Notice is hereby given of the

Climate Change Subcommittee

Wednesday 6 November 2024 at 1:30 pm

Environment Southland Council chamber, 220 North Road, Invercargill
24/CCS/65

Committee Members

Cr Maurice Rodway (Chair)
Cr Robert Guyton
Cr Lyndal Ludlow
Cr Peter McDonald
Cr Phil Morrison
Cr Eric Roy
Chairman Nicol Horrell *(ex officio)*
Mr Stewart Bull (Mana Whenua Representative)

Agenda

This meeting will be livestreamed through YouTube and will be available to view on our website. https://www.es.govt.nz/about-us/live-stream

Rachael Millar

General Manager, Strategy, Policy and Science

RECOMMENDATIONS IN COUNCIL REPORTS ARE NOT TO BE CONSTRUED AS COUNCIL POLICY UNTIL ADOPTED BY COUNCIL

Terms of Reference – Climate Change Subcommittee

The Climate Change Subcommittee will work in genuine partnership with Mana Whenua/Te Ao Mārama Inc, recognising the importance of enduring and collaborative relationships between Environment Southland and Mana Whenua/Te Ao Mārama Inc.

The Climate Change Subcommittee has been established to provide advice and to report back to Council on:

1. The development of the regional climate change strategy.
2. Regional, national and international climate change developments, including emerging issues and impacts, changes in legislative frameworks and their implications for Council's climate change strategies, policies, plans, programmes and initiatives.
3. Effective regional leadership on climate change to reduce greenhouse gas emissions and ensure a climate resilient future for Murihiku Southland.
4. Opportunities for collaboration with other regional councils and territorial authorities on climate change and climate resilient communities, including the regional climate change inter-agency group.
5. Opportunities for advocacy to central government to align.
6. Environment Southland regional climate change programmes and initiatives, including enabling the Murihiku Southland community to adapt to climate change and support the region's transition to a low emissions economy.
7. Environment Southland's internal work programme as a climate change leader aiming to reduce its own carbon footprint.

These Terms of Reference are a living document and will be reviewed by the committee, as required.

1 Welcome I Haere mai

2 Apologies I Ngā pa pouri

At the time of the agenda closing, no apologies had been received for this meeting.

3 Declarations of interest

At the time of the agenda closing, no declarations of interest had been received for this meeting.

4 Public forum, petitions and deputations I He huinga tuku korero

At the time of the agenda closing, no public forum, petitions or deputations were received for the meeting.

5 Confirmation of minutes I Whakau korero

Attached are the minutes from the Climate Change Subcommittee meeting held 14 August 2024.

Minutes of the Climate Change Subcommittee of the Southland Regional Council Meeting

Held at Environment Southland, 220 North Road, Invercargill
Wednesday, 14 August 2024 at 1:30 pm

Present:

Cr Maurice Rodway (Chair)
Cr Lyndal Ludlow
Cr Peter McDonald
Cr Phil Morrison (Deputy)

Mrs Rachael Millar (General Manager Strategy, Science and Engagement)
Mrs Mikayla Wass (Committee Advisor)

1 Welcome I Haere mai

The Chairman welcomed everyone to the 14 August 2024, Climate Change Subcommittee meeting.

2 Apologies I Ngā pa pouri

Resolved:

Moved Cr Ludlow, seconded Cr McDonald that apologies be accepted on behalf of Cr Eric Roy and Chairman Nicol Horrell.

Carried

3 Declarations of interest

There were no declarations of interest made by councillors.

4 Public forum, petitions and deputations I He huinga tuku korero

There were no public forum, petitions or deputations presented at the meeting.

5 Confirmation of minutes I Whakau korero

Resolved:

Moved Cr Morrison, seconded Cr McDonald that the minutes of the Climate Change Subcommittee meeting held on 18 October 2023 be confirmed as a true and accurate record.

Carried

6 Notification of extraordinary items/urgent business I He panui autaia hei totoia pakihi

There were no extraordinary items or urgent business tabled for inclusion in the agenda.

7 Questions I Patai

There were no questions asked by the councillors.

8 Chairman and councillors reports I Ngā purongo-a-tumuaki me ngā kaunihera

There were no Chairman or councillor reports

9 Reports

9.1 Revised Regional Climate Change Strategy

This item provided the Climate Change Sub-committee with an update on the Regional Climate Change Inter-agency Working Group's (RCCWG) revision of the proposed Regional Climate Change Strategy in response to community feedback received as part of the Environment Southland Long-term Plan consultation process.

Resolved:

Moved Cr Ludlow, seconded Cr McDonald that Council:

1 **receive the report - Revised Regional Climate Change Strategy.**
2 **note the changes made to the proposed Regional Climate Change Strategy, resulting from the deliberations by the Regional Climate Change Working Group hearing panel.**
3 **endorse the revised Regional Climate Change Strategy and recommend the revised Strategy to the Environment Southland Strategy & Policy Committee for adoption in October.**

Carried

9.2 Organisational emissions reduction progress update

This item was to provide an update on progress being made to develop an initial organisational emissions reduction approach; in line with the guidance considered by the Climate Change Sub-committee in October 2023 and endorsed by the Strategy and Policy Committee in November 2023.

Resolved:

Moved Cr Ludlow, seconded Cr Morrison that Council receive the report - Organisational emissions reduction progress update.

Carried

10 Extraordinary/urgent business I Panui autia hei totoia pakihi

There were no extraordinary items or urgent business tabled for inclusion in the agenda.

11 Public excluded business I He hui pakihi e hara mo te iwi

There was no public excluded business.

12 Termination

There being no further business, the chairman closed the meeting at 2:42 pm.

6 Notification of extraordinary items/urgent business I He panui autaia hei totoia pakihi

At the time of the agenda closing, no notification of extraordinary or urgent business had been received for this meeting.

7 Questions I Patai

At the time of the agenda closing, no questions had been received for this meeting.

8 Chairman and councillors reports I Ngā purongo-a-tumuaki me ngā kaunihera

At the time of the agenda closing, no Councillor Reports were received for the meeting.

9 Reports

9.1 Environment Southland's Second Greenhouse Gas Emissions Annual Report

Report by: Anke Habgood, Senior Strategy Advisor
Approved by: Rachael Millar, General Manager Strategy, Policy & Science
Report Date: 16 October 2024

Purpose

To present the second Organisational Greenhouse Gas (GHG) Emissions Annual Report.

Summary

The organisational GHG emissions reporting project has now concluded its second measurement of Environment Southland's GHG emissions for the year ended 30 June 2024. The inventory and report have been verified by a third party.

The report establishes that Environment Southland produced 2,085.84 tCO2-e of GHG emissions during the 23/24 financial year. This is a 30.76 tCO2-e (1%) reduction to the organisational baseline measurement for the year ending 30 June 2023.

The council's BAU operations emissions (excluding construction and extraordinary works and capital transport) are 1,358.45 tCO2-e. This represents a 4% increase of 57.18 tCO2-e over the baseline year (FY 22/23) which reported 1,301.27 tCO2-e.

With two inventories having now been undertaken, confidence in the process is beginning to develop. These two inventories combined are informing recommendations on next steps that can be taken, to establish an organisational emissions reduction pathway, as well as associated sensible and achievable interim targets.

Recommendation

It is recommended that the Climate Change Subcommittee **resolve to:**

1 Receive the report - Environment Southland's Second Greenhouse Gas Emissions Annual Report.

Background

In December 2022 Council commenced a project to develop its Organisational Greenhouse Gas (GHG) Emissions Baseline Inventory for the 22/23 financial year. The project sits within the broader climate change and community resilience portfolio.

Establishing an organisational GHG emissions baseline was a key step towards setting out an organisational emissions reduction pathway and identifying sensible and achievable interim emissions reduction targets towards Environment Southland achieving net zero GHG emissions by 2050.

Some key reasons Environment Southland commenced measuring its organisational emissions are:

- to understand our current impact;
- to identity our material emissions sources;
- to inform and prioritise emissions reduction activity;
- to measure our emissions reduction progress;
- to work towards organisational Net Zero GHG 2050; and
- to 'walk the talk' in supporting Murihiku Southland communities in the climate change space.

Environment Southland's GHG emissions measurement follows the Ministry for the Environment detailed guidance and complies with the relevant ISO standards.

There has been significant organisational learning associated with GHG emissions measurement – in terms of determining what needs to be counted; how it needs to be counted and setting up systems for ongoing measurement. This learning and systems improvement is ongoing, as Environment Southland works towards bringing this project in-house.

Environment Southland's Second Greenhouse Gas Emissions Annual Report

The second Environment Southland Greenhouse Gas Inventory Report, for the year ending June 2024 has now been completed (see appendix 1 attached). This report has been verified by a third party (assurance statement in appendix 2 attached; and verification report in appendix 3 attached).

The report establishes that Environment Southland produced 2,085.84 tCO2-e of GHG emissions during the 23/24 financial year. Of the 2,085.84 tCO2-e emissions, 727.39 tCO2-e related to capital and extraordinary projects and the remaining 1,358.45 tCO2-e are considered to be BAU.

As can be seen in Figure 1 below, transportation and work-related services, capital construction and extraordinary projects, employee commuting and transport fuel (motor vehicle usage) continue to be the major contributors to Environment Southland's baseline, accounting for 91.36% of total emissions.

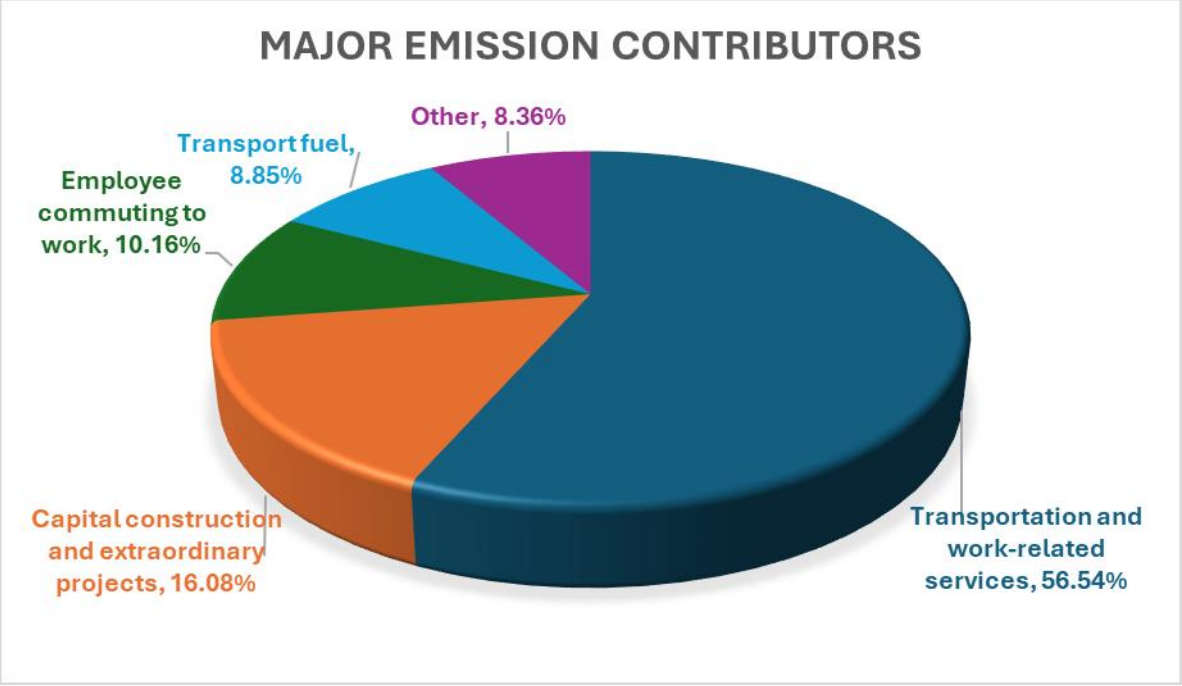


Figure 1: major emissions contributors for Environment Southland during the 23/24 financial year.

Comparison of second inventory with baseline inventory

The compilation of this annual GHG report has validated the approach and findings from the Baseline year. There were no significant issues uncovered that compromise the Baseline report.

MfE has made a number of changes to their 2024 emissions factors however none are deemed significant enough to warrant a retrospective update to the emission factors used in the Baseline calculation. The Baseline report used the MfE 2023 Emission factors.

The following table sets out Council's emissions for the year ended 30 June 2024, compared to the Baseline year ended 30 June 2023:

	EMISSIONS (measured in tonnes p.a.)	FY24 CO2e Total	Baseline CO2e Total	Variance CO2e Total	Variance CO2e %age
	DIRECT EMISSIONS				
1	**Category 1: Direct emissions and removals**				
1.1	Stationary combustion - Diesel	0.18	0.51	-0.33	-64%
1.2	Stationary combustion - Biomass (N2O and CH4)	2.41	0.27	2.14	793%
1.3	Transport fuel	201.41	212.88	-11.47	-5%
1.4	Refrigerant and other gases	0.00	0.00	0.00	0%
1.5	Forestry - natural (removal)	-189.53	-189.65	0.12	0%
1.6	Forestry - managed (land use changes)	0.00	0.00	0.00	0%
	Total direct emissions and removals	**14.47**	**24.00**	**-9.53**	**-40%**
	INDIRECT EMISSIONS				
2	**Category 2: Indirect emissions from purchased energy**				
2.1	Purchased energy - electricity use	42.99	36.41	6.58	18%
	Total indirect emissions from purchased energy	**42.99**	**36.41**	**6.58**	**18%**
3	**Category 3: Indirect emissions from freight and transportation**				
3.1	Transportation and related services	545.74	420.92	124.82	30%
3.2	Freight of other goods	0.00	0.00	0.00	0%
3.3	Business travel	69.25	89.04	-19.79	-22%
3.4	Employee commuting to work	231.28	239.46	-8.18	-3%
3.5	Employee working from home	0.71	1.22	-0.51	-42%
	Total indirect emissions from freight and transportation	**846.98**	**750.64**	**96.34**	**13%**
4	**Category 4: Indirect emissions from products and services**				
4.1	Works related products and services	740.78	479.47	261.31	55%
4.2	Energy transmission and distribution losses	3.14	4.22	-1.08	-26%
4.3	Provision of water supply	0.27	0.29	-0.02	-6%
4.4	Disposal of solid and liquid waste	5.87	6.25	-0.38	-6%
4.5	Capital and extraordinary projects (works)	365.84	520.55	-154.71	-30%
4.6	Embodied emissions on capital construction materials	65.50	294.78	-229.28	-78%
	Total indirect emissions from products and services	**1,181.40**	**1,305.56**	**-124.16**	**-10%**
	Total Organisational GHG Emissions	**2,085.84**	**2,116.60**	**-30.76**	**-1%**

Fit with strategic framework

OUTCOME	CONTRIBUTES	DETRACTS	NOT APPLICABLE
Managed access to quality natural resources	X		
Diverse opportunities to make a living	X		
Communities empowered and resilient	X		
Communities expressing their diversity	X		

Attachments

1. ES GHG Emissions 2024 Report - with verification [**9.1.1** - 33 pages]

Greenhouse Gas Emissions Annual Report

FOR THE YEAR ENDED 30 JUNE 2024

environment SOUTHLAND REGIONAL COUNCIL
Te Taiao Tonga

Prepared by:

Selman & Associates
Invercargill
021 682 255 | neil@selman.co.nz

October 2024

Environment Southland
is the brand name of
Southland Regional Council

Contents

1. Executive Summary

This report is a calculation of the GHG emissions due to activities by, or under the control of, Environment Southland for the financial year ended 30 June 2024.

Environment Southland's total GHG emissions for the year ended 30 June 2024 are calculated to be 2,085.84 tonnes of carbon dioxide equivalent gas, which equates to 10.75 tonnes per FTE employee and 20.37 kg per Southland resident.

The total represents a 30.76 tonnes (1%) reduction in GHG emissions over the previous / baseline year which reported 2,116.60 tonnes of emissions.

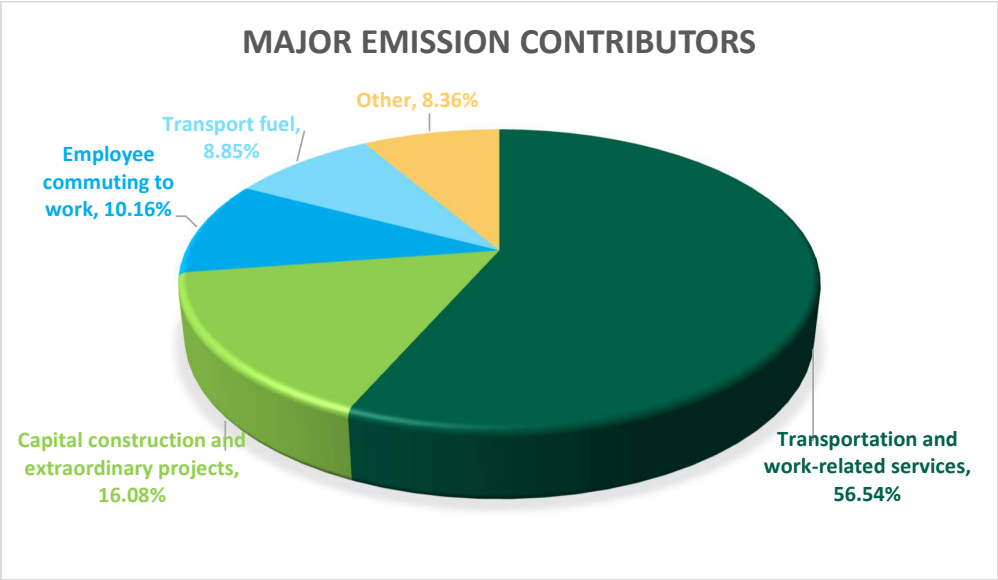
The following table lists the GHG emissions, by Council's categories and subcategories, for the financial year ended 30 June 2024.

Category	Description	T CO2e	%
4.1	Works related products and services	740.78	35.51%
3.1	Transportation and related services	545.74	26.16%
4.5	Capital and extraordinary projects (works)	365.84	17.54%
3.4	Employee commuting to work	231.28	11.09%
1.3	Transport fuel	201.41	9.66%
3.3	Business travel	69.25	3.32%
4.6	Embodied emissions on capital construction materials	65.50	3.14%
2.1	Purchased energy - electricity use	42.99	2.06%
4.4	Disposal of solid and liquid waste	5.87	0.28%
4.2	Energy transmission and distribution losses	3.14	0.15%
1.2	Stationary combustion - Biomass (N2O and CH4)	2.41	0.12%
3.5	Employee working from home	0.71	0.03%
4.3	Provision of water supply	0.27	0.01%
1.1	Stationary combustion - Diesel	0.18	0.01%
1.4	Refrigerant and other gases	0.00	0.00%
1.6	Forestry - managed (land use changes)	0.00	0.00%
3.2	Freight of other goods	0.00	0.00%
1.5	Forestry - natural (removal)	-189.53	-9.09%
	Total	**2,085.84**	**100.00%**

Table 1: Category summary GHG Emissions Report for the year ended 30 June 2024

Major emission contributors

Capital construction and extraordinary projects, transportation and work-related services, transport fuel, and employee commuting to work, are the major contributors to Environment Southland's GHG emissions, accounting for approximately 92 % of total emissions.



Graph 1: Major Emission Contributors
(NB The percentages represented in the graph are the total percentages of emissions prior to the reduction from the Forestry – natural, and therefore differ from other percentages presented elsewhere in the report.)

Business as usual (BAU)

Included within this year's emissions are capital construction and extraordinary project (works) and capital transport emissions of 661.89 T (520.55 T Baseline) and embodied emissions on capital construction materials of 65.50 T (294.78 T Baseline).

These capital and extraordinary emission sources have been shown separately, as while we expect these types of projects to continue, they will fluctuate in size and timing, impacting Council's total emissions and potentially masking movements in the BAU emissions.

The council's BAU operations emissions (excluding construction and extraordinary works and capital transport) are 1,358.45 T. This represents a 4% increase of 57.18 T CO2e over the baseline year which reported 1,301.27 T.

Report development

Council and staff will be the primary users of this report. It has been prepared to provide transparency of emissions in order to inform decision making and emissions reduction activity.

The development of this report has followed:

- ISO 14064-1:2018 Greenhouse Gases – Part 1: Specification with guidance at the organisation level for quantification and reporting of greenhouse gas emissions and removals,
- MfE Measuring emissions: A guide for organisation (2024 detailed guide), and
- Carbon Neutral Government Programme (CNGP) – A guide to managing your greenhouse gas emissions (Version 3.0, May 2023), including the CNGP Guide Appendix 2 – A guide to measuring and reporting GHG emissions under the CNGP.

Verification

This report was independently verified by Toitu in September / October 2024. Toitu's verification statement is attached in Appendix 3.

2. Movement Summary

Environment Southland compiled its Organisational Greenhouse Gas (GHG) Emissions Baseline for the financial year ended 30 June 2023. This report is the first annual GHG report following the completion of the baseline and is for the financial year ended 30 June 2024.

The compilation of the first annual GHG report has validated the approach and findings from the Baseline year. There were no significant issues uncovered that compromise the Baseline report.

MfE has made a number of changes to their 2024 emissions factors however none are deemed significant enough to warrant a retrospective update to the emission factors used in the Baseline calculation. The Baseline report used the MfE 2023 Emission factors.

The following table sets out Council's emissions for the year ended 30 June 2024, compared to the Baseline year ended 30 June 2023.

