. J., & Schwendenmann, L. (2013). Species assemblage patterns around a dominant emergent tree are associated with drought resistance. *Tree Physiology*, 33(12), 1269–1283. <https://doi.org/10.1093/treephys/tpt095>
- Yang, Z., Huang, W., McKenzie, J. E., Xu, R., Yu, P., Chen, G., Yu, W., Wu, Y., Liu, Y., Wen, B., Hales, S., Lavigne, E., Ye, T., Zhang, Y., Coelho, M. d S. Z. S., Matus, P., Tantrakarnapa, K., Kliengchuay, W., Saldiva, P. H. N., ... Li, S. (2026). Risk, burden, and trend of infectious disease hospitalisations associated with floods: A multicountry, time-series study. *Lancet Planetary Health*, 10(1), 101411. <https://doi.org/10.1016/j.lanplh.2025.101411>
- Yang, Z., Huang, W., McKenzie, J. E., Xu, R., Yu, P., Wu, Y., Liu, Y., Wen, B., Zhang, Y., Yu, W., Ye, T., Zhang, Y., Ju, K., Hales, S., Coelho, M. d S. Z. S., Matus, P., Tantrakarnapa, K., Guo, Y. L., Kliengchuay, W., ... Li, S. (2025). Hospitalization risks associated with floods in a multi-country study. *Nature Water*, 3, 561–570. <https://doi.org/10.1038/s44221-025-00425-8>
- Yang, Z., Huang, W., McKenzie, J. E., Xu, R., Yu, P., Ye, T., Wen, B., Gasparrini, A., Armstrong, B., Tong, S., Lavigne, E., Madureira, J., Kyselý, J., Guo, Y., & Li, S. (2023). Mortality risks associated with floods in 761 communities worldwide: Time series study. *BMJ*, 383, e075081. <https://doi.org/10.1136/bmj-2023-075081>
- Yletyinen, J., Tylianakis, J. M., Stone, C., & Lyver, P. O’B. (2022). Potential for cascading impacts of environmental change and policy on indigenous culture. *Ambio*, 51, 1110–1122. <https://doi.org/10.1007/s13280-021-01670-3>
- Yukich Clendon, O. M. M., Carpenter, J. K., Kelly, D., Timoti, P., Burns, B. R., Boswijk, G., & Monks, A. (2023). Global change explains reduced seeding in a widespread New Zealand tree: Indigenous Tūhoe knowledge informs mechanistic analysis. *Frontiers in Forests and Global Change*, 6, 1172326. <https://doi.org/10.3389/ffgc.2023.1172326>
- Zekollari, H., Huss, M., Schuster, L., Maussion, F., Rounce, D. R., Aguayo, R., Champollion, N., Compagno, L., Hugonnet, R., Marzeion, B., Mojtavavi, S., & Farinotti, D. (2024). Twenty-first century global glacier evolution under CMIP6 scenarios and the role of glacier-specific observations. *The Cryosphere*, 18(11), 5045–5066. <https://doi.org/10.5194/tc-18-5045-2024>