EMISSIONS (measured in tonnes p.a.)		FY24 CO2e Total	Baseline CO2e Total	Variance CO2e Total	Variance CO2e %age
	DIRECT EMISSIONS				
1	**Category 1: Direct emissions and removals**				
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1.3	Transport fuel	201.41	212.88	-11.47	-5%
1.4	Refrigerant and other gases	0.00	0.00	0.00	0%
1.5	Forestry - natural (removal)	-189.53	-189.65	0.12	0%
1.6	Forestry - managed (land use changes)	0.00	0.00	0.00	0%
	Total direct emissions and removals	**14.47**	**24.00**	**-9.53**	**-40%**
	INDIRECT EMISSIONS				
2	**Category 2: Indirect emissions from purchased energy**				
2.1	Purchased energy - electricity use	42.99	36.41	6.58	18%
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3.3	Business travel	69.25	89.04	-19.79	-22%
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4.5	Capital and extraordinary projects (works)	365.84	520.55	-154.71	-30%
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	Total indirect emissions from products and services	**1,181.40**	**1,305.56**	**-124.16**	**-10%**
	Total Organisational GHG Emissions	**2,085.84**	**2,116.60**	**-30.76**	**-1%**

Council's total emissions reduced by 30.76 tonnes of CO2e over the year to 30 June 2024.

The significant subcategory variances are:

EMISSIONS (measured in tonnes p.a.)		FY24 CO2e Total	Baseline CO2e Total	Variance CO2e Total	Variance CO2e %age
1.2	Stationary combustion – Biomass (N2O and CH4)	2.41	0.27	2.14	793%
	There was a change in MfE's emission factor, that is responsible for this variance.				
1.3	Transport fuel	201.41	212.88	-11.47	-5%
	There was a reduction of 2,630 litres in Council's fuel usage, along with a transition from diesel toward petrol. These factors will be largely due to the change in the make-up of Council's fleet.				
2.1	Purchased energy – electricity use	42.99	36.41	6.58	18%
	There was an increase in activity, with Council assets consuming 589,768 kWh in FY24, compared with 490,683 in the baseline year. The Stead Street pump house was the most significant contributor consuming an extra 73,060 kWh.				
3.1	Transportation and related services	545.74	420.92	124.82	30%
	There were increases in aircraft services and vehicle transport, however the most significant contributor was heavy haulage which was rock transportation relating to flood bank works and construction.				
3.3	Business Travel	69.25	89.04	-19.79	-22%
	While emissions were down, this was due to a change in MfE's emission factor, as actual air travel activity was 304,487 passenger.kms, up from 268,841 passenger.kms in the baseline year.				
4.1	Works related products and services (BAU)	740.78	479.47	261.31	55%
	There has been a swing from 4.5 Capital and extraordinary projects (works) activity which accounts for much of this increase. Included within the swing is the Undaria Works activity, which has reduced to a BAU level and been included within this subcategory.				

	In addition, there has been an increase in the amount of works activity, in particular excavation activity, which was up on the baseline year.				
4.5	Capital and extraordinary projects (works)	365.84	520.55	-154.71	-30%
	There has been a swing to 4.1 Works related products and services (BAU), which offsets this reduction. Included within the swing is the Undaria Works activity, which has reduced to a BAU level and been removed from this subcategory.				
4.6	Embodied emissions on capital construction materials	65.50	294.78	-229.28	-78%
	This reduction is reflective of the substantial reduction in the amount construction materials (concrete and steel) used in the Stead Street pump house.				

3. Defining Boundaries

The purpose of defining boundaries is to provide transparency of what is included within an organisation's GHG emissions baseline report. This will prevent double counting (i.e. counting by multiple organisations) and assist the production of future GHG emission reports.

Organisational Boundary

The organisational boundary is the boundary of the organisation as it applies to the measurement of GHG emissions. This typically aligns with legal and organisational structures.

An organisation may set its boundaries by one of the following approaches:

1. Control - the organisation accounts for 100 % of the GHG emissions and removals over which it has financial or operational control. The organisation can choose between financial or operational control.
2. Equity share - the organisation accounts for its portion of GHG emissions and removals from respective operations that it has a share of ownership.

To seek consistency and alignment among local councils, a staff inter-agency group was established (as a sub-group of the staff-level Regional Climate Change Working Group). The group has agreed to apply the operational control approach to establishing organisational boundaries.

Under this approach councils include 100 % of an organisation's GHG emissions within its organisational boundary when it has operational control over the organisation. Operational control has been defined as the authority (or greatest authority) to introduce and implement operating policies, health and safety policies, or environmental policies.

To ensure consistent treatment among the inter-agency group, the group developed an Inter-Agency Organisational GHG Boundaries diagram (appendix 1), setting out the agreed treatment of agencies the inter-agency group have in common.

For organisations that Council is involved with, but does not have operational control, it could look to influence the organisation to self-report its GHG emissions and removals.

Environment Southland's Organisational Boundary is set out in figure 1. While Council is involved with a range of organisations, the only one that meets the control criteria and is included within its organisational boundary is Emergency Management Southland.

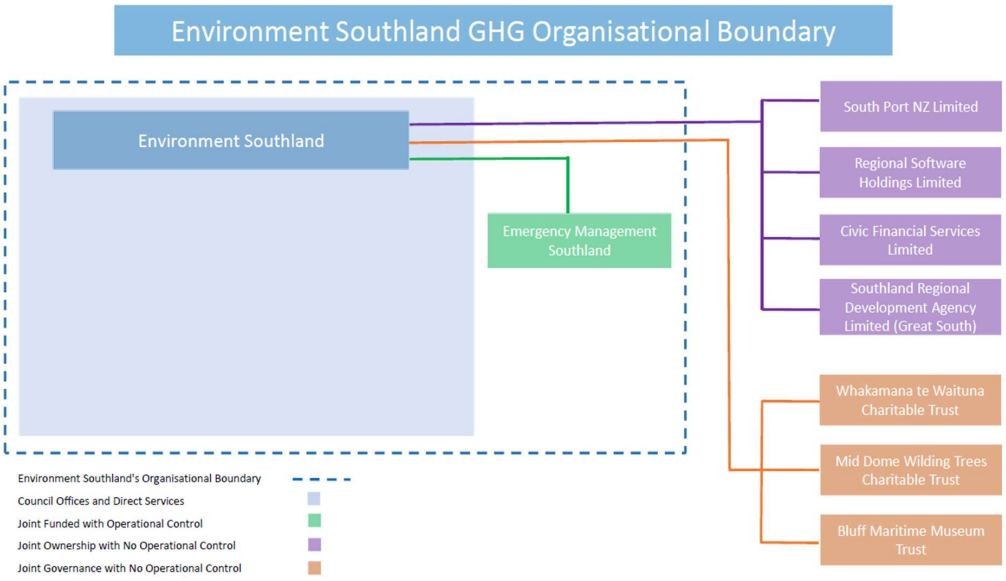


Figure 1. ES's Organisational Boundary

Emergency Management Southland

Emergency Management Southland (EMS) is co-funded by the region's councils and its financial results are apportioned to all councils, however the EMS Joint Arrangement states that Environment Southland (ES) will provide operational management, giving ES operational control in accordance with the organisational boundary approach. Consequently, EMS has been included with Environment Southland's organisational boundary.

South Port NZ Limited (SPNZ)

Environment Southland holds a majority equity stake in SPNZ (66.48 %) and is instrumental in appointing its governance, however SPNZ is a publicly listed company on the NZX stock exchange and Council ensures that it remains at arm's length and has no operational involvement.

Regional Software Holdings Limited

Environment Southland is a minor stakeholder without operational control.

Civic Financial Services Limited

Environment Southland is a minor stakeholder without operational control.

Southland Regional Development Agency Limited (Great South)

Environment Southland is a minor stakeholder without operational control.

Whakamana te Waituna Trust

Environment Southland provides two of six trustees, so does not hold operational control.

Mid Dome Wilding Trees Charitable Trust

Environment Southland is one of several partners involved in this operation and does not have operational control.

Bluff Maritime Museum Trust

Environment Southland provides some governance but does not have operational control.

Operational (Reporting) Boundary

Council's GHG Emissions Baseline report includes the emissions that are the result of operations within Council's organisational boundary over the reporting period.

Council's operations include the activities of, or under the control of, Council. This includes ordinary operations, extraordinary operations, and capital developments. The extraordinary operations and capital developments are inconsistent in nature and not expected to occur year on year. They have been reported separately to provide transparency of standard operations.

Where Council has co-funded operational services with partner agencies, the default expectation is that Council will account for the portion of emissions relating to its percentage of funding. For further explanation of the proposed approach see Proposed Approach to Co-funding with Partner Agencies (appendix 2).

4. Emission Calculation Methodology

In general, the process for calculating the emissions is:

1. Identify emission sources;
2. Collect the sources activity data over the reporting period (measured by the activity unit); and
3. Determine the sources emission factor (which sets out the activity unit).

The GHG inventory comprises a list of the emission sources and the sources activity (measured by the activity unit). The source's activity is then multiplied by the source's emission factor to determine the total emissions for the source.

An example being a diesel utility vehicle (an emissions source) that is driven (a source activity) and consumes one litre of diesel (activity unit) emits 2.68 kg CO2 e (activity unit emission factor).

The emissions from all organisational sources are added to determine the total organisations emissions.

Emission Source Identification

The data source summary tables set out the identified emission sources within Council's GHG inventory.

Identifying the emission sources within some of the subcategories was relatively straight forward as there was either a single emission source and/or single supplier, however for many subcategories it required a detailed review of suppliers' invoices to identify sources amongst the range of procured goods and services.

The following process was used to identify sources from supplier invoices:

Step 1: Obtain a full list of active suppliers for the period.

Step 2: Identify those suppliers that are likely to use emission sources to provide the goods and services to Council. This included:

- Accommodation providers (e.g. hotels, motels, motor lodges)
- Heavy freight transporters (e.g. rock and quarry transport)
- Heavy earthmoving vehicle users (e.g. diggers, cranes)
- Aerial works services (e.g. helicopters, aircraft)
- Passenger transporters (e.g. flights, taxis, rental vehicles)
- Other suppliers deemed worthy of inclusion.

Step 3: Identify other suppliers with annual spend over $50,000 and review their invoices to determine whether they have emission sources and activity.

Step 4: Work through the identified suppliers' invoices to obtain data on emission sources and source activity.

Step 5: Compile a register of suppliers, their emission sources and their source activity.

Step 6: Add this data into Council's GHG inventory.

Supplier Data

A significant amount of emission data was obtained from Council's suppliers.

While Council seeks robust data that provides clear visibility of emission causes that can lead to good decision making and emission reduction, Council also recognises the need to be pragmatic and to accept that suppliers often do not (yet) have the systems or processes required to capture and retain the required data.

In instances where detailed, measured data was not available, Council has derived satisfactory data from calculations and extrapolations. The data quality has been disclosed in the data source summary tables.

It is expected that the availability and quality of supplier data will improve as suppliers develop their GHG emissions source and activity measurement systems. As systems develop, the reporting process will become easier and the supplier's data will move up Council's data quality table (Table 2), improving its quality and the accuracy of Council's emission reporting.

Council has the opportunity to use its influence and procurement processes to support and encourage this transition.

	Data Quality		
	Questionable	**Satisfactory**	**Robust**
Emission Source	Unknown	Similar	Known
Source Activity	Estimated	Derived	Measured
Emission Factor		Default (MfE)	Measured (MfE)

Table 2: Council's data quality table

Significance Criteria

While compiling the GHG inventory, consideration has been given to the significance of the emissions source data and the source activity data.

Consideration involved assessing:

- The availability of information.
- The volume of the emissions and its impact on the overall baseline.
- The cost and benefit associated with obtaining better quality data.

The process involved determining if the required information was readily available, and if not, then determining the impact of the probable emissions on the overall baseline. The approach taken to obtain data ensured that the effort applied to obtain it was relative to the probable impact it had on the baseline.

Underpinning this process has been Council's intention to be pragmatic, while providing adequate information to inform Council's reduction planning.

Council's GHG Inventory Framework

Council's GHG inventory framework sets out the identified source activity types, the emitting activity and the activity units that were used to measure the level of activity. The activity units are those used in the MfE Emission factors.

Cat	Classification	Source activity type	Activity	Activity unit
1	**Direct GHG emissions and removals**			
1.1		Stationary combustion	Diesel used	L
1.2		Stationary combustion	Wood used	Kg
1.3		Transport fuel	Petrol and diesel used	L
1.4		Refrigerant gases	Gases leaked	L
1.5		Forestry – natural	Regeneration	Hectares
1.6		Forestry – managed	Land use change	Hectares
2	**Indirect GHG emissions from purchased energy**			
2.1		Purchased energy	Electricity used	KWh
3	**Indirect GHG emissions from freight and transportation**			
3.1		Transportation and related services: Heavy haulage Vehicle transport fuel Helicopter services Aircraft services	 Transport Diesel used Flight time Av gas used	 L L Hours L
3.2		Freight of other goods	Transport	T.km
3.3		Business travel	Air travel Hotel nights Rental Taxi	Passenger.km Guest nights Km $
3.4		Employee commuting to work	Fuel used	L
3.5		Employee work from home	Electricity and waste	Days
4	**Indirect GHG from products and services**			
4.1		Works related products and services: Earthmoving works Tractor services	 Diesel used Diesel used	 L L

4.2	Energy transmission and distribution losses	Electricity used	KWh
4.3	Provision of water supply	Water used	Staff No.
4.4	Disposal of solid and liquid waste	Solid waste Liquid waste	Kg Staff No.
4.5	Capital construction and extraordinary project works	Diesel used Transport	L L
4.6	Embodied emissions in capital construction materials	Various	Various

Emission Source Exclusions

The following emissions have been excluded from the GHG baseline:

Potential emission source	Reason for exclusion
Category 3: Freight of other goods (subcategory 3.2).	Council's freight of other goods was insignificant with limited available data.
Embodied emissions in purchased goods (non-capital). **NB. Embodied emissions in purchased goods (capital) are included in subcategory 4.6.**	Council was unable to obtain meaningful data on the embodied emissions relating to its purchase of non-capital goods and, as its objective is to obtain emission transparency to inform reduction activity, Council has opted not to include spend based emission factor calculations.
Category 5: Indirect GHG emissions associated with the use of products from the organisation.	This category does not apply to Council as it does not produce products.
Category 6: Indirect GHG emissions from other sources.	No other sources are known.
Emissions from leasehold land owned by Council	Council does not have direct operational control over the leaseholder's activity so, in accordance with the Organisational Boundary criteria set in Section 3, this has been excluded as outside of Council's organisational boundary.

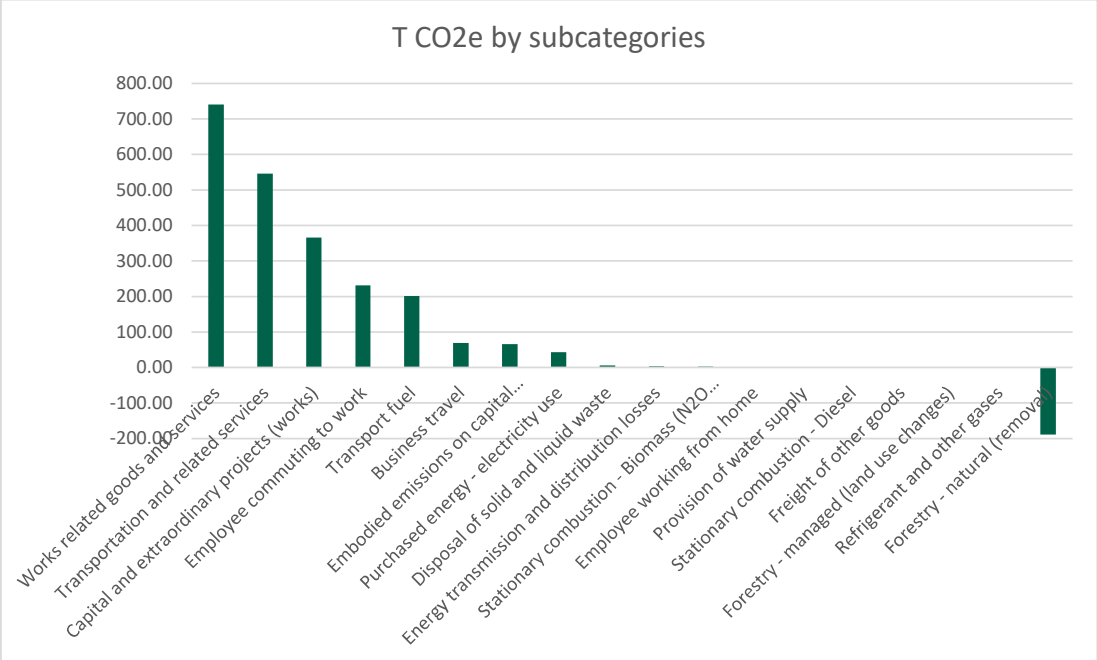
5. GHG Inventory

GHG Emissions Report for the year ended 30 June 2024

(the following report presents the total of each category and subcategory of Council's GHG inventory.)

	EMISSIONS (measured in tonnes p.a.)	CO2e TOTAL	Carbon dioxide CO2	Methane CH4	Nitrous Oxide N2O
	DIRECT EMISSIONS				
1	**Category 1: Direct emissions and removals**				
1.1	Stationary combustion - Diesel	0.18	0.18	0.00	0.00
1.2	Stationary combustion - Biomass (N2O and CH4)	2.41	0.00	2.14	0.27
1.3	Transport fuel	201.41	197.25	0.78	3.46
1.4	Refrigerant and other gases	0.00	0.00	0.00	0.00
1.5	Forestry - natural (removal)	-189.53	-189.53	0.00	0.00
1.6	Forestry - managed (land use changes)	0.00	0.00	0.00	0.00
	Total direct emissions and removals	**14.47**	**7.90**	**2.92**	**3.73**
	INDIRECT EMISSIONS				
2	**Category 2: Indirect emissions from purchased energy**				
2.1	Purchased energy - electricity use	42.99	41.40	1.53	0.05
	Total indirect emissions from purchased energy	**42.99**	**41.40**	**1.53**	**0.05**
3	**Category 3: Indirect emissions from freight and transportation**				
3.1	Transportation and related services	545.74	538.57	0.65	6.82
3.2	Freight of other goods	0.00	0.00	0.00	0.00
3.3	Business travel	69.25	68.97	0.02	0.37
3.4	Employee commuting to work	231.28	223.75	2.12	5.60
3.5	Employee working from home	0.71	0.69	0.03	0.00
	Total indirect emissions from freight and transportation	**846.98**	**831.98**	**2.82**	**12.79**
4	**Category 4: Indirect emissions from products and services**				
4.1	Works related products and services	740.78	729.72	1.11	10.34
4.2	Energy transmission and distribution losses	3.14	3.03	0.12	0.00
4.3	Provision of water supply	0.27	0.26	0.01	0.00
4.4	Disposal of solid and liquid waste	5.87	0.36	4.14	1.37
4.5	Capital and extraordinary projects (works)	365.84	360.38	0.55	5.11
4.6	Embodied emissions on capital construction materials	65.50	65.50	0.00	0.00
	Total indirect emissions from products and services	**1,181.40**	**1,159.25**	**5.93**	**16.82**
	Total Organisational GHG Emissions	**2,085.84**	**2,040.53**	**13.20**	**33.39**

	DIRECT EMISSIONS IN TONNES OF CO2 FROM BIOMASS		
	Biogenic GHG emissions (outside of boundary) - Biomass CO2	28.56	28.56
	LIABILITY TYPE		
	Contingent liability (carbon sequestered since the base year)	-379.18	



Graph 2: Tonnes of CO2e by subcategories

6. Data Source Summary Tables

The following tables set out the details relating to the data source activity types included in Councils GHG inventory.

Category 1: Direct GHG emissions and removals

1.1 Stationary combustion – Diesel

Sources included:	Emergency generator based at Price Street.
Activity data:	Supplier invoiced litres.
Data quality:	Robust data obtained.
Emission factor:	MfE Summary of Emission Factors 2024 – Fuel Table.

1.2 Stationary combustion – Biomass

Sources included:	Heating boiler based at Price Street.
Activity data:	Supplier invoiced wood volume.
Data quality:	Satisfactory / robust derived data obtained. The activity data was received as wood volume and was converted to weight on the basis of 1m3 equals 210kg.
Emission factor:	MfE Summary of Emission Factors 2024 – Fuel Table.
Comments:	As per the MfE emissions factors, the GHG calculation includes the CH4 and N2O emissions but excludes the CO2 emitted. For transparency the CO2 is shown separately as Direct emissions of CO2 from Biomass.

1.3 Transport fuel

Sources included:	All vehicles owned and leased by Council.
Activity data:	Supplier invoiced litres.
Data quality:	Robust data obtained.
Emission factor:	MfE Summary of Emission Factors 2024 – Fuel Table.

1.4 Refrigerant and other gases

Sources included:	All heat pumps and refrigeration appliances on Council premises.
Activity data:	Activity is measured based on gas top ups provided by suppliers.
Data quality:	No data available as there was no activity in the reporting period.
Emission factor:	MfE Summary of Emission Factors 2024 – Refrigerant Table.
Comments:	MfE guidance recommends the use of a top up activity method where we determine leakage by the amount of gas required to fill the equipment.

1.5 Forestry - Natural

Sources included:	All Council owned natural forests and high value asset (HVA) sites.
Sources excluded:	Managed forests.
Activity data:	Hectares of regenerating forestry that comply with specified size and age criteria were obtained from Council's Biodiversity HVA register.

Data quality:	Satisfactory / robust derived data obtained.
Emission factor:	MfE Summary of Emission Factors 2024 – Agriculture, Forestry and Land Use Table. Pre 1990 regenerating natural forest factors were used.
Comments:	Where the mean height of a forest area is less than its expected maturity height, it has been assumed that the forest is between 30 – 100 years old and therefore regenerating.

1.6 Forestry – Managed (land use changes)

Sources included:	All Council owned managed forests.
Sources excluded:	Natural forests.
Activity data:	Hectares of land use changed, however there were no changes this year so there was no activity.
Data quality:	No data available as there was no activity in the reporting period.
Emission factor:	MfE Summary of Emission Factors 2024 – Agriculture, Forestry and Land Use Table.
Comments:	Council has applied the averaging accounting method. Under this approach Council will account for land use changes, which includes the removals resulting from the first rotation of a newly planted forest. Council will hold those removals until there is another land use change such as deforestation, when Council will then account for the emissions. Under this approach there is no requirement to account for activity that is not land use change, such as subsequent harvesting and replanting of rotations of the managed forest.

Category 2: Indirect GHG emissions from purchased energy

2.1 Purchased energy

Sources included:	All Council owned and operated properties, including various powered monitoring sites.
Sources excluded:	Council leased out properties as Council does not control usage.
Activity data:	KWh obtained from supplier invoices.
Data quality:	Robust data obtained.
Emission factor:	MfE Summary of Emission Factors 2024 – Purchased Energy Table.

Category 3: Indirect GHG emissions from freight and transportation

3.1 Transportation and related services

Council engages contractors to provide a range of services for the community. The tables set out the primary freight and transportation related services and the approach towards determining the associated emissions.

Sources included:	Heavy truck haulage.
Activity data:	Litres of diesel used was obtained from some suppliers, and for others the dollar spend on invoice was converted, at a standard haulage rate, to litres of diesel used.
Data quality:	Robust / satisfactory derived data obtained.
Emission factor:	MfE Summary of Emission Factors 2024 – Road Freight Table.

Sources included:	Vehicles used for passenger transport.
Activity data:	Kms travelled were obtained from supplier invoices.
Data quality:	Robust / satisfactory derived data obtained. The vehicles were taken to be diesel utilities.
Emission factor:	MfE Summary of Emission Factors 2024 – Passenger Transport Table.

Sources included:	Helicopter services.
Activity data:	Activity hours were obtained from supplier invoices. If hours weren't available a standard hourly rate was applied to determine activity hours.
Data quality:	Satisfactory derived data obtained. An AS350B Squirrel was deemed to be the standard emission source.
Emission factor:	MfE Summary of Emission Factors 2024 – Helicopter Table.

Sources included:	Aircraft services.
Activity data:	Suppliers advised aviation gas litres used.
Data quality:	Robust data obtained.
Emission factor:	MfE Summary of Emission Factors 2024 – Fuel Table.

3.2 Freight of other goods

Sources included:	There were no significant sources of other freight.
Activity data:	No significant activity.
Data quality:	No data obtained.
Emission factor:	MfE Summary of Emission Factors 2024 – Road Freight Table.

3.3 Business travel

Sources included:	Business travel – including flights, taxis, rentals, and accommodation.
Sources excluded:	Work related travel.
Activity data:	Flights = passenger.km Taxis = dollars spent (incl GST) Rental = kms Accommodation = room nights
Data quality:	Robust data obtained from a range of suppliers.
Emission factor:	MfE Summary of Emission Factors 2024 – Various Tables.

3.4 Employee commuting to work

Sources included:	Staff and councillors commuting to and from work and using their private vehicle for council work.
Activity data:	Kms travelled in private vehicles, obtained from staff survey and expense claim forms.
Data quality:	Satisfactory data obtained with the survey achieving a 64% response rate that was extrapolated to represent all staff.
Emission factor:	MfE Summary of Emission Factors 2024 – Private Transport Table.

3.5 Employee working from home

Sources included:	Home emissions relating to staff working from home.
Sources excluded:	Partial WFH days.
Activity data:	Work from home days, obtained from staff survey.
Data quality:	Satisfactory data obtained with the survey achieving a 64% response rate that was extrapolated to represent all staff.
Emission factor:	MfE Summary of Emission Factors 2024 – Work from Home Table.

Category 4: Indirect GHG emissions from products and services

4.1 Works related products and services

Council engages contractors to provide a range of products and services for the community. The tables set out the primary works related products and services and the approach towards determining the associated emissions.

Sources included:	Earthmoving works.
Activity data:	Activity hours were obtained from supplier invoices. If hours weren't available a standard hourly rate was applied to determine activity hours.
Data quality:	Satisfactory derived data obtained. A 20T excavation digger was deemed to be the standard emission source, which uses an average of 14 litres of diesel per hour.
Emission factor:	MfE Summary of Emission Factors 2024 – Fuel Table.

Sources included:	Tractor services (includes mowing).
Activity data:	Activity hours were obtained from supplier invoices.
Data quality:	Satisfactory derived data obtained. A 30 HP tractor was deemed to be the standard emission source, which uses an average of 6.6 litres of diesel per hour.
Emission factor:	MfE Summary of Emission Factors 2024 – Fuel Table.

4.2 Energy transmission and distribution losses

Sources included:	All Council owned and operated properties, including various powered monitoring sites.
Sources excluded:	Council leased out properties as Council does not control usage.
Activity data:	KWh obtained from supplier invoices.
Data quality:	Robust data obtained.
Emission factor:	MfE Summary of Emission Factors 2024 – Energy T&D Table.
Comments:	This category covers energy loss when purchased energy is transported from point of generation to Council owned locations.

4.3 Provisions of water supply

Sources included:	Usage of water at all Council owned and operated properties.
Sources excluded:	Council leased out properties as Council does not control usage.
Activity data:	Based on per capita calculations.
Data quality:	Satisfactory data obtained.
Emission factor:	MfE Summary of Emission Factors 2024 – Water Supply Table.

4.4 Disposal of solid and liquid waste

Sources included:	Solid and liquid wastage from all Council owned and operated properties.
Sources excluded:	Council leased out properties as Council does not control usage.
Activity data:	Based on per capita calculations.
Data quality:	Questionable / satisfactory data obtained.
Emission factor:	MfE Summary of Emission Factors 2024 – Waste Table.

4.5 Capital construction and extraordinary projects

Sources included:	Capital construction of: Stead St Pump House, Stop Bank development and extension works.
Sources excluded:	Typical annual stop bank maintenance. The embodied emissions in the significant capital materials as these are reported separately in 4.6 Embodied emissions on capital construction materials.
Activity data:	Various.
Data quality:	Various.
Emission factor:	MfE Summary of Emission Factors 2024 – Various Tables.
Comments:	The timing of the activity relating to capital projects has been included when the materials were delivered (as per invoice date) or when the services were performed.

4.6 Embodied emissions on capital construction materials

Sources included:	Significant construction materials used in the Stead Street Pump House project.
Activity data:	Based on volumes of concrete and steel materials used in the construction.
Data quality:	Robust data obtained.
Emission factor:	CO2NSTRUCT embodied emissions tool.

Comments:	The timing of the activity relating to capital projects has been included when the materials were delivered (as per invoice date) or when the services were performed.

Direct emissions of CO2 from biomass

Biogenic GHG emissions (outside of boundary) – Biomass

Sources included:	Heating boiler based at Price Street.
Activity data:	Supplier invoiced wood volume.
Data quality:	Satisfactory / robust derived data obtained. The activity data was received as wood volume and was converted to weight on the basis of 1m3 equals 210kg.
Emission factor:	MfE Summary of Emission Factors 2024 – Fuel Table.
Comments:	As per the MfE emissions factors, the GHG calculation includes the CH4 and N2O emissions but excludes the CO2 emitted. For transparency the emitted CO2 is shown here as being outside of the Council's reporting boundary.

Liability type

Contingent liability (carbon sequestered since base year)

Sources included:	All Council owned natural forests and high value assets (HVA).
Sources excluded:	Natural forests.
Activity data:	Hectares of regenerating forestry that comply with specified size and age criteria were obtained from Council's Biodiversity HVA register.
Data quality:	Satisfactory / robust derived data obtained.
Emission factor:	MfE Summary of Emission Factors 2024 – Agriculture, Forestry and Land Use Table.
Comments:	The liability is the sum of the annual sequestered carbon since the base year.

7. GHG Management Opportunities

The following work streams will provide some opportunity for Council to improve its GHG management.

Improve data

Improving data availability and quality will result in better reporting efficiency and effectiveness.

For some suppliers there may be a need to include emission reporting as a requirement within their engagement contract and for others it will merely be a request to provide specific data on their invoices or to collate the data elsewhere and send through periodic reports.

Include GHG emissions in procurement

There is a need for emissions to become a criteria that is considered in the scoping, design and procuring of services. This may include considering emission sources, source activity and total emissions relating to a project and setting specific emission removal requirements as part of the Request for Proposal (RFP), and/or evaluating suppliers' proposals on the basis of their intended emission sources and expected total emissions in relation to their proposed provision of the required services.

As noted above there will likely be a need to include emission reporting within supplier engagement contracts.

Reduction strategies

It is considered best practice to reduce emissions prior to undertaking activity to remove emission, such as planting forests.

To reduce emissions consideration should be given to:

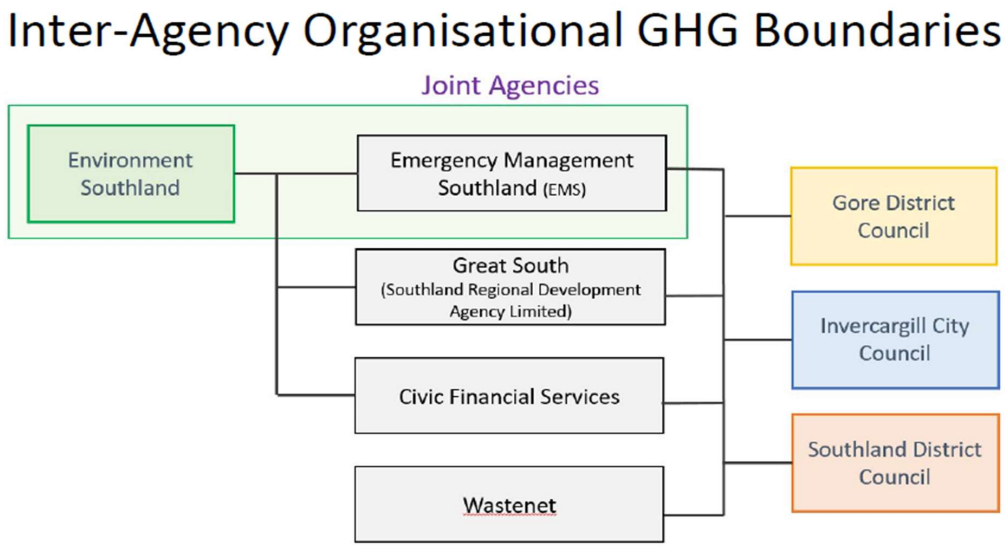
- Reducing activity – which involves designing different, more efficient ways to achieve the required outcome.
- Selecting more efficient sources – which will reduce the emissions from the activity undertaken.

8. Glossary

Biomass	Material of biological origin, excluding material embedded in geological formations and material transformed to fossilised material.
CO2-e	Carbon dioxide equivalent. The impact of each GHG is expressed in terms of its global warming potential (GWP) by converting its impact to a unit of CO2. CO2-e is the sum of all gases expressed in units of CO2.
Greenhouse Gas (GHG)	Gases that influence the way the Earth's atmosphere traps heat.
GHG inventory	A quantification of an organisations GHG sources, sinks, emissions, and removals.
Organisational boundary	The boundary applied to measure GHG emissions. Typically aligning with a legal or organisational structure.
Operating (reporting) boundary	The grouping of emissions sources to be included within the report, which include direct and indirect emissions that the organisation controls or influences.
Sequestered carbon	The CO2 removed from the atmosphere and captured in a GHG reservoir.

9. Appendices

Appendix 1: Inter-Agency Organisational GHG Boundaries



Emergency Management Southland

Emergency Management Southland (EMS) is co-funded by the region's councils and its financial results are apportioned to all councils, however the EMS Joint Arrangement states that Environment Southland (ES) will provide operational management, giving ES operational control in accordance with the agreed inter-agency organisational boundary approach. Consequently, 100 % of EMS is included within Environment Southland's organisational boundary.

Great South (Southland Regional Development Agency Limited)

All councils are shareholders in Great South with varying financial obligations, but no council has direct operational control. Consequently, Great South is outside of each council's organisational boundary.

Civic Financial Services Limited

All councils are shareholders in Civic Financial Services, but no council has direct operational control. Consequently, Civic Financial Services is outside of each council's organisational boundary.

WasteNet Southland

WasteNet is a joint committee of the Invercargill City, Southland District, and Gore District councils to provide the co-ordinated delivery of waste management and minimisation services across Southland. All three territorial authorities have representation in the governance group and have influence, but not operational control, over kerbside collection and the disposal of waste via the procurement of services. Consequently, WasteNet and its contractors remain outside the councils' organisational

boundaries. The creation and processing of waste and recycling is outside of each council's reporting boundary; however, each council is responsible for the collection, transfer, and transport of waste services by contractors and will include their portion of those procured services within their reporting boundaries.

Appendix 2: Approach to co-funding with partner agencies

(Partner agencies largely being local and central government agencies.)

Principle

Where Council is procuring operational services of a significant nature, the suppliers' operational emissions per dollar of funding will be used as the basis of attributing the emissions to each co-funder that is significantly influencing the operations and the procuring of the services.

If a co-funder is providing funds as a donation or a grant and is not significantly influencing the operations or procurement of services, emissions will be allocated amongst the remaining significantly influential co-funders.

The co-funding principles provide a default expectation; however, the approaches should be discussed during the development of the funding agreement and an allocation method agreed upon and written into the agreement. The overriding principle is that whichever approach is likely to result in better inclusion of emissions as a decision-making factor is the one that should be selected.

Rationale

There will often be a relationship between the emissions from the service and the cost of the service. The emissions per dollar allocation method allows each co-funder to jointly take responsibility for the emissions associated with the operation. This facilitates constructive discussion during the Request for Proposal evaluation phase as to the emissions related to the cost of the service and the selection of the best overall service provider with due consideration of emissions. If this approach is not taken, there is a risk of tension with some co-funders opting for the lower cost option with no consideration for the emissions.

Appendix 3: Toitu Verification Statement

TOITŪ ENVIROCARE

INDEPENDENT AUDIT OPINION

Toitū Verification

TO THE INTENDED USERS

Organisation subject to audit:	Environment Southland (Southland Regional Council)
Audit Criteria:	ISO 14064-1:2018 ISO 14064-3:2019 Audit & Certification Technical Requirements 3.0
Responsible Party:	Environment Southland (Southland Regional Council)
Intended users:	Council and staff
Registered address:	220 North Road, Waikiwi, Invercargill, 9810, New Zealand
Inventory period:	01/07/2023 - 30/06/2024
Inventory report:	ES GHG Emissions 2024 Report.pdf

We have reviewed the greenhouse gas emissions inventory report ("the inventory report") for the above named
Responsible Party for the stated inventory period.

RESPONSIBLE PARTY'S RESPONSIBILITIES

The Management of the Responsible Party is responsible for the preparation of the GHG statement in accordance with ISO 14064-1:2018. This responsibility includes the design, implementation and maintenance of internal controls relevant to the preparation of a GHG statement that is free from material misstatement.

VERIFIERS' RESPONSIBILITIES

Our responsibility as verifiers is to express a verification opinion to the agreed level of assurance on the GHG statement, based on the evidence we have obtained and in accordance with the audit criteria. We conducted our verification engagement as agreed in the audit letter, which define the scope, objectives, criteria and level of assurance of the verification.

The International Standard ISO 14064-3:2019 requires that we comply with ethical requirements and plan and perform the verification to obtain the agreed level of assurance that the GHG emissions, removals and storage in the GHG statement are free from material misstatement.

Reasonable assurance is a high level of assurance, but is not a guarantee that an audit carried out in accordance with the ISO 14064-3:2019 Standards will always detect a material misstatement when it exists. The procedures performed on a limited level of assurance vary in nature and timing from, and are less in extent compared to reasonable assurance, which is a high level of assurance. The procedures performed on a limited level of assurance vary in nature and timing from, and are less in extent compared to reasonable assurance, which is a high level of assurance. Misstatements are differences or omissions of amounts or disclosures, and can arise from fraud or error. Misstatements are considered material if, individually or in the aggregate, they could reasonably be expected to influence the decisions of readers, taken on the basis of the information we audited.

GHG quantification is subject to inherent uncertainty because of incomplete scientific knowledge used to determine emissions factors and the values needed to combine emissions of different gases.

BASIS OF VERIFICATION OPINION

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

VERIFICATION

We have undertaken a verification engagement relating to the Greenhouse Gas Emissions Inventory Report (the 'Inventory Report')/Emissions Inventory and Management Report of the organisation listed at the top of this statement and described in the emissions inventory report for the period stated above.

The Inventory Report provides information about the greenhouse gas emissions of the organisation for the defined measurement period and is based on historical information. This information is stated in accordance with the requirements of International Standard ISO 14064-1 Greenhouse gases – Part 1: Specification with guidance at the organisation level for quantification and reporting of greenhouse gas emissions and removals (ISO 14064-1:2018).

VERIFICATION STRATEGY

Our verification strategy used a combined data and controls testing approach. Evidence-gathering procedures included but were not limited to:

- activities to inspect the completeness of the inventory;
- interviews of site personnel to confirm operational behaviour and standard operating procedures; —sampling of fuel records to confirm accuracy of source data into calculations;
- recalculation of emissions;
- review and confirmation of emission factor application;
- sampling of supplier and contractor invoices for accuracy of data transfer;
- testing of assumptions on relationship between $ expenditure and fuel use;
- reconciliation of business travel emissions;
- recalculation of energy usage;
- examination of staff commuting related emissions;
- review of assumptions related to type of machinery usage.
- The data examined during the verification were historical in nature.

QUALIFICATIONS TO VERIFICATION OPINION

The following qualifications have been raised in relation to the verification opinion:
Category 3 and 4 emission sources for purchased goods & services are heavily assumptions based, using dollar spend data and an industry average to estimate emissions. Changes in assumptions could significantly impact the measurement of these emissions.

VERIFICATION LEVEL OF ASSURANCE

	tCO_2e Location based	Level of Assurance
Direct Emissions:		
Category 1	204.00	**Reasonable**
Indirect emissions from imported energy:		
Category 2	42.99	**Reasonable**
Indirect emissions from transportation		
Category 3 freight and business travel	69.25	**Reasonable**
Indirect emissions from products used by organisation:		
Category 3 excluding freight and business travel	777.73	**Limited**
Indirect emissions from products used by organisation:		
Category 4	1,181.40	**Limited**
Indirect emissions from other sources:		
Total gross emissions	**2,275.38**	
Category 1 removals	-189.53	**Limited**
Total net emissions	**2,085.84**	

RESPONSIBLE PARTY'S GREENHOUSE GAS ASSERTION (CERTIFICATION CLAIM)

Southland Regional Council trading as Environment Southland has measured its greenhouse gas emissions in accordance with ISO 14064-1:2018 in respect of the operational emissions of its organisation.

VERIFICATION CONCLUSION

We have obtained all the information and explanations we have required. In our opinion, the emissions, removals and storage defined in the inventory report, in all material respects:

- comply with ISO 14064-1:2018 ; and
- provide a true and fair view of the emissions inventory of the Responsible Party for the stated inventory period.

OTHER INFORMATION

The responsible party is responsible for the provision of Other Information to meet Programme requirements. The Other Information may include climate related disclosures around Governance, Strategy and Risk management, emissions management, reduction plan and purchase of carbon credits, but does not include the information we verified, and our auditor's opinion thereon.

Our opinion on the information we verified does not cover the Other Information and we do not express any form of audit opinion or assurance conclusion thereon. Our responsibility is to read and review the Other Information and consider it in terms of the programme requirements. In doing so, we consider whether the Other Information is materially inconsistent with the information we verified or our knowledge obtained during the verification.

Verified by:		**Authorised by:**	
Name:	Tom Worley	Name:	Billy Ziemann
Position:	Verifier, Toitū Envirocare	Position:	Certifier, Toitū Envirocare
Signature:		Signature:	
Date verification audit:	17 September 2024	Date:	11 October 2024
Date opinion expressed:	1 October 2024		

9.2 Presentation by National Public Health Service

Report by: Anke Habgood, Senior Strategy Advisor
Approved by: Rachael Millar, General Manager Strategy, Policy & Science
Report Date: 24 October 2024

Purpose

For the National Public Health Service (NPHS) to present the Climate Change and Health in Waitaha Canterbury report – May 2023.

To consider the relationship between climate change impacts and health for the Murihiku Southland region.

Summary

The Climate Change and Health in Waitaha Canterbury report identifies linkages between external climate change hazards and impacts with health and wellbeing impacts within our communities.

Being aware of these connections will support Environment Southland staff and Councillors understand the social and health related impacts that are likely to be anticipated in Southland as our climate changes. Furthermore, health related impacts will be able to be considered in decision making.

Recommendation

It is recommended that the Climate Change Subcommittee **resolve to:**

1 Receive the report - Presentation by National Public Health Service.

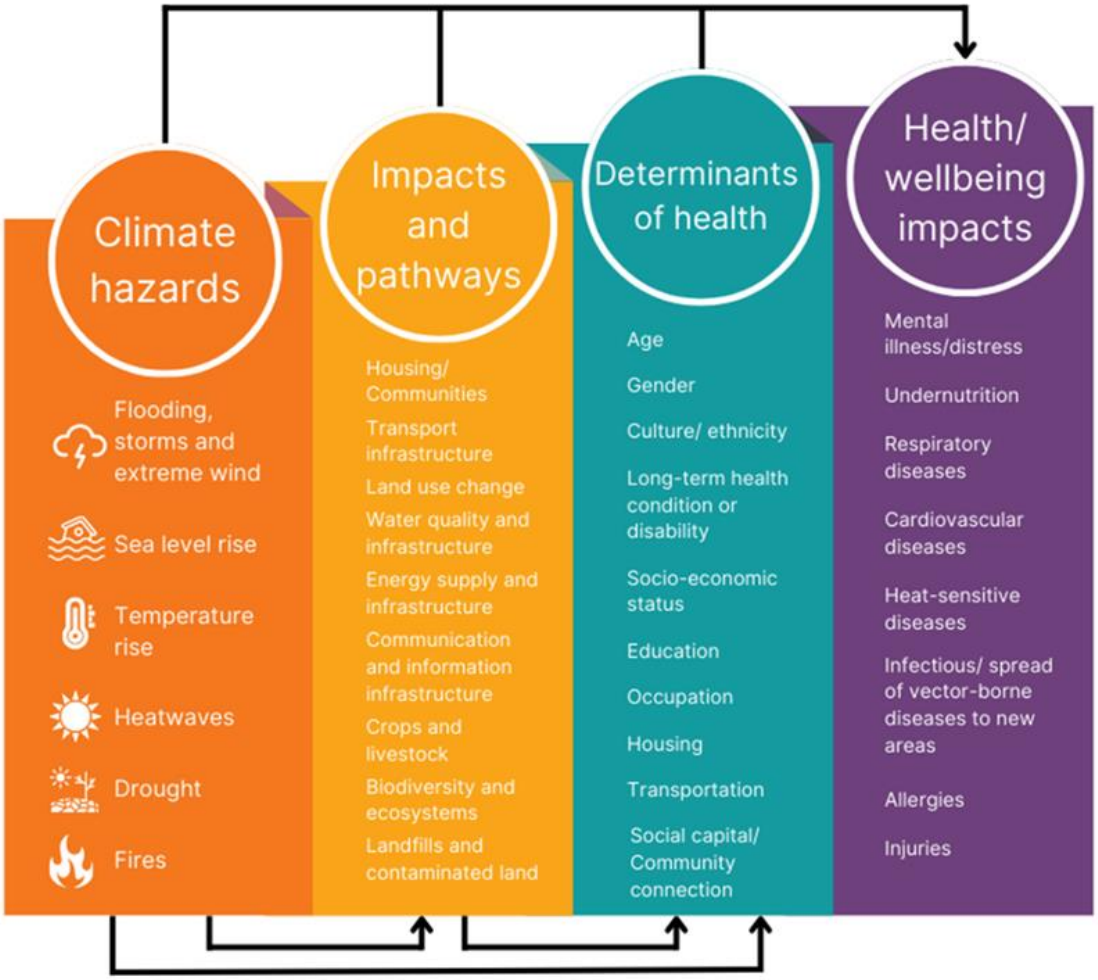
Background

Earlier this year, the National Public Health Service (NPHS) was a submitter on the Regional Climate Change Strategy. The NPHS are most concerned about the health and wellbeing impacts on people from climate change.

The NPHS was supportive of the Regional Climate Change Strategy and the regional collaborative approach being undertaken. The NPHS also signaled their interest in becoming a part of this regional collaboration to support the consideration of a health lens over climate change actions as they are developed.

In May 2023, the Policy and Information teams of the National Public Health Service produced the 'Climate Change and Health in Waitaha Canterbury' report. This report is attached in appendix 1.

The Waitaha report is a health impact assessment in relation to climate change for the Canterbury region. A key diagram that illustrates the relationship between climate hazards and health / wellbeing impacts is below.



The NPHS have been invited to attend the Environment Southland Climate Change Sub-committee meeting to present their perspective on the relationship between climate change impacts and health.

This will also enable an opportunity to consider how continued collaboration with the NPHS may assist in developing a regional response to our changing climate.

Fit with strategic framework

OUTCOME	CONTRIBUTES	DETRACTS	NOT APPLICABLE
Managed access to quality natural resources	X		
Diverse opportunities to make a living	X		
Communities empowered and resilient	X		
Communities expressing their diversity	X		

Attachments

1. Climate Change Health Waitaha Canterbury [**9.2.1** - 98 pages]

Climate Change and Health in Waitaha Canterbury

A scoping and profiling report to inform Health Impact Assessment

Prepared by the Policy & Information Teams,
Te Mana Ora
National Public Health Service

May 2023

Te Whatu Ora
Health New Zealand

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This document has been prepared by a member(s) of the Information Team, Te Mana Ora and has been through a process of internal Public Health Specialist review.

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Te Pae Māhutonga graphics courtesy of Healthy Christchurch.

Contents

Purpose of this report

The central purpose of this report is to increase understanding of the interactions between people, the environment, and the climate in Waitaha Canterbury – to provide planners and decision-makers and the wider community with information that can shape the development of effective responses to climate change.

The scope and extent of climate-related health and wellbeing impacts can be strongly influenced by location and it is important that regional-level adaptation strategies are matched to the specific geographic and demographic characteristics of the Waitaha Canterbury region. This report presents the interim findings of a scoping and profiling assessment that outlines the connections between climate change and health, relevant to the people of Waitaha Canterbury. This report does not specifically cover adaptation or mitigation/transition risks; however, this report does provide some commentary on adaptation and mitigation strategies that could help reduce the health and wellbeing impacts of climate[1].

This report describes a range of climate change related determinants of health – incorporating broad perspectives of health and wellbeing. This report encompasses the first steps of assessing the health and wellbeing impacts of climate change across Waitaha Canterbury and the potential effects on the health and wellbeing of the population and the distribution of those effects within the population [2].

About this report

This report was developed by the Policy and Information Teams, Te Mana Ora | Community and Public Health, National Public Health Service, Te Whatu Ora: to support decision making and long-term planning. This work evolved from preliminary conversations with staff at the Christchurch City Council and Environment Canterbury, who were interested in Waitaha Canterbury-specific information on the health and wellbeing impacts of climate change. Additionally, the report aimed to incorporate and highlight Māori perspectives and the health and wellbeing implications of climate change for Māori.

This scoping and profiling interim report is not a completed Health Impact Assessment (HIA), as the assessment/quantification of the identified impacts is yet to be undertaken for Waitaha Canterbury. However, the report collates and summarises key information to help local planners and decision makers plan for health and wellbeing risks of climate change in Waitaha Canterbury and represents the first step in completing a Health Impact Assessment.

[1] Risks associated with the transition to a low carbon economy.

Introduction

Anthropogenic climate change is a global public health emergency. It poses both a major threat and a major opportunity for planetary health and health equity [3]. Addressing the threat and realising the opportunity to improve health and wellbeing requires global action by governments and non-government organisations at all levels and will only be achieved in close collaboration with the community. More progress is needed to ensure that action is delivered at the scale and pace required to prevent the most significant harmful impacts that could arise as a result of climate change [4].

A determinants of health approach

Many factors affect people's health[2] and wellbeing. Climate change impacts our health and wellbeing in many ways - one way to consider the factors which influence our health and wellbeing is through a determinants of health approach. Figure 1 shows the main factors that affect the health of individuals and communities. In this report, the organisation and presentation of information has been guided by this framework, where it has been practical to do so.

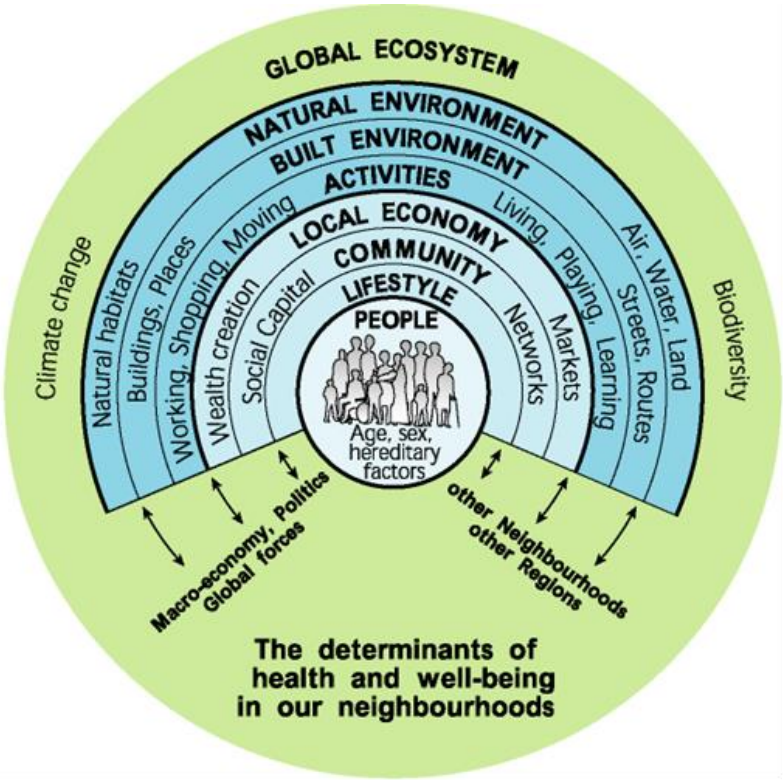


Figure 1: Barton and Grant's (2006) 'map' of the determinants of health

Source: Barton and Grant, A health map for the local human habitat [7]

The figure shows a map of the determinants of health developed by Barton and Grant (2006) from an earlier concept "A socio-environmental model of health" by Dahlgren and Whitehead (1991)[8]. Barton and Grant place individuals' age, sex (at birth) and hereditary characteristics in the centre of the figure, as their

[2] There will likely be differences in peoples' use of, and understanding of, the term 'Health'. As a point of reference, the 1986 WHO definition is provided here — 'Health is a resource for everyday life, not the objective of living. Health is a positive concept emphasizing social & personal resources, as well as physical capabilities' [5. WHO. The Ottawa Charter for Health Promotion; 1986; Ottawa. World Health Organization. Also see [6. Huber M, Knottnerus JA, Green L, Horst Hvd, Jadad AR, et al. (2011) How should we define health? *BMJ* 343: d4163.

influence on health are largely fixed. Surrounding them, however, are influences that are modifiable by policy. First, there are lifestyle/personal behaviour factors, such as smoking habits and physical activity. Second, individuals interact with their peers and immediate community and are influenced by them. Next, a person's ability to maintain their health is influenced by their living and working conditions, and access to essential goods and services (next two layers). Next, a person's ability to maintain their health is influenced by the natural environment, including natural habitats – air, water, and land. Finally, the global ecosystem (including climate change) exerts influence over all the inner layers – shaping economic, cultural and environmental factors in the overall society. The model emphasises interactions: individual lifestyles are embedded in social norms and networks, and in living and working conditions, which in turn are related to the wider socioeconomic and cultural environment. The determinants can be positive/protective factors, or risk factors [8, 9]. Risk factors or risk conditions (e.g., polluted air, socioeconomic deprivation) cause or contribute to health problems and diseases that are potentially preventable. Protective factors are factors that eliminate or reduce the the risk of disease (e.g., healthy diet, immunisation, social support, sense of purpose). The importance of the contribution of different risk factors to the total burden of disease should be assessed so that priorities can be set and appropriate interventions and strategies developed [8].

Social gradients in health

Social gradients in health and wellbeing are evident within most countries, including Aotearoa New Zealand. The observed pattern is one of generally poorer health and wellbeing and a shorter lifespan being associated with each successively less advantaged position in any given system of social stratification [10]. There is increasing interest in how to identify and respond to variations in health and wellbeing outcomes that are unjust and occur due to modifiable causes that are not related to personal choice. The literature on the social determinants of health [e.g., 11, 12-15] points to substantial and unjust differences in health and wellbeing between different population groups, caused by modifiable social arrangements (such as access to healthcare or opportunity for employment) [16].

One approach to understanding the root causes of these inequities in health and wellbeing is to focus on the pathways and mechanisms that bring about the social gradients [17]. Table 1 and Figure 2 outline and describe five central (causal) mechanisms behind social inequities in health. The importance of a specific upstream ('the mechanisms of society') or downstream risk factors ('the physical and biological') can be different in different regions. For each of the five mechanisms, a group of interventions or policy entry points (A–D in Figure 2) exist. Each region needs its own assessment of which determinants of health and wellbeing are the most significant for the local context.

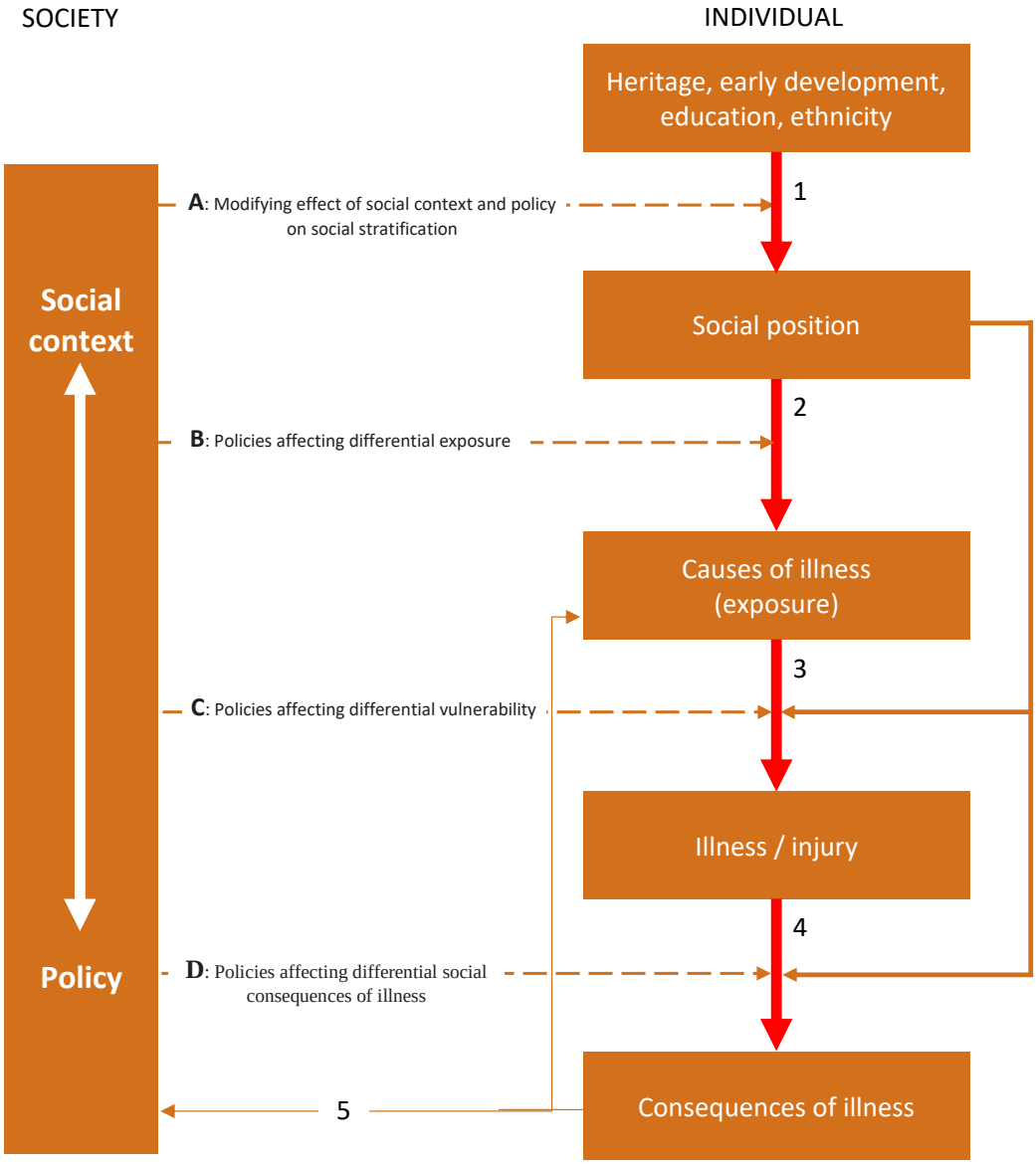


Figure 2: Five central mechanisms behind social inequities in health and associated policy entry points

Five central causal mechanisms behind social inequality in health (1–5) and associated policy entry points (A–D) related to social inequality in health. Causal mechanism 1 = social stratification and the associated different levels of power and resources; causal mechanism 2 = effect of social position on health through differential exposure; causal mechanism 3 = differential vulnerability; causal mechanism 4 = differential consequences of illness; causal mechanism 5 = whereby consequences of illness feed back into the causal pathway and impact upon society.

Note: this adaptation of Diderichsen et al's. 1998 diagram incorporates incremental updates from Diderichsen et al. 2001 and 2012.

Adapted from: [16, 18, 19]

Table 1: Mechanisms that bring about the social gradients in health, from Diderichsen et al. 1998, 2001 & 2012

Pathway	Description
1: Social stratification, different levels of power and resources	Societies create a range of social positions, which individuals, through education and in other ways, try to attain. In this social stratification, education, heritage, gender, age, ethnicity, and health play a central role. Social position exerts a powerful influence on the type, magnitude and distribution of health risks experienced within different socioeconomic groups. Groups that are better off typically have more power and opportunities to live a healthy life than groups that are less privileged. The cumulative outcome of all the pathways as they interact and operate over a lifetime contribute to intergenerational effects.
2: Differential exposure to health hazards	Exposure to almost all risk factors (material, psychosocial and behavioural) is inversely related to social position – that is, the less advantaged the social position, the greater the exposure to different health hazards. In real life, 'long chains of causality' act through the organisation of labour, and social relationships assert their influence through physiological mechanisms, psychological processes, and/or health behaviour.
3: Differential vulnerability: the same level of exposure leading to differential impacts	The same level of exposure can lead to differential impacts between groups due to differences in social support systems cultural and financial support and, greater likelihood of low-income groups being exposed simultaneously to several (a cluster of) risk factors that reinforce each other (mutual interaction), and biology/heredity factors. Particularly relevant is the interaction between earlier exposures (pathway 1) and those that occur later in life (pathway 2).
4: Differential illness consequences	Illnesses and injuries affect survival, functional ability and quality of life as well as people's opportunities to participate in work life and social life in general. These consequences are influenced by the social position of the individual because social position can impact access to treatment and rehabilitation as well as work and other demands, all of which is critical to the individual's chances of returning to work despite a reduced functional ability. Barriers to accessing care and to the job market, even with reduced working ability, can result in large economic losses due to illness.
5: Different social and economic effects of being sick; consequences for the individual and for society	Poor health may have many adverse consequences for the life and livelihood of individuals, including loss of earnings from employment, loss of a job altogether, and social isolation or exclusion, brought about by unemployment or restrictions on activities because of the illness – may result in a 'negative spiral'. At the same time, sick people may face additional financial burdens due to out-of-pocket payments for healthcare. For society, the consequences of illness impact upon the overall costs of illness and on supply of labour – whereby, the consequences of illness 'feed back' into the causal pathway and further impact upon society.

Note: this adaptation of Diderichsen et al's. 1998 table incorporates incremental updates from Diderichsen et al. 2001 & 2012.

Adapted from: [16, 18, 19]

Our Climate is Changing

Global warming[3] and subsequent global climate change are consequences of human-caused emissions, mainly from fossil fuel-based power generation and transport, agriculture, and industry, which increase the heat-retaining capacity of the lower atmosphere[4] [20, 21]. The Intergovernmental Panel on Climate Change (IPCC) has concluded that unmitigated carbon emissions will lead to heating of at least several degrees Celsius by 2100, resulting in high impacts of local, regional, and global risks to natural ecosystems and human society. Climate change is part of a larger set of human-induced global environmental changes, which include land degradation, ocean acidification, depletions of the ozone layer, reduced soil fertility and fresh-water resources, and disruptions to biodiversity stocks and ecosystem functioning [20].

The global scale and economic intensity of contemporary human activity are unprecedented [22, 23]. Increasingly, interrelated and widespread environmental impacts are resulting from population growth, intensive economic activities, urbanisation, and consumerism [23-25]. These global changes fundamentally influence patterns of human health and healthcare activities [20, 23, 26-33].

Human activities are estimated to have already caused approximately 1.1°C of global warming above pre-industrial levels (likely range of 0.95°C to 1.2°C)[5] [34, 35]. Global warming is likely to reach 1.5°C between 2030 and 2050, if emissions continue to increase at the current rate [36, 37] (Box 1). Global surface temperature has increased faster since 1970 than in any other 50-year period over at least the last 2000 years. In 2019, atmospheric CO_2 concentrations (410 parts per million) were higher than at any time in at least 2 million years [37]. Human-induced climate change has already caused multiple observed changes in climate systems [21, 38, 39]. For example, in 2022, much of Aotearoa New Zealand experienced temperatures that were above average (+0.51°C to +1.20°C above the annual average) or in some parts of the country, well above average (>1.2°C above the annual average). Based on The National Institute of Water and Atmospheric Research's (NIWA's) seven station series which began in 1909, the year 2022 was Aotearoa New Zealand's warmest year on record and 2022 was also Aotearoa New Zealand's 8th most unusually wet year on record, based on an analysis of NIWA's Virtual Climate Station Network dating back to 1960 [40].

Pathways limiting warming to 1.5°C will require rapid and far-reaching transitions in energy use, land use, urban infrastructure, industrial systems [36], and carbon dioxide removal technologies [41], and limiting temperature rise to 1.5°C can only be achieved if global CO_2 emissions start to decline well before 2030 [36]. Emissions reductions under Nationally Determined Contributions from signatories to the Paris Agreement are consistent with a global warming of 2.5-3.0°C above pre-industrial temperatures by 2100 [38]. Much

Box 1

Why the 1.5°C threshold?

At the 2015 Paris Climate Conference, 195 nations agreed to curb greenhouse gas emissions sufficiently to limit global warming to "well below" 2 degrees Celsius above pre-industrial levels. However, many nations called for the goal of '*pursuing efforts to limit*' global temperature rise to 1.5°C above pre-industrial levels (the 1.5 degrees target having first been proposed within UN Climate Change documents in 2010, or earlier). Subsequently, the 1.5 degrees target has been adopted as the lower temperature value in climate modelling scenarios.
Current modelling highlights stark environmental differences between the two warming targets (i.e., 1.5°C vs. 2°C).

However, the 2023 IPCC's analysis now predicts that the 1.5° C temperature threshold will be exceeded around 2040-2050.
The IPCC state that "negative emissions" will be required to bring the temperatures back down after overshooting 1.5° C. However, the technologies required, such as carbon capture and storage, are not yet commercially viable.

[3] In this report, the term *global warming* refers to a gradual increase in average global surface temperature (as one of the consequences of anthropogenic emissions) and the term *climate change* describes the resultant amplification of natural climate variability.
[4] This list only includes emissions, however, deforestation also increases the net carbon dioxide (CO_2) in the atmosphere by reducing the amount of natural carbon dioxide removal.
[5] IPCC 2022 Working Group I, assessed this as the *very likely* range, or 90-100% probability.

deeper emission reductions are needed prior to 2030 to limit warming to 1.5°C. Without these global actions, the world will exceed its carbon budget and may experience high levels of warming (4- 6°C) by 2100 [36]. Warming in the range of 4–6°C will result in many populated areas of the world being unable to support human health and wellbeing.

How does a changing climate impact human health?

Figure 3 outlines the main categories of climate hazards and health and wellbeing impact pathways, including those that are direct, indirect, and those that affect (or act through) the social determinants of health and wellbeing. The causal links are explained in greater detail in Tables 14 to 19.

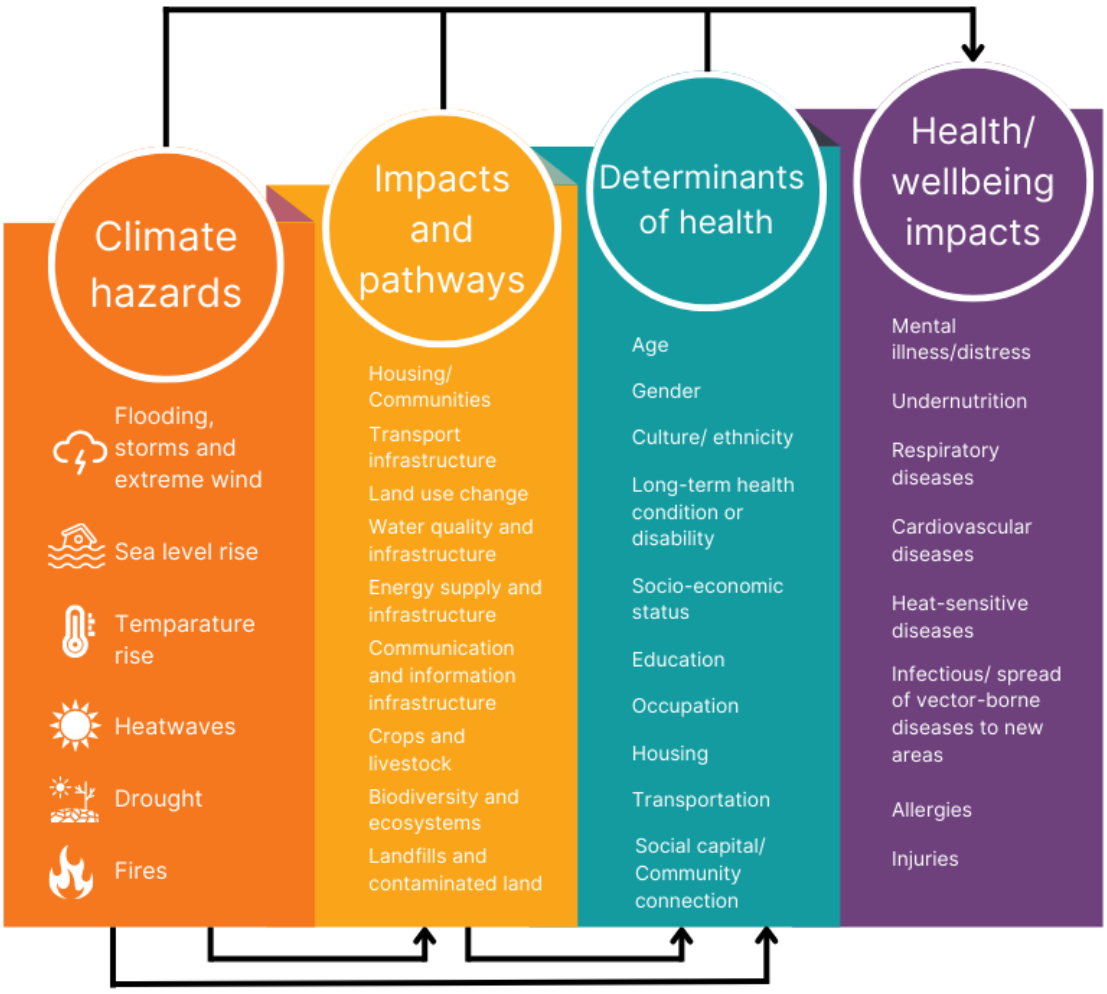


Figure 3: Direct and indirect effects of climate change on health and wellbeing, created from [4, 39, 42, 43]

The figure shows how climate change poses a range of threats to human health and survival in multiple, interacting ways. Impacts can be direct (e.g., injuries during extreme weather events such as a storms and floods) or indirectly mediated through the effects of climate change on ecosystems (e.g., agricultural losses/undernutrition, changing patterns of disease) [39, 42]. After 1·1°C warming, many anticipated threats have already become real-world health and wellbeing impacts.

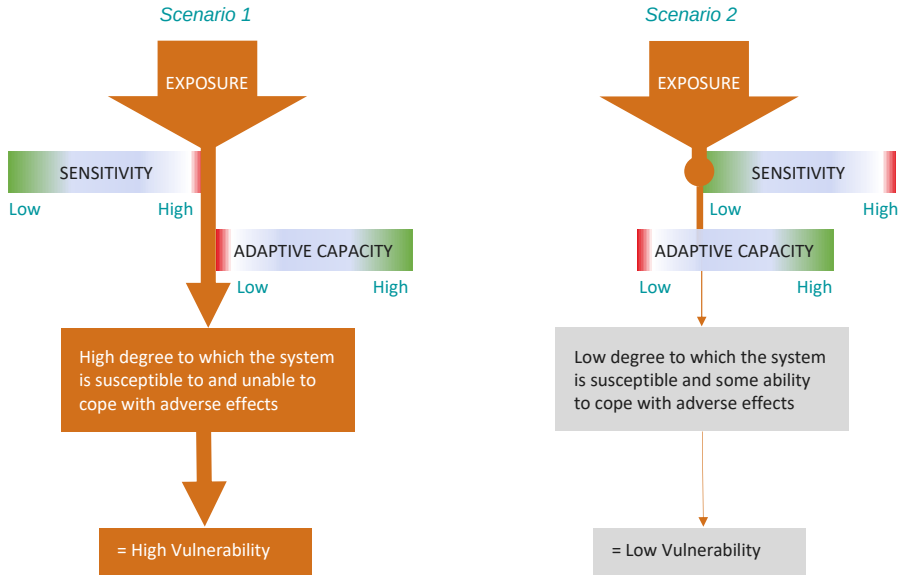
The scale of future risks to human health and wellbeing generally depend on numerous interactions between specific hazards, exposures, sensitivities, and adaptive capacity. Climate-related risks for natural and human systems depend largely on the future magnitude and rate of warming, geographic location, levels of development, and ultimately on the choices and implementation of mitigation and adaptation options [21, 38]. The effects of climate change are being felt today, and have been described as representing an 'unacceptably high and potentially catastrophic risk to human health' [39, p.1861] which 'threaten[s] to undermine the past 50 years of gains in public health' [42, p.581].

Vulnerability

In this document, a specific and narrow definition of *vulnerability* is applied, as set out by the IPCC:

> 'the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change' [44, p.976, 45].

The IPCC considers vulnerability to have three component parts or dimensions: *exposure*, *sensitivity*, and a*daptive capacity* (Figure 4). Therefore, vulnerability broadly refers to the propensity of exposed elements such as human beings, their livelihoods and assets, to suffer adverse effects when impacted by hazard events [44-47]. Vulnerability is related to predisposition, susceptibilities, and capacities (see also, Table 1) [47][6]. The concept of vulnerability stresses the fundamental importance of examining the preconditions and context of societies and communities and elements at risk to effectively promote risk reduction and climate change adaptation [45]. In some locations and amongst some groups of people with high exposure, high sensitivity, and/or low adaptive capacity, the net costs of climate change will be significantly larger than the global average [34, 45, 48].



Created from: IPCC AR6 [34]

Figure 4: Exposure, sensitivity and adaptive capacity; three elements that contribute to overall vulnerability

In scenario 1, the group has a high sensitivity to the exposure and low capacity to adapt resulting in high vulnerability, and potentially, a high health burden. In scenario 2, the group has a low(er) sensitivity to the exposure and some capacity to adapt; resulting in (relatively) low vulnerability and potentially little appreciable health burden. The figure shows a simplistic pathway between a climatic variable and the subsequent health impact, although, there are often multiple exposures, multiple steps, and multiple interactions, and vulnerability can manifest at any point in the pathway(s).

[6]Terms like *marginalised* and *underserved* might be more accurate and appropriate in some instances; to call attention to external factors and systemic issues that result in unmet needs.

Cascading, compounding & transboundary risks

The IPCC AR6 report (2022) [34] puts significant emphasis on regional information in order to better understand the context for both impacts and responses to climate change, and it provides new information on cascading, compounding, and transboundary risks (Figure 5 & 6).

Cascading risks/impacts occur when an extreme hazard generates a sequence of secondary events in natural and human systems (e.g., physical, natural, social, economic) whereby the resulting impact is significantly larger than the initial impact [34, 35].

Compound impacts/events refer to the combination of multiple drivers and/or hazards that contribute to societal and/or environmental risk [38], including simultaneous exposure/sensitivity changes, which may further increase risks (for example, if populations further concentrate on coasts or along rivers) [49].

Finally, transboundary risks go beyond a single site of impact, or group of actors, to potentially impact capability across multiple sectors. Transboundary risks have significant implications for healthcare delivery, whereby climate-related disasters can quickly overwhelm regional systems and their capacities to deliver healthcare, requiring inter-regional support and potentially international responses (due, for example, to the infrastructure failures shown in Figure 6) [50].

Figure 5: Simple schematic showing the interactions between compounding and cascading risks

Source (Figures 5 & 6): IPCC AR6 [51] p.83

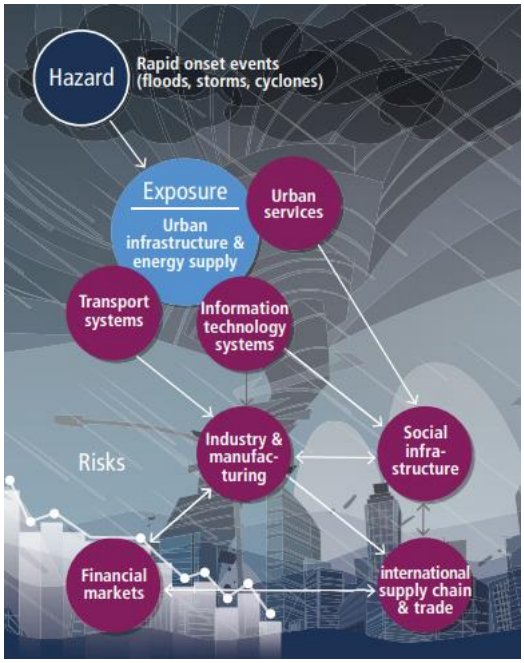


Figure 6: Urban infrastructure failures cascade risk and loss beyond the city

Climate impacts are already cascading, compounding, and aggregating across sectors and systems due to complex interactions [35, 36, 52]. Cascading impacts propagate via interconnections and systemic factors, including supply chains, shared reliance on connected systems and resources, infrastructure, and essential goods and services (e.g., the health system is exposed to complex interactions, including the many possible barriers to staff being able to attend work during extreme weather events; such as injury, childcare needs, and/or dysfunctional transport systems) [52]. The capacity of critical systems such as information, communication and Technology systems, water infrastructure, healthcare, electricity and transport networks is being stretched, with impacts cascading to other systems and places, exacerbating existing hazards and generating new risks [53, 54]. In Aotearoa New Zealand, multiple extreme snow, rainfall and wind events have occurred that have impacted road networks, power and water supply, and wastewater and stormwater services and business activities (e.g., Cyclone Bola, Cyclone Gabrielle) [54-56]. Community and infrastructure services are periodically disrupted during extreme

weather events, triggering impacts from the interdependencies across communities and individuals [57, 58]. Climate change impacts will limit the ability of institutions and governance systems to manage climate risks (e.g., local governments being under resourced and ill-equipped to respond to climate change impacts on cities, settlements, infrastructure, supply-chains, and essential services – and/or unable to cope with large scale losses of infrastructure in low-lying coastal areas) [59].

Projected impacts also cascade across national boundaries via markets, movement of humans and other organisms, and geopolitics (e.g., migration from near-neighbours as a pathway for adaptation, and changes in production and trade patterns) [49, 52]. The scale of impacts is projected to challenge the adaptive capacity of sectors, governments, and institutions [49], including the insurability of assets and risks to lenders [59]. There is uncertainty about whether standard integrated assessment models can estimate cascading and compounding impacts across systems and sectors [49, 52]. Climate responses may face limits and/or fail to achieve their objectives, involve trade-offs among objectives or across stakeholders, involve unintended consequences for other groups or societal objectives, or increase other climate risk drivers [60].

Equity

Climate change can affect human health and wellbeing through many direct and indirect pathways, making the identification and assessment of health effects due to climate change challenging and complex [45, 61]. Populations' vulnerability to climate change and associated health and wellbeing impacts, will largely depend on the their baseline health and wellbeing status as well as socio-economic, ecological and political factors [62]. Most of the anticipated health and wellbeing impacts of climate change are negative and predicted to outweigh, by far, potential positive health and wellbeing effects (e.g., lower health risks from extreme cold) worldwide [36, 63]. Generally, climate impacts will disproportionately affect the welfare of impoverished, marginalised and/or underserved people, in large part, because they lack adaptation resources [52]. Generally, those who have historically contributed the least to current climate change (in terms of emissions) are disproportionately affected. Within countries, the evidence shows that, in general, the less advantaged an individual's socioeconomic position, the worse their health. Climate change will increase the steepness of this social health gradient [13, 64] [27, 62, 65-70] [39, 42]. Adaptation policies should be as equitable as possible, because some groups in society have less knowledge and/or less social, human and financial capital with which to adapt (Box 2). Intergenerational equity is also an important consideration within the context of climate change action [71]. Article 3 of the UNFCCC framework [72] describes this concept in terms of the need to protect the climate system for the benefit of present and future generations of humankind. The continuing relevance of intergenerational equity as a guiding principle shaping climate action is also reaffirmed by the Paris Agreement preamble [73].

Box 2

Equity

The principle of equity is central to issues of environmental sustainability – recognising that many of the impacts of global warming, and some potential impacts of the mitigation actions required, fall disproportionately on the poor and vulnerable

Māori health and equity

Climate change will result in different exposures and degrees of impact for different population groups; depending on geographic location, age, ethnicity, pre-existing health status, socioeconomic circumstances, and other pre-existing factors [74, 75]. Māori and Pacific people in Aotearoa New Zealand are at greater risk of many of the adverse health and wellbeing impacts of climate change, compared with the general population [68, 76][7]. A disproportionately high number of Māori and Pacific people in Aotearoa New Zealand live in socioeconomically disadvantaged circumstances, and socioeconomic disadvantage is a significant driver of poor health and wellbeing outcomes [67, 77, 78]. Māori may also experience unique impacts related to indigenous relationships with the environment and/or reduced access to cultural resources [67].

[7] Many equity issues for Māori may also be experienced by Pacific Peoples living in Aotearoa New Zealand and by low income New Zealanders.

Exposures related to climate change can be expected to exacerbate pre-established and disproportionate burdens and susceptibilities to disease for Māori, across many health conditions [67]. These effects are predicted to act most strongly on the more climate-sensitive conditions, such as water/food/vector-borne diseases, direct injuries due to extreme weather events, respiratory diseases, heat stress, and mental health conditions [32, 39, 42, 79, 80]. Further, reduced agricultural production could lead to higher unemployment, and wide-ranging economic and social impacts, including impacts on income distribution, attitudes and health behaviours [81]. Overall, climate change will increasingly exert an influence on and through the broader social determinants of health in Aotearoa New Zealand (and globally), and progress on adaptation will require the health sector to increasingly engage with the multiple sectors outside health, in areas such as trade, agriculture, employment, and education (working in a 'Health in All Policies' way) [82, 83].

Closely intertwined with psychological and spiritual wellbeing (as well as physical health), are the practical ways in which ancestral lands, wetlands, and waterways support customary resources and strengthen practices such as mahinga kai (food gathering and cultivation areas), rongoā rākau (Māori healing), including access to indigenous flora for plant medicines, and harvesting of harakeke (flax) and other materials used for practical, artistic, or ceremonial purposes (Table 2). These ongoing relational links with whenua (land), and tūrangawaewae (family connections) are crucial to the cultural and psychological wellbeing of Māori and the transmission of mātauranga Māori. The link between people and ecosystems will be tested by a changing climate, which poses an additional challenge for maintaining Māori identity and practising manaakitanga (ethics of care) and kaitiakitanga (intergenerational sustainability). For example, an inter-generational approach: “Mō tātou, ā, mō kā uri ā muri ake nei – for us and our children after us” is central to *Te Kounga Paparangi* [84], Ngāi Tahu’s 88-point action plan to mitigate climate change, build resilience, and promote sustainable business practices.

Table 2: Māori identity and wellbeing is threatened by climate change

Māori identity and wellbeing is threatened by climate change
Te whenua, te wai, and taonga species are being affected by climate change, which threatens traditional practices connected to Māori identity and wellbeing. Te reo and tikanga are deeply connected to the natural environment. Narratives and proverbs resonate within cultural landscapes and often signify the importance of keystone species and other landscape features to different whānau/hapū/iwi.
The timing of tohu (signs) are changing Traditional tohu are used to help forecast changes in the natural environment. They are becoming less reliable, and this is affecting planting, daily decision-making, and activities like resource gathering and hunting.
Culturally significant places are at risk of being damaged Many marae and urupā are threatened by flooding and erosion from sea-level rise and extreme weather events. Sea-level rise is not only likely to damage cultural sites through processes such as coastal erosion, storm surge, and flooding, it is also likely to force some whānau/hapū/iwi in at-risk areas to seek alternative locations, intermittently or permanently severing the link between whānau/hapū/iwi, whenua and taonga.
The loss of taonga species Taonga species are central to Māori identity and wellbeing. A warming climate is affecting where some species can live, their numbers, and size.
Ability to manaaki is threatened Manaakitanga is a way of life and is especially important on marae where local delicacies are offered generously to manuhiri. Climate change threatens the reliability of tohu, abundance of kai, and sometimes the marae itself. This poses risks for the maintenance and transfer of traditional skills, expertise and values and has implications for language retention, tribal identity and wellbeing.
Maori wellbeing is connected to te taiao Taha tinana: physical wellbeing. Rongoā, mahinga kai Taha wairua: spiritual wellbeing. Karakia, waiata Taha hinengaro: mental wellbeing. Mātauranga, tikanga Taha whānau: social wellbeing. Manaakitanga, whanaungatanga Adapted from Durie, 1985
Matauranga may not be passed on. Losing traditional resources from the moana, awa, and ngahere is not just a loss in the present. It affects future generations because the tikanga and mātauranga Māori associated with the resource and the practices around its harvest and use would also be lost.
Cascading risks Cascading risks include the loss of customary knowledge about environmental constraints and ecological principles, and potential grief and anxiety about failing to meet fundamental obligations to other species and to provide for future generations.
Glossary – awa: river | kai: food | karakia: prayer | mahinga kai: food gathering place | manaakitanga: the practice of hospitality | manuhiri: visitors | marae: cultural gathering centre | mātauranga: knowledge | moana: ocean | ngahere: forest | rongoā: medicinal plants | taonga species: treasured species | tikanga: customary protocols | tohu: environmental indicator | urupā: burial grounds | wai: water | waiata: songs | whanaungatanga: socialisation | whenua: land
Ministry for the Environment, & Stats NZ. (2020). New Zealand's Environmental Reporting Series: Our atmosphere and climate 2020. In. Retrieved from www.mfe.govt.nz and www.stats.govt.nz. p.56

Text from [85, p.56]

Decolonisation

Despite a long history of natural resource management, as well as having clear kaitiakitanga (guardianship) rights and responsibilities, Māori currently face considerable barriers to climate change adaptation due to the ongoing impacts of colonisation. Decolonisation (in this case, with respect to health) refers to 'fighting against ingrained systems of dominance and power in the work to improve the health of populations' [86, p.1]. Colonialism is at the root of the global economic system that perpetuates human-caused climate change and is responsible for the social conditions that limit Indigenous peoples' resilience and adaptation capacity. Several scholars [68, 87-90] suggest that it is not possible to understand or address the impacts of climate change for indigenous health without acknowledging and confronting colonisation. One of the key issues in relation to climate change and indigenous health is that incompatibility (i.e., between indigenous and non-indigenous) often exists between the underlying intent, values, and principles; and the ways in which health-related interventions are implemented (e.g., non-indigenous actors not establishing and maintaining relationships with Māori, or omitting the explicit inclusion of spirituality) [68, 88].

Decolonisation of health, then, involves Western systems of knowledge being subject to critical inquiry [91]. This involves the transfer of power to indigenous communities, the recognition of indigenous knowledge as a critical foundation for climate change and health solutions, and a commitment to uphold Indigenous Peoples' rights to self-determination [92]. Decolonisation has been described as

> 'an individual and collective process of revealing and analysing the historic and contemporary impact of colonisation, monoculturalism and institutional racism, combined with political movement towards the recognition of sovereignty' [93, p.78, 94].

In addition, others note that addressing racism 'entails detecting, confronting and preventing racist policies, practices and attitudes' [95, p.30]. Decolonisation has also been described as being about 'shifting power and resources to enable indigenous control … a domain led by Māori, working to enable tino rangatiratanga' [95, p.44].

In Aotearoa New Zealand and more locally in Waitaha Canterbury, the higher risk[8] of adverse health and wellbeing impacts from climate change for Māori can be attributed to a range of up-stream factors (determinants) (Table 3) [96, 97]. Further, there is significant risk that policies adopted to address climate change, both mitigation and adaptation, could exacerbate inequities [98]. As a result of indigenous peoples' overall poorer access to resources to respond, climate change threatens cultural survival and potentially undermines human rights [99].

Table 3: Summary of relationships between climate change and Indigenous health

Risks of adverse health impacts from climate change	Mechanisms/details*
Greater pre-existing burden of disease	Baseline inequities due to the effects of colonisation, and increasingly due to climate-sensitive health conditions such as infectious diseases, chronic heart and lung diseases, and mental illness.
Occupational inequities	Māori are more likely to work outdoors than non- Māori and therefore have greater exposure to outdoor heat and air pollution.
Contamination of seafood/kai moana	A common customary food source for coastal Māori communities, and sensitive to changes in sea temperature and to pollution.
Systemic inequities in healthcare services	Poorer access to and quality of care for Māori.
Disproportionate socioeconomic disadvantage	Increased risk of problems such as food insecurity and increased risk of damage to vulnerable housing and infrastructure due to climate change. Risks to Māori tribal investment in forestry, agriculture and horticulture sector operations, and tourism.
Disproportionate risk to cultural, social, and economic determinants of health, as well as cascading risks for tribal identity and spiritual wellbeing	Including, loss of biodiversity/tāonga species - impacting cultural wellbeing, relationships with whenua - and also relocating marae, urupa/burial sites and other places of cultural/spiritual significance. Economic determinants, due to heavy investment in climate-sensitive primary industries such as agriculture, fishing, and forestry.

Sources: [52, 88, 100-105]
*While each of the relationships in Table 3 are evidence based, the precise quantitative estimates of these differences are not available for Waitaha Canterbury.

Addressing the inequities faced by Māori and Pacific people is a stated priority for the Aotearoa New Zealand Government [106]. Climate change adaptation planning in Waitaha Canterbury must take into account those aspects which are unique to the context, particularly Te Tiriti o Waitangi, in order to reduce existing Māori health inequities [107]. The impacts for indigenous health (co-benefits/harms) can be highly dependent on individual policy characteristics and contextual factors. Without explicit attention, Māori will be disproportionately affected by climate change [95, 98].

Significant adaptation actions will be needed to manage the health and wellbeing impacts of climate change over the long term; primarily by reducing vulnerabilities, building resilience, and enhancing human capacities, and reducing exposure to its harmful effects, all while paying close attention to Māori health gain, and health and wellbeing equity [36]. There are significant risks that governments will be unable to

[8] This interim report does not attempt to quantify these risks or any relative differences between groups.

uphold Māori interests, values and practices under Te Tiriti o Waitangi, creating new, modern-day treaty breaches [56, 108].

The Rauora framework

Within the Aotearoa New Zealand context, the Rauora Framework (Figure 7) [109] exemplifies the importance of supporting indigenous self-determination and recognising indigenous knowledge as critical foundations for climate change and health solutions [88]. Within the 2022 *Draft National Adaptation Plan* [110], and subsequently, *Aotearoa New Zealand's first national adaptation plan* [111] the Government acknowledged an indigenous worldview of climate change, as described by the Rauora Framework [109]. The Rauora framework was developed by Ihirangi, the operational arm of Te Pou Take Āhuarangi (Climate Lead) for the National Iwi Chairs Forum. The Rauora framework outlines a set of cohesive cultural values and principles from which to approach climate action. It promotes transformative action as a means through which resilience can be strengthened. The principles of balance, interconnectedness, working together and inter-generational equity are outlined and complemented by a set of Māori values. The framework is a foundation from which "iwi, hapū and whānau can apply their own mātauranga-a-iwi (knowledge with an iwi-specific base)" [110, p19]. For the Crown, the framework acknowledges that its Tiriti partners have a worldview that sits outside Western interpretations, and one that the Government has commitments to uphold [110].

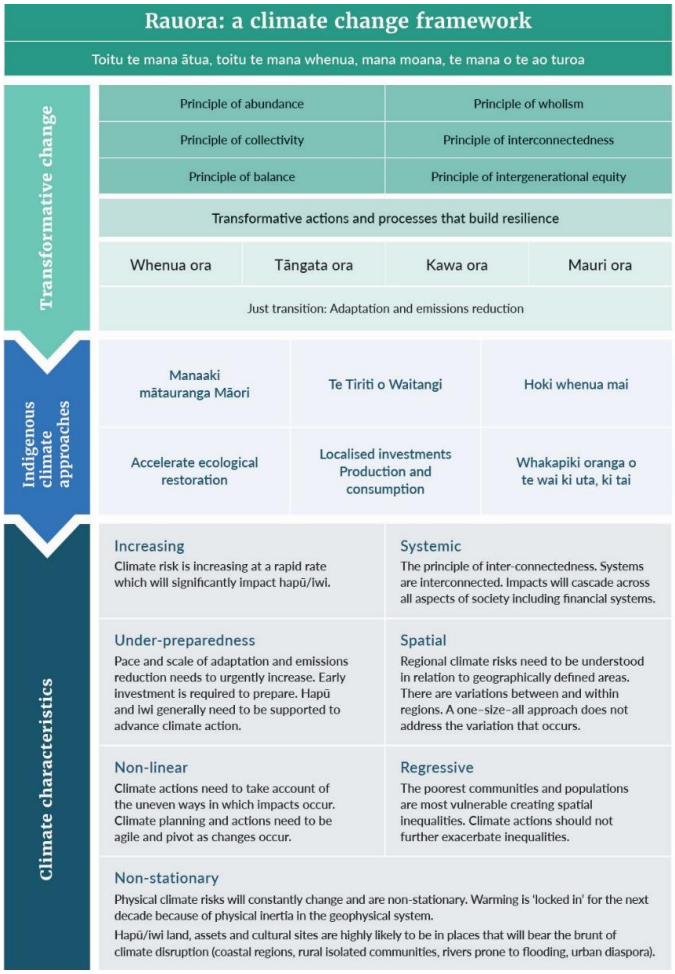


Figure 7: Rauora: a climate change framework

Source: This version copied from *Aotearoa New Zealand's first national adaptation plan* [111] based on the IHIRANGI Rauora framework 2021 Exploring An Indigenous Worldview: Framework for the National Climate Change Adaptation Plan [109]

Policy context overview

More than 25 international, national, regional and local-level treaties, frameworks, protocols, laws, plans and strategies, spanning the last 30-years now directly influence climate policy and implementation in Waitaha Canterbury. The 1992 United Nations Framework Convention on Climate Change [72] is considered the foundational international structure for negotiating climate change agreements. The Convention was signed in 1992 at the Earth Summit in Rio de Janeiro – today more than 190 countries have joined. Convention parties and the various subsidiary groups meet regularly to discuss the implementation of the Convention, including the implications of the latest scientific research, opportunities for collective action, ways to support countries to respond to climate change, and the provision of financial and technological support to help vulnerable countries that need to take action. Subsequent global frameworks, policies and treaties include the Kyoto Protocol (1997)[112], the Paris Agreement (2015) [113], and the Sustainable Development Goals (2015) [114]. An example of local-level action is provided in Box 3, several key Aotearoa New Zealand agreements and strategies [115] are briefly outlined below (Table 4), and a more comprehensive set of international and national frameworks and agreements is presented more fully in Appendix B.

Box 3
Local climate emergency declarations

Locally, on 16 May 2019, Environment Canterbury became the first Council in New Zealand to make a climate emergency declaration; formally dedicating itself to consideration of climate change at the heart of all it does. The following week, the Christchurch City Council declared a Climate and Ecological Emergency and set the greenhouse gas emissions targets of net zero greenhouse emissions by 2045 (excluding methane), and to halve emissions by 2030 compared with 2016-17 levels [1].

Table 4: Key Aotearoa New Zealand legislation, agreements, plans and strategies that can shape the development of effective responses to climate change

Legislation, agreements, plans and strategies	Implications/actions
Climate Change Response Act 2002	Councils must have regard to national adaptation and emission reduction plans. This act established the NZ Climate Commission, which provides policy advice to central government
Local Government Act 2002	Councils must promote social, cultural, economic and environmental wellbeing for current and future residents
New Zealand Coastal Policy Statement 2010	Councils must plan for a minimum of 100-year time horizon and give priority to nature-based response options
Climate Change Response (Zero Carbon) Amendment Act 2019	Sets national emission reduction targets and polices aligned with the Paris Agreement
Resource Management Amendment Act 2020	Councils may now consider greenhouse gas emissions as part of air discharge consents
National Adaptation Plan 2022	Creates a national framework for adaptation and identifies specific roles for councils
Emissions Reduction Plan 2022	Sets greenhouse gas emissions budgets for Aotearoa New Zealand and specific actions for Councils
Pae Ora (Healthy Futures) Act 2022	Provides a clear mandate to work in collaboration on the determinants of health, including work in climate change

Methods

This report highlights interactions between people, the environment, the changing climate, and various mitigation and adaptation options [116]. This is in line with the Health in All Policies (HiAP) approach, an approach promoted by the World Health Organization (WHO) which aims to consider public health across policy sectors [117, 118]. Health impact assessment is 'a process which systematically judges the potential, and sometimes unintended, effects of a project, program, plan, policy, or strategy on the health of a population and the distribution of those effects within the population' [2, p.4]. The findings outlined in this interim report cover the first steps of health impact assessment and are intended to improve decision-making and advocacy to minimise negative health and wellbeing impacts and maximise positive health and wellbeing impacts, to ensure under-recognised health concerns are highlighted, and to promote Hauora Māori and health and wellbeing equity [65, 119, 120]. Climate policies in all sectors can have significant impacts on population health and wellbeing.

The assessment of health impacts generally follows a step-by-step approach

Given the complexity of climate change, a step-by-step structured approach is needed to assess health impacts and add knowledge about specific health and wellbeing outcomes[9]. The structured approach primarily examines exposure-response relationships (under a changing climate) and provides relevant findings for decision makers. In particular, the approach considers the wider determinants of health and any potential co-benefits and/or unintended impacts of climate policies [118].

Exposure-response relationships and specific health and wellbeing outcomes can be studied using a step-wise process [120-122], for example:

1. Screening (possible risks)
2. Scoping (vulnerability, profiling of climate, region and population)
3. Assessment of impacts and reporting (quantifying)
4. Decision-making and recommendations
5. Evaluation, monitoring and follow-up [119, 121].

Steps not included in this interim report.

Screening

The scope and extent of climate-related health impacts is strongly influenced by location, and it is important that strategies to adapt to climate change are formulated at the Waitaha Canterbury/local level. This step includes a preliminary consideration of links between climate change and determinants of health and factors affecting vulnerability to climate-related health and wellbeing effects. Exposure, sensitivity and adaptive capacity are the three fundamental elements that contribute to overall vulnerability and it is critical that stakeholders have a shared understanding of these elements. An understanding of vulnerability helps to ensure that adaptation strategies target vulnerable groups and reduce potential inequities with respect to the health and wellbeing burden of climate change [121].

Working tables 14 to 19 list variables potentially affected by climate change that can affect human health and wellbeing. The tables help to establish a common understanding of the many health and wellbeing impacts that may be considered during planning processes. The available resourcing may not allow the full consideration of all listed impacts, and some impacts may not be relevant for some locations.

[9] Several international standards set out the principles and requirements for health impact assessment, including key guidelines from the ISO; Australian Standards®; and the New Zealand Ministry for the Environment: – ISO 14090:2019 Adaptation to climate change - Principles, requirements and guidelines – ISO 14091:2021 Adaptation to climate change - Guidelines on vulnerability, impacts and risk assessment – AS 5334:2013 Climate change adaptation for settlements and infrastructure - A risk-based approach – New Zealand Ministry for the Environment, 2020, National Climate Change Risk Assessment (NCCRA).

Scoping

The scoping phase identified the key concepts, populations, and sources of data, for consideration in this project, including:

- a preliminary consideration of links between climate change and determinants of health, and
- factors affecting vulnerability (exposure, sensitivity, and adaptive capacity, see below) to climate-related health and wellbeing effects.

Scoping considers input from many sources, including preliminary literature searches and IPCC reports. It is not practical (or possible) to address all the direct and indirect health effects that are theoretically possible and relevant to Waitaha Canterbury, therefore, the selection of the main issues was informed by the literature, along with priorities that had been raised by stakeholders. Generally, scoping involves the consideration of the potential severity of health effects, the size and likelihood of the effects, and the potential of the effects to exacerbate health and wellbeing inequities. Future iterations of this report may result in changes in the final list of issues included (carried forward for further analysis), based on stakeholder input and further research.

Table 5 categorises the potential determinants of health/effects of climate change into nine main groups, collated from multiple sources, and based on the World Health Organization's definition of health (Box 4). The table lists an extensive range of potential health and wellbeing impacts that may be considered during the process. However, available resources did not enable a full consideration of all listed impacts and some of the listed impacts are less relevant for Waitaha Canterbury. Therefore, the climate-related impacts of most concern for the population being considered have been short-listed in this initial report, and/or carried forward for more detailed risk assessments in future stages of this project.

Box 4

Health

"Health is a resource for everyday life, not the objective of living. Health is a positive concept emphasizing social & personal resources, as well as physical capabilities"

Source: WHO. The Ottawa Charter for Health Promotion; 1986; Ottawa. World Health Organization

Table 5: Indirect and direct effects of climate change

Direct Effects of Extreme Climate Events	
1. Physical hazards (i.e., primary health effects/risks include death, injury, and/or loss of public welfare) that may result directly from extreme climate events including: • drought • heat waves • wildfire • wind and storms • heavy rainfall • flooding • landslides • sea level rise • coastal inundation • increased ultraviolet radiation • decreased air quality	
Indirect effects of climate change	
2. Environmental • Air quality • Water quality • Soil quality • Food contamination/availability/supply • Pathogens • Vector-borne disease factors /vermin • Changes to intermediate-host ecology • Broader environmental issues (CO_2 emissions) • Food production—crops and animals (e.g., undernutrition related to disruption of food production and water supply, including access to drinking and irrigation water) • Visual amenities (green space, coastline)	3. Ecological • Loss of habitat • Impacts on plant diseases, pests, weeds • Physical changes to land—coastline, rivers, erosion, landslides • Changes to groundwater levels • Flora and fauna—change in distribution • Increases in toxin-producing organisms
4. Socio-economic • Employment • Occupational health and safety (e.g., heat stress) • Social networks • Local business • Economic issues (poverty and disadvantage increased; diverse health consequences of livelihood loss) • Crime • Housing • Population changes	5. Psychosocial • Risks of dis-information •Mental health—control over life, stress, anxiety • Community wellbeing • Social conflict (consequences of tension and conflict – domestic and international – owing to climate change-related declines in basic resources) • Effects of aesthetic and cultural impoverishment • Effects on child development (e.g., mental health impacts, effects on learning) • Social change and population displacement/migration to Aotearoa New Zealand
6. Lifestyle • Exercise • Diet • Health behaviour • Alcohol/drugs	7. Technological • Accidents (mechanical, chemical, etc.) • Fire, explosions • Waste treatment
8. Services • Resource availability • Access to emergency services • Routine access to health services (the ability of the health system to respond to any increased population health needs –in any future circumstance – might be limited by the degradation of infrastructure and by the economic stressors that climate change brings) • Routine access to other services (e.g. schools, shops, transport, social services)	9. Infrastructure • Energy • Transport • Telecommunication • Water • Waste

Sources: [29, 38, 42, 56, 80, 121, 123-125]

Populations of Concern

Climate change acts at many levels and with varying impacts on health and wellbeing outcomes. Across Waitaha Canterbury, people and communities differ in their exposures, their inherent sensitivity, and their adaptive capacity to respond to and cope with climate change-related health threats. Many determinants of health interact with climate factors to affect health risks. Some groups face several stressors related to both climate and non-climate factors [29, 30, 62]. In general, climate change plays a multiplier role, typically amplifying or extending a population's pre-existing health risks or problems, along with the introduction of new risks (e.g., vector borne disease)[10].

Estimation of population sensitivity to climate change-related stressors requires the evaluation of many factors: including reviewing the population data and indicators to obtain a population profile for the geographical area of interest; identifying and describing the sensitivity of each identified population sub group to each climate change-related stressor; evaluating the level of exposure of each population sub group to each climate hazard (and combinations of exposure/groups); and finally combining population sensitivity and exposure to determine and describe priority population sub-groups or populations of concern. Note that not all of these steps have been systematically applied to the population of Waitaha Canterbury at this stage of the project, however, a list of commonly-identified populations of concern is presented in Table 6. While the list is not exhaustive, these populations of concern are those most commonly identified and discussed in reviews of climate change health and wellbeing impacts; based on the evidence presented in the peer-reviewed literature. Multiple factors, all with some degree of uncertainty, will determine geographic vulnerability across Waitaha Canterbury. Further, none of these groups are homogeneous – individuals have differential resources, knowledge, social, human and financial and capacities with which to adapt.

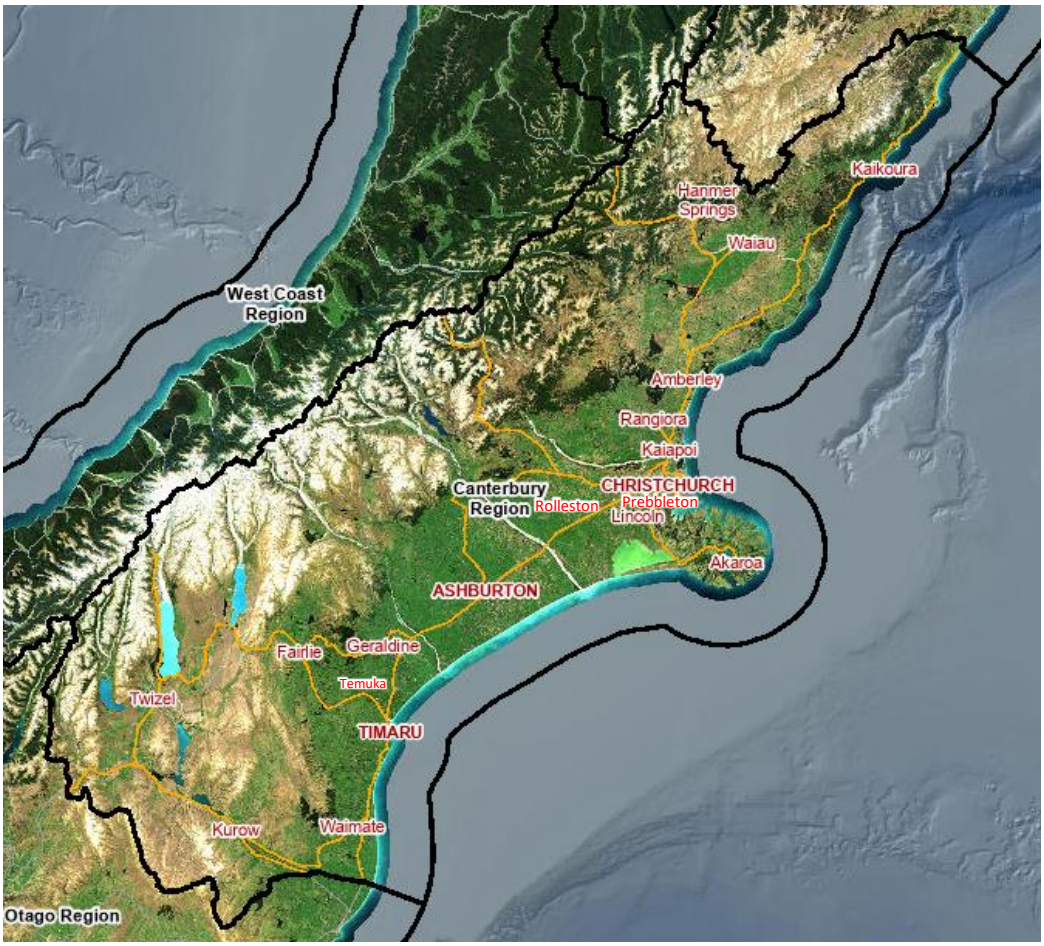
[10] A variety of other factors will also influence these health problems and may have greater impacts than climate change, however, the multiplier effect will generally apply.

Table 6: Non-exhaustive, non-prioritised, commonly identified populations of concern; with respect to the effects of climate change on health

Group	Rationale/issues
Those with low income/ socioeconomically disadvantaged populations	The greatest health burdens related to climate change are likely to fall on those with the least socioeconomic advantage. Most affected are individuals with inadequate shelter or resources to find alternative shelter in the event their community is disrupted.
Indigenous peoples (+ some overlap with immigrant groups/ culturally/linguistically diverse backgrounds)	Hapu/iwi populations have increased vulnerabilities to climate change because of several compounding factors, including: living close to the coast, or in isolated or socioeconomically disadvantaged communities, pre-existing health conditions; existing impacts of colonisation; may have poorer access to expertise and data; may have poor existing physical infrastructure; may have multiply owned land base/restrictions on use/loss of traditional homelands and territories; may be heavily invested in primary industries; may have a high volume of inadequate housing; may be already be experiencing environmental stress; may be less involved/included in national and regional decision making/policy setting (noting that many of these factors are likely to be true for some individuals, but not necessarily for Māori as a whole.
Children	Children are susceptible to dehydration which generally makes them more vulnerable to heat-related morbidity and mortality. Children are especially vulnerable to a variety of infectious diseases including water- and food-borne diseases. Children may also be more vulnerable to psychological complications of extreme weather events related to climate change. General life stage impacts, and lower adaptive capacity/less able to prepare or respond to changes.
Young people	More likely to be anxious about the future
Older adults	Older adults are more sensitive to temperature extremes, particularly heat. The elderly are also more likely to have pre-existing medical conditions, including cardiovascular and respiratory illnesses as well as limited mobility, which may put them at greater risk of severe morbidity or mortality from climate-related events or conditions.
Pregnant women	Pregnant women are likely to be more susceptible to adverse health effects in the aftermath of extreme weather events, due to the impacts of environmental toxins, limited access to safe food and water, psychological stress, and disrupted healthcare access
Persons with disabilities	People with mobility and cognitive constraints may be at particular risk during heat waves and other extreme weather events.
Persons with pre-existing or chronic medical conditions	People with chronic medical conditions have an especially heightened vulnerability for the health impacts of climate change. Those with chronic medical conditions are also at risk of worsened status as the result of stressors and limited access to medical care during extreme events.
People living or working in at-risk locations	People living in socioeconomically disadvantaged urban or isolated rural areas, floodplains, coastlines. Subject to isolation and disruption of services due to extreme weather, and to social and economic stressors.
Occupational Groups	Certain occupational groups, primarily by virtue of spending their working hours outdoors, are at greater risk of climate-related health outcomes. Outdoor workers in rural or suburban areas, such as construction, electricity, and utility workers. Outdoor workers have increased exposures to air pollution and heat stress, especially if work tasks involve heavy exertion. Volunteers and first responders are also at greater risk.
Other	Those living in specific geographical areas such as, isolated rural areas, floodplains, coastlines, and other at-risk locations subject to extreme weather and persistent climate change effects.

Profile of Waitaha Canterbury

This section provides general information on the climate scenario being considered, the local environment (natural and built), and the Waitaha Canterbury (Figure 8) community/population. Information for temperature and rainfall patterns, sea-level rise and extreme weather events relevant to Waitaha Canterbury have been included. The basic characteristics of the natural and built environment are described including the topography, specific features, and areas of human settlement. This includes brief descriptions of the populated areas that are potentially more exposed to the impacts of climate change. The profile of the local community includes population demographics, and some health information for selected climate-sensitive health outcomes, and health inequities.



Source: Canterbury Maps Viewer mapviewer.canterburymaps.govt.nz/

Figure 8: Waitaha Canterbury region of Aotearoa New Zealand

Waitaha Canterbury region of Aotearoa New Zealand is located in the central-eastern South Island. The region covers an area of approximately 44,503 square kilometres, making it the largest region in the country by area. The population of Waitaha Canterbury is approximately 650,000 (estimated, June 2022) [126] which gives an overall population density of approximately 15 people per km^2. The region is home to 12.8% of Aotearoa New Zealand's population [126]. There are approximately 225,000 occupied private dwellings in the region. Christchurch is the South Island's largest city and the country's second-largest urban area, and home to 58 percent of the region's population. Other major towns and cities include Timaru, Rolleston, Ashburton, Rangiora, and Kaiapoi. One significant characteristic of the built

environment is the Waitaki hydro scheme. The hydroelectric power scheme consists of eight power stations from Lake Tekapo to Lake Waitaki, along with six canals totalling 56 kilometres, and about 50% of Aotearoa New Zealand's hydroelectric storage. The scheme generates energy from water flowing from the Southern Alps and the scheme is critical to Aotearoa New Zealand's electricity supply.

Climate change in Aotearoa New Zealand and Waitaha Canterbury

The 2021 Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) [34] puts greater emphasis on regional information in order to better understand the context for both impacts and responses. The report provides distilled and summarised technical information and climate change projections relevant to Aotearoa New Zealand, from the Working Group I report titled 'The Physical Science Basis' [127] (Table 7 & Table 8). A limited number of downscaled Canterbury specific projections are also available from the Ministry for the Environment's 2018 report [128] based the on the IPCC's 2013 AR5 data [37].

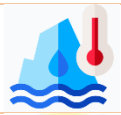
Canterbury-specific projections are imperfect, because directly applying global climate predictions to local scales is challenging due to the limited representation of spatial detail on local scales, which cannot reflect some geographical and topographical features. However, further updating of regional climate change projections for Aotearoa New Zealand is underway, with new projections to be published by the World Climate Research Programme (WCRP) in 2024 with the release of the 'CMIP6' [129] global model. Until the CMIP6-based regional downscaling is completed, regional climate model projections reported by the Ministry for the Environment in 2018 [128] can continue to be used with reasonable confidence (Table 7 for Canterbury-specific and Table 8 for all of Aotearoa New Zealand). However, strong inter-annual variability may still occur. In addition, NIWA is undertaking extensive research and modelling of national and regional flooding hazards. This five-year NIWA-led research programme will develop a system to map flood hazard consistently across the whole country. It will reveal how flood risks might change over the next 100 years because of changes to rainfall and sea level from climate change, as well as due to land-use changes [130]. The current model estimates that mean temperature will increase for Aotearoa New Zealand (relative to the 1986-2005 period) by 1.6°C by 2110 [34, 37, 52]. In Aotearoa New Zealand, annual average temperatures have already risen 1.1°C, above pre-industrial levels [56, 131], and coastal sea level records show an average increase of 1.8 mm per year between 1900 and 2018, increasing to 2.4 mm/year from 1961‑2018, mostly due to climate change [132]. Both temperature and sea level are expected to continue to rise. The IPCC [Australasia] report concludes that increased atmospheric warming is 'almost certain' for Aotearoa New Zealand as the 21st century progresses [52, 133].

These changes in average temperature will have large effects on the likelihood and frequency of future extreme weather events [133] and local and regional differences in the type and extent of the consequences are expected [32]. In Aotearoa New Zealand, populations living in different social, economic, and physical conditions will be affected differently by climate changes. Low-income and remote populations are typically more vulnerable to physical hazards, undernutrition, infectious diseases, and the health and wellbeing consequences of displacement [30].

Table 7: Waitaha Canterbury climate change projections

	Key climate change projections for Waitaha Canterbury
	Average number of 'hot days' per year (maximum temperature ≥25°C) is predicted to increase: Canterbury, present 27 up to 62 by 2100 and 'cold nights' (minimum temperature of 0°C or below), 46 reducing to 9 by 2100.
	Daily extreme winds increase in eastern regions especially Canterbury, increases of up to 10 per cent or greater by the end of the century. Cyclones are likely to occur at a similar frequency, but tropical cyclones will likely be stronger and cause more damage when making landfall. However, there is low confidence for Canterbury-specific projections.
	Mean precipitation: substantial variation around the country but a pattern of annual precipitation changes where there is a west-east gradient in rainfall, with the largest increases in the west of the South Island, and the largest decreases in the east including North Canterbury. Winter decreases for Canterbury (Christchurch and Hanmer) and increases for Tekapo.
	Sunshine Hours: Increases of up to 10 per cent on the West Coast in summer, and smaller increases elsewhere with notable exception of the coastal Canterbury where sunshine is predicted to decrease. The reduced summer sunshine levels in coastal Canterbury are consistent with increased rainfall there.
NOTE: The regional climate model projections reported in Ministry for the Environment (2018): Climate Change Projections for Aotearoa New Zealand can continue to be used with reasonable confidence pending further updates likely to be published in 2024	

Table 8: New Zealand climate change projections

	Key climate change projections for Aotearoa New Zealand
	The mean global warming from 1850-1900 levels to 2011-2020 levels is 1.09°C An increase of mean air temperature of +3.1°C (2.20 to 4.05°C 10-90 percentile range) relative to 1995-2014, is predicted by end century under the high-emissions 'SSP5-8.5' 'business as usual' 'no-policy' baseline global warming scenario. Evidence of observed changes in extreme weather events and their attribution to human influence has strengthened since the IPCC's Fifth Assessment Report (AR5) in 2018.
	Annual rainfall patterns are expected to change, with increases projected in the west and south of Aotearoa New Zealand. Projected winter and spring rainfall follow the annual increase in the west and south, but with less rainfall in the east and north. More summer rainfall is expected in the east of both islands, with less in the west and central North Island.
	Cyclones: according to the IPCC's 2013 AR5 report [134] it is considered likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged over the 21st century. However, maximum wind speeds and rainfall rates will increase (i.e., similar frequency but tropical cyclones will likely be stronger and cause more damage when making landfall).
	River flooding, drought severity and fire weather are projected to increase in most areas of the country.
	Glaciers: Relative to 2015, glaciers in Aotearoa New Zealand are projected to lose between 33% and 77% of their mass by the end of the century If emissions are high in the future
	Marine heatwaves: If emissions are high in the future, median marine heatwave intensities could increase between 80 and 100% by the end of the century and conditions that we refer to as marine heatwaves today could become permanent year-round by the end of the century.

Source: [128, 134]

Waitaha Canterbury – Statistics NZ | Tatauranga Aotearoa place summary

The area administered by the Canterbury Regional Council consists of all the river catchments on the east coast of the South Island from that of the Waiau Toa / Clarence River, north of Kaikōura, to that of the Waitaki River, in South Canterbury. The area is commonly divided into North Canterbury (north of the Rakaia River to the Conway River), Mid Canterbury (from the Rakaia River to the Rangitata River), South Canterbury (south of the Rangitata River to the Waitaki River) and Christchurch City. Christchurch City is the South Island's largest city (approximately 60 percent of Waitaha Canterbury's population) and other major towns and cities are listed in Table 9, ranked by size.

Table 9: Largest cities or towns in Canterbury Statistics New Zealand June 2022 estimate

Rank	City/Town	Population	Notes
1	Ōtautahi Christchurch	377,900	The largest city in the South Island, lies on the South Island's east coast, just north of Banks Peninsula on Pegasus Bay.
2	Timaru	28,600	A significant port city in southern Canterbury, located 157 km southwest of Christchurch and 196 km northeast of Dunedin.
3	Rolleston	28,000	Largest town in the Selwyn District, in the Canterbury region, located on the Canterbury Plains 22 km south-west of Christchurch, and is part of the wider Christchurch metropolitan area. Previously considered a satellite town of Christchurch.
4	Ashburton	20,600	Largest town is the Ashburton District located 85 km south west of Christchurch, sometimes regarded as a satellite town of Christchurch, is the centre of an agricultural and pastoral farming district.
5	Rangiora	19,700	Largest town of the Waimakariri District, in Canterbury, located 29 km north of Christchurch, part of the Christchurch metropolitan area.
6	Kaiapoi	13,400	A satellite town of Christchurch located in the Waimakariri District 17 km north of central Christchurch, close to the mouth of the Waimakariri River.
7	Lincoln	9,180	Located in the Selwyn District, 22km south of Christchurch, home to Lincoln University (agricultural tertiary institution).
8	Prebbleton	5,260	Small town 11 km southwest of the centre of Christchurch and about 2 km south of the outlying industrial suburb of Hornby.
9	Temuka	4,660	Located 15 km north of Timaru and 142 km south of Christchurch; a service town to the sheep and dairy farming region.
10	Waimate	3,600	Small town located in the Waimate district 45.7 km south of Timaru

Source: Statistics New Zealand June 2022 estimate [126]

Population counts for Waitaha Canterbury Region

The population pyramids shown in Figure 9 and Figure 10 illustrate the age distribution of a population in the Waitaha Canterbury region, using 2018 Census resident population count data. The pyramids compare the age structure of the population groups, in this case, overall population (all ethnicities) and Māori (Figure 10) and by sex at birth.

Figure 9: Population counts, all ethnicities, by age and sex, Waitaha Canterbury region, 2018 Census

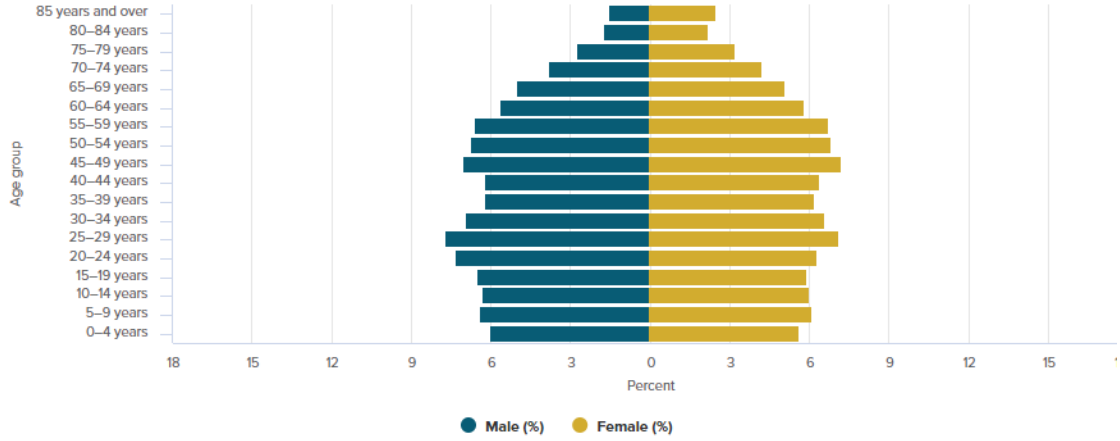
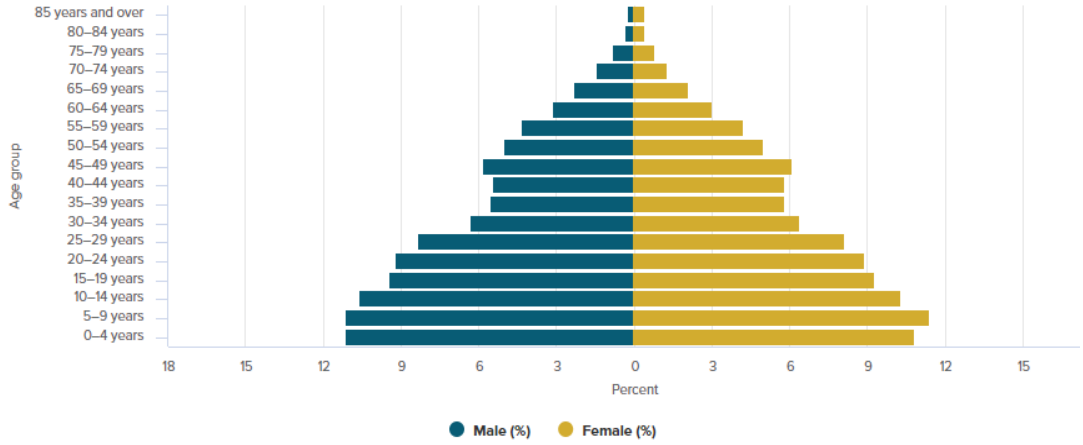


Figure 10: Population counts, Māori, by age and sex, Waitaha Canterbury region, 2018 Census



	All ethnicities*	Māori
Number of people	599,694	56,298
Median age	38.7 years	24.4 years

*Overall population

The figure shows that in 2018, the Māori ethnic group had a markedly different age structure from the total population in Waitaha Canterbury. In 2018, the Māori ethnic group had a substantially younger population, with approximately half of Māori aged from 0 to 24 years. The younger age structure of the Māori ethnic group reflects both higher birth rates and lower life expectancy.

Table 10 presents the Census usually resident population for Waitaha Canterbury and Aotearoa New Zealand, by ethnic group (total responses), 2018.

Table 10: Census usually resident population for Waitaha Canterbury region and Aotearoa New Zealand, by ethnic group (total responses), 2018

Category	Canterbury Region (%)	New Zealand (%)
European	82.4	70.2
Māori	9.4	16.5
Pacific peoples	3.2	8.1
Asian	11.1	15.1
Middle Eastern/Latin American/African	1.2	1.5
Other ethnicity	1.4	1.2

The table shows that at the time of the 2018 Census, the European ethnic group was the largest in the Waitaha Canterbury area, with 82.4 percent of the usually resident population identifying as being of European ethnicity. Over nine percent of the Waitaha Canterbury population identified as being of Māori ethnicity and 11.1 percent identified as being of Asian ethnicity. Pacific, Middle Eastern/Latin American/African (MELAA) and Other ethnicities were identified by 3.2 percent, 1.2 percent, and 1.4 percent of the population, respectively. When compared with New Zealand overall, Waitaha Canterbury had smaller proportions of residents identifying as being of Māori, Pacific, Asian or MELAA ethnicity.

Work

Tables 11 and 12 present the work and labour force status for people aged 15 years and over in Waitaha Canterbury, 2018 Census.

Table 11: Work and labour force status for people aged 15 years and over in Waitaha Canterbury region, 2018 Census

Category	2018 (%)
Employed full-time	51.1
Employed part-time	15.5
Unemployed	3.2
Not in the labour force	30.2

Table 12 presents the broad categories of occupations for people aged 15 years and over in Waitaha Canterbury and Aotearoa New Zealand, according to the 2018 Census.

Table 12: Occupations for people aged 15 years and over in Waitaha Canterbury region and Aotearoa New Zealand, 2018 Census

Category	Canterbury Region (%)	New Zealand (%)
Managers	17.6	18
Professionals	20.8	23
Technicians and trade workers	13.9	12.1
Community and personal service workers	9.4	9.5
Clerical and administrative workers	10.6	10.9
Sales workers	9.3	9.2
Machinery operators and drivers	6.7	6
Labourers	11.7	11.3

Health profile: chronic health conditions that may be sensitive to climate change

As noted above, several climate-related hazards threaten the health of people with chronic medical conditions. Chronic conditions are an important global, national, and individual health concern [135, 136]. The self-reported prevalence of hypertension, stroke, diabetes, asthma, ischaemic heart disease, and mood and/or anxiety disorder for the general adult population, and for Māori in Waitaha Canterbury, are presented in Appendix A - sourced from the 2021/22 New Zealand Health Survey[11] (NZHS). The NZHS provides 'snap shot' information about the health and wellbeing of New Zealanders, as well as time-series information describing overall trends. However, the time-trend data cannot be used to establish causality, or to describe direct relationships with climate change variables, as changes to the prevalence of these health conditions will be influenced by many determinants (including climate change).

Like other environmental stressors, climate change can be expected to have differential effects on different subpopulations, depending on a variety of susceptibility factors [137]. Biological sensitivity, socioeconomic factors, geography, and adaptive capacity may each contribute to heightened risk for climate-sensitive health outcomes [138] and these factors are likely to vary considerably across Waitaha Canterbury. The climate-sensitive health and wellbeing priorities are likely to vary across geographical areas and may cluster together. Clusters are important as they may be highly amenable to large improvements in health and wellbeing outcomes through relatively simple shifts in healthcare delivery [136]. Overall, the burden from climate-sensitive health conditions is projected to increase [137].

Activity limitations

Activity limitations was a new output topic in the 2018 Census. A person is regarded as disabled if they have 'a lot of difficulty' or 'cannot do at all' one or more of the six activities in the activity limitations questions (walking, seeing, hearing, cognition, self-care, and communication). These six questions are the *Washington Group Short Set* of questions on disability and they were designed for use with the general population. Table 13 presents self-reported activity limitations, by age, for Waitaha Canterbury compared with Aotearoa New Zealand overall, overall population (all ethnicities) and Māori, using 2018 Census data.

Table 13: Activity limitations, by age, Waitaha Canterbury region compared with Aotearoa New Zealand, overall population (all ethnicities) and Māori, 2018 Census

All ethnicities	Canterbury (%)	New Zealand (%)	Māori	Canterbury (%)	New Zealand (%)
Under 15 years	2.8	3	Under 15 years	4.1	4.3
15–29 years	3.4	3.5	15–29 years	5.3	5.3
30–64 years	4.5	4.8	30–64 years	7.5	8.7
65 years and over	17.1	17.7	65 years and over	21.9	24.8

The table shows that at the time of the 2018 Census, for those 65 years and over, approximately 17 percent of the usually resident population, all ethnicities, in Waitaha Canterbury indicated that they had 'a lot of difficulty' or 'cannot do at all' one or more of the six activities in the activity limitations questions (similar to New Zealand overall). Approximately 22 percent of the usually resident Māori population of Waitaha Canterbury (65 years and over) indicated that they had an activity limitation (lower than for Māori across New Zealand overall, 24.8%).

[11] The New Zealand Health Survey is a continuous survey, enabling the publication of annual updates on the health of New Zealanders. Many of the indicators in the New Zealand Health Survey ask the respondent to recall their experiences from the past 12 months.

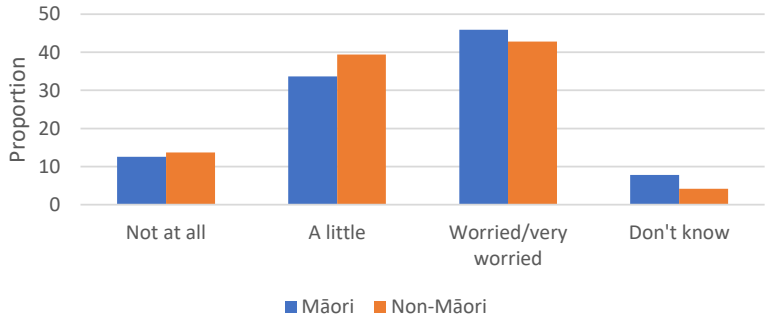
Climate change impacts: public understandings and attitudes

Climate change impacts will be experienced most intensely at the local level [139] and communities have local knowledge of their social, political, economic, and environmental circumstances which can inform responses to climate change impacts [140]. Several questions in the 2020 Canterbury Wellbeing Survey [141][12] asked greater Christchurch residents about their 'impressions of climate change' (beliefs, values, perceptions, knowledge, awareness, opinions and concerns). The figures below show respondents' level of concern about climate-related impacts, their consideration of sustainability in their consumption choices (what they do, buy, use), their impressions of the impact that climate change might have on the health of people in New Zealand, and their impressions of community preparedness.

Concern about climate change

Figure 11 presents respondents' level of concern or worry about the impact of climate change. The figure presents the level of personal worry indicated by non-Māori and Māori respondents to the 2020 Canterbury Wellbeing Survey (those aged 18 years and over). Respondents were asked to indicate whether they were *not at all* worried, *a little* worried, or *worried/very worried* about the impact of climate change (or *don't know*).

Figure 11: Extent of worry about the impact of climate change, in greater Christchurch, 2022



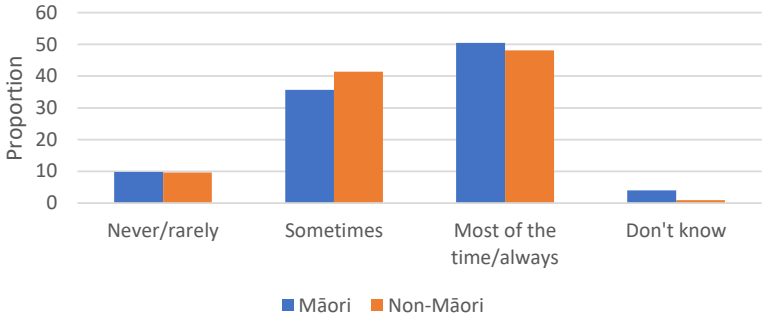
Most respondents indicated that they were either *a little* or *worried/very worried* about the impact of climate change (*a little*: non-Māori 39.4%, Māori 33.7%; and *worried/very worried* non-Māori 42.8%, Māori 45.9%). Approximately 14 percent of non-Māori respondents and 12.6 percent of Māori respondents indicated that they were *not at all* worried about the impact of climate change (few respondents selected *don't know*). The differences shown between Māori and non- Māori are not statistically significant.

[12] A representative, serial, cross-sectional survey that is repeated annually and gathers self-reported wellbeing data to supplement the monitoring of wellbeing in greater Christchurch. The sample size is approximately 2,500 residents 18 years and over.

Consumption choices

Figure 12 presents the extent to which Canterbury Wellbeing Survey respondents consider sustainability and the environment when making choices about what to do, buy, or use in their daily lives. The figure presents the level of consideration indicated by non-Māori and Māori respondents to the 2020 Canterbury Wellbeing Survey (those aged 18 years and over). Respondents were asked to indicate whether they considered sustainability and the environment: *never/rarely*, *sometimes*, or *most of the time/always* (or *don't know*).

Figure 12: Frequency of considering sustainability and the environment when making daily choices, in greater Christchurch, 2022

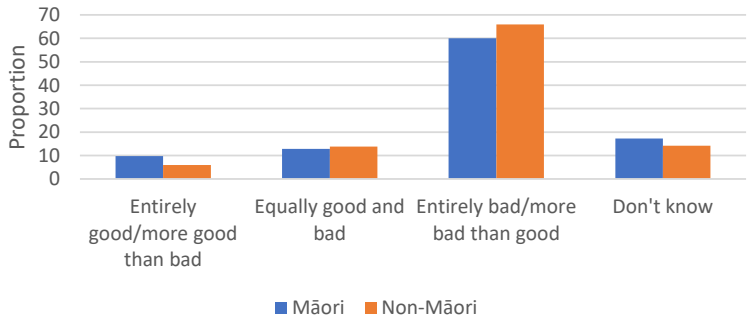


Most respondents indicated that they consider sustainability when making choices about what they do, buy, or use in their daily lives (*sometimes*: non-Māori 41.4%, Māori 35.7%; and *most of the time/always,* non-Māori 48.1%, Māori 50.5%). Approximately 10 percent of non-Māori and Māori respondents indicated that they *never/rarely consider* sustainability when making choices about what they do, buy, or use (less than 5% selected *don't know*). A higher proportion of Māori respondents indicated that they consider sustainability *most of the time/always* compared with non-Māori.

Climate change and health

Figure 13 presents Canterbury Wellbeing Survey respondents' impressions of the impact that climate change might have on the health of people in New Zealand. The figure presents the impressions of non-Māori and Māori respondents to the 2020 survey (those aged 18 years and over). Respondents were asked to indicate whether they consider the impacts on health will be *entirely good/more good than bad*, *equally good and bad*, or *entirely bad/more bad than good* (or *don't know*).

Figure 13: Impression of the impact of climate change on the health of people in New Zealand, in greater Christchurch, 2022



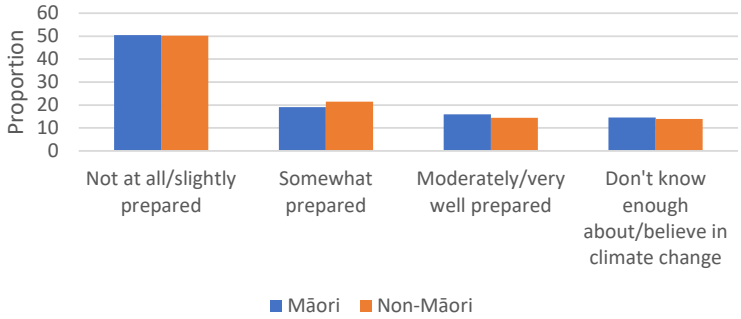
The figure clearly indicates that most respondents think climate change will likely exert a net negative impact on the health of people in New Zealand. Approximately 66 percent of non-Māori and 60 percent of Māori respondents indicated that they think the impacts will be *entirely bad/more bad than good*. Less than 10 percent of respondents indicated that they think the impacts will be net positive (*entirely good/more good than bad;* non-Māori 6%, Māori 9.8%). Approximately 14 percent of non-Māori and 13

percent of Māori respondents indicated that the impacts will be *equally good and bad* (similar proportions indicated that they *don't know*). The differences shown between Māori and non- Māori are not statistically significant.

Climate change preparedness

Figure 14 presents the respondents to the 2022 Canterbury Wellbeing Survey (non-Māori and Māori aged 18 years and over) rating of their communities' level of preparedness to plan for and respond to the impacts of climate change. Respondents were asked to select from four response options: *Not at all/slightly*, *Somewhat*, or *Moderately/very well prepared*, or *Don't know enough* or *don't believe in climate change)*.

Figure 14: Impression of community preparedness to plan for and respond to the impacts of climate change, in greater Christchurch, 2022



The figure shows an overall impression of a lack of climate change preparedness at the local level. Approximately half of all respondents indicated that their community is currently *not at all* or only *slightly prepared* to plan for and respond to the impacts of climate change. Just fourteen percent of non-Māori respondents and 16 percent of Māori respondents in greater Christchurch indicated that their community is *moderately* or *very well prepared* to plan for and respond to the impacts of climate change. Approximately 20 percent of respondents indicated that their community is *Somewhat prepared*; and less than 15 percent of respondents indicated that they either *Don't know enough or don't believe in climate change.*

Summary

Most respondents to the 2022 Canterbury Wellbeing Survey indicated that they personally worry about the impact of climate change and that they consider sustainability and the environment when making choices about what they do, buy, or use in their daily lives. While most respondents think climate change will exert a net negative impact on the health and wellbeing of people in New Zealand, few think their community is sufficiently prepared to plan for and respond to the impacts of climate change.[13]

[13] A separate analysis has shown a clear positive relationship between perceived climate change preparedness and age. Lower proportions of respondents from younger age groups reported that their community is moderately or very well prepared to plan for and respond to the impacts of climate change (data not shown, Canterbury Wellbeing Survey, in print). This result appears relevant to intergenerational equity.

Impacts, population groups and responses

Flooding, Storms and Extreme Winds

The impacts of climate-related hazards on human health and wellbeing are complex and compounding, with many inter-related causal pathways. Table 14 is focused on the impacts of flooding, storms, and extreme winds. The infrastructure, economic, biodiversity and direct impacts of flooding, storms and extreme winds are noted in the first column (e.g., housing and communities). These impacts are used to inform the focus of the content explored in 'Te Ao Māori lens' and the 'Health / Wellbeing Impact' columns. The 'Most Affected Population Groups' column outlines some of the population groups that are more likely to be impacted by the climate-related hazard. It is important to note that these population groups are largely similar across the hazards and impacts. Finally, possible adaptive and mitigating responses can be found in the last column, all of which are directly or indirectly beneficial to health and wellbeing.

Note and Acknowledgement – The 'Te Ao Māori lens' column of the table below draws on the report: He huringa āhuarangi, he huringa ao: a changing climate, a changing world*, prepared for Ngā Pae o te Māramatanga by Manaaki Whenua - Landcare Reaseach.*

Table 14: Impacts, population groups and responses – Flooding, Storms and Extreme Winds

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Housing and communities	Loss of coastal land, urupā, marae, and other sites of cultural significance due to flooding may impact Māori cultural, spiritual, and mental wellbeing [68].	Damp and water-damaged homes can lead to mould and poor air quality, causing respiratory health issues including asthma, respiratory infections, and rheumatic fever [43]. Damp and water-damaged homes are expensive for families to heat and dry, and the quality of housing that people live in further exacerbates existing health inequities [142]. Displacement, damage and loss of housing from flooding, storms or extreme wind are associated with overall poor mental health outcomes including Post Traumatic Stress Disorder, anxiety, depression and increased risk of suicide [143, 144]. Living in a flood-zone and anticipating potential flooding can also cause general mental distress, depression, anxiety and sleep disturbance [142]. Lack of emergency planning or shelter for family animals and pets can negatively impact wellbeing and	People living in a flood zone Emergency response workers and volunteers Children Older Adults People with physical health needs People with mental health needs Disabled people Low-income households Homeowners without insurance/ under-insured Business owners Displaced residents / communities [150]. People living in social housing	Adapting or relocating existing cultural infrastructure will be necessary to protect these cultural places, and the overall cultural, spiritual, and mental wellbeing of Māori [151]. Encouraging and enhancing social connectedness, social cohesion, and social networks in a community ensures greater community resilience and protects against the worst health and wellbeing outcomes from climate change. Strong community ties can provide closer monitoring, assistance, and support to community members who will be most affected by climate change [67]. New housing and infrastructure needs to be designed to be resilient to the changing climate. This may mean changes to land-use policies as well as

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		also strongly influence decision-making of households. In New Zealand, 64% of households have at least one companion animal [145], and often emergency accommodation or temporary accommodation post-flood or storm event may not allow pets. [146]. Crowding of emergency relief centres from displaced residents can also impact health, including increased risk of infectious diseases [4]. Stress from the loss of housing and housing issues can result in an increase in tobacco, alcohol and other substance use, increase in medication need and use [143]. Stress from the loss of housing and housing issues can result in an increase in family violence [4]. Homeowners in flood-zones or flood prone areas can experience financial insecurity as insurance companies become more risk-adverse to insuring flood-prone areas; some properties may become uninsurable [142, 144, 147]. Renters and tenants living in social housing can struggle to find suitable accommodation post-flood or storm, if their house is damaged in a flood event. In the recent Auckland flood, tenants in Kāinga Ora homes have had to remain in their damaged houses after the event, as there is high demand and limited alternative housing available [148]. No insurance or under-insurance may impact homeowners' ability to sell their property and successfully relocate, causing financial stress and considerable mental distress [142]. On-going flooding or risk of flooding may cause a lack of investment into an area, or businesses and services may start to withdraw from areas that are in flood-prone areas[142]. A lack of investment and provision of services in a community may lead to higher levels of		consideration of materials used in building new housing [152]. Existing housing stock, particularly social housing and housing owned by councils, may require increased maintenance costs and funding to upgrade these properties to be resilient to climate change [152]. Allocating emergency funding that supports families with less resources to keep their companion animals with them or in a temporary shelter will support mental health and wellbeing and ensure that households do not suffer the additional loss of their companion animal. There are significant health and safety considerations when restoring homes after flood damage, BRANZ provides a comprehensive guide for remediation of New Zealand homes following flooding [153]. Changing our urban infrastructure can protect against the worst impacts of flooding, for example using porous cement for new roads, carparks, and footpaths to help reduce the stormwater runoff [154].The CCC Surface Water Strategy 2009-2039, captures examples of key policy interventions including the use of porous paving in urban areas [155]. Adapting to flooding requires urban centres to consider and invest in water sensitive urban design to manage stormwater. The concept of a ‘sponge city’ can be a helpful way to approach city design. This recommends permeable

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		unemployment, increased financial stress, and mental distress for residents [142]. Flooding and storms can cause an increase in rodents and pests resulting in a greater risk of infectious diseases [149].		pavements, rainwater gardens, green roofs, and more green spaces and trees within neighbourhoods to help absorb and filter the excess water from flooding [156]. Natural and constructed wetland areas can also provide a place for excess stormwater to go; additionally, wetland plants help to filter the water, as well as provide a critical space for biodiversity [157]. Relocation or managed retreat of communities impacted by flooding or sea level rise needs to involve extensive and meaningful community engagement and consultation to support and protect community agency [142]. Adaptation responses to protect a community from flooding can cause disruption and loss to community identity, sense of belonging, and community connections. Acknowledging the difficulty of adaptation policies to community wellbeing is important to ensure that residents and communities impacted are supported appropriately [142].
Transport infrastructure	Damage to transport infrastructure may impact access to marae, urupā, and other places of cultural significance.	Damage to transport infrastructure impacts the accessibility of locations for residents, emergency services, businesses, tourism, and recreational visitors [158]. Transport infrastructure damage can impact access to critical healthcare services including hospitals, pharmacies and local general practitioners [142, 159]. Transport infrastructure damage can slow down emergency services trying to reach affected communities. Lack of access to crucial services and businesses can also impact the local economy, causing businesses and	People who commute for work or study People living in remote communities Low-income households Business owners People with physical health needs People with mental health needs Disabled people Children Young People	Collaborative and integrated processes and policies are needed to reduce the risks of climate change events. For example, climate change impacts and planning need to be integrated into transportation policies and long-term plans [165]. De-carbonising the transport system is an important and necessary way to reduce emissions and mitigate the impacts of climate change [159]. Communities and areas that are vulnerable to flooding need to have a

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		services to close or need to relocate due to lack of financial viability [142]. Small rural communities may be particularly impacted as they may not have the funding to easily repair the roads or bridges impacted by flooding [160]. Damage to transport infrastructure and flooding of roads can result in school closures, impacting the education and important social connections of children and young people [161]. Flooding and damage to transport infrastructure could have an impact on access to recreational spaces and facilities, impacting people's physical activity and their community connectedness [162]. Isolation or lack of access to communities due to damaged transport infrastructure will create supply chain issues and mean shortages and lack of access to food, healthcare supplies, fuel and other basic household needs [158]. Food, fuel, and medicine supply lines often follow a 'just-in-time' supply process for the purposes of economic efficiency. This means that there are often limited reserves available and reduced access to these critical items can be felt quickly by community members if they do not have their own emergency supplies. For example, on the West Coast, there are sufficient food supplies for two days in reserve in the supermarkets [163]. Airport closure and lack of access to ports due to road damage could prevent the movement of exports and imports, causing delays and further disrupting the supply chain [158]. Ongoing economic cost to maintain, repair, or retreat transport infrastructure likely to increase; general maintenance and quality of roads may deteriorate leading to more economic cost to individuals as the		clear flood evacuation transport plan and policy including planning for alternative routes, road closures, and transport capacity [166]. In addition, plans for the provision of emergency food, water supplies, and medicines will be needed, especially in the immediate aftermath of a flood event. Changing climate has widespread implications for transport planning, operation, maintenance, network, and vehicle function. Within the context of Canterbury, it is important to consider the implications of climate events on transport infrastructure within the local environment and address or plans to address the key vulnerabilities of that place. Pro-active investment in adaptation and planning is necessary to prevent the worst impacts of climate change on transport infrastructure [165].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		road quality damages their vehicles and limits transport options [164].		
Water quality and infrastructure	Changing rainfall, water levels and flooding runoff into rivers and lakes will likely impact taonga fish species and mahinga kai for Māori. This may have cultural, spiritual and physical health implications [105].	Increased rainfall and flooding can result in runoff and contamination of recreational water, shellfish, and drinking water supplies with faecal pathogens from humans and animal (cattle) resulting in diseases causing gastroenteritis (giardiasis, salmonellosis). Additionally, runoff can cause contamination in water from toxic chemicals and heavy metals associated with causing cancer [67, 167]. Increased rainfall and coupled with increased temperatures can also increase the risk of mosquito-borne diseases [43]. Flooding and storms can overwhelm water infrastructure systems and result in sewerage overflows, loss of drinking water, and closure of health facilities and aged care facilities that cannot function without safe water supplies [168]. Flooding can result in increased risk of gastrointestinal illnesses and infectious diseases [43, 123], due to contamination or disruption to essential services such as electricity, water and sewerage [4]. For example, heavy rainfall was found to be the cause of a water contamination issue that led to nearly 5,500 people falling ill with gastroenteritis and contributed to 3 deaths in Havelock North, New Zealand [43, 169]. The total economic cost of this event was estimated to be $21,029,288; with the majority of this cost sitting with households having to boil and buy water, and take time off work to manage the event [170]. The household cost was approximately $2,440 per household. Flooding can increase the risk of food- and water-borne illness due to contamination or disruption to essential services such as electricity, water and sewerage [4].	Children Older Adults People with physical health needs People with mental health needs Disabled people Low-income households People without access to internet People without access to phone	To support water infrastructure, where practical, stormwater rooftop collection can help reduce the water runoff and prevent the stormwater system being overwhelmed [152]. To support water infrastructure, having areas of vegetation where excess water can be held, for example marshland, will help reduce the stormwater system being overwhelmed and ensure that flooding and overflows do not take place in inappropriate areas [152].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Energy supply and infrastructure		Flooding and storms can damage energy infrastructure resulting in lack of electricity needed for heating and cooking, and to power computers and home appliances and lighting, and for medical supplies and equipment [171]. Damaged energy infrastructure can cause electrical burns and electrical injuries [172]. Lack of power can disrupt critical services including healthcare services and hospitals, as well as the supply of power to critical care devices for people with existing health conditions [123].	People reliant on electricity for heating Children Older Adults People with physical health needs People with mental health needs Disabled Peoplae	Diversification of energy sources, to include renewable and localised energy, can create more resilience to climate change events [173]. Improving the affordability of renewable energy sources for communities can strengthen local resilience to climate change events [171]. Ensuring that plans and strategies are in place for instances of power outage. This includes making sure that backup or portable generators are available for critical community emergency centres which are resistant to flooding. Generators are essential for providing emergency water purification systems. The plans and strategies also need to incorporate education of people required to operate the generators [174].
Communication and Information Infrastructure		Flooding and severe storms can destroy critical communication and information infrastructure. This can result in a lack of knowledge for coordinating disaster response, as communities and people effected by the storm are unable to communicate their needs and the scale of hazards they are experiencing [175]. Additionally, emergency communication can be impacted and important safety messages to communities impacted by the flooding or storm may not be received. This may result in higher mortalities, a lack of emergency preparedness, and increased panic and distress for affected communities and households [176]. Destruction of communication and information infrastructure can also lead to a rise in misinformation or disinformation around the emergency unfolding, causing greater social and community harm [175].		Develop community education plans and education packages around emergency preparedness e.g. on topics like ensuring water is safe to drink and making a toilet for your household. This would involve working with and utilising resources developed by Civil Defence. Inter-organisational communications plans and MOU should be prepared in advance and agreed to go out via different media outlets.

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Crops and livestock	Ngāi Tahu manage more than 10,000 ha of farm and forestry land in Te Waipounamu, including 9,407 ha of land for beef farming and 6,757 ha of land for dairy farming in Waitaha Canterbury. Flooding that impacts agricultural land will affect Māori economic interests in farming beef, lamb, and dairy. [105]. The increasing cost of food may also affect Māori communities, who already experience higher levels of food insecurity [68].	Flooding, storms and extreme winds may impact local food supplies by causing damage to crops; this may also cause food prices to increase contributing to further health inequities [177]. Damage from flooding, storms, and extreme winds may have economic impacts for rural communities, farmers, and agricultural workers. Flooding can cause considerable damage to the insect population, including bees and other pollinators, which are critical for crop yields, and could therefore have an impact on food security [178]. In the recent flooding in Hawke's Bay and Tai Rāwhiti, it is estimated between 5000 – 6000 beehives were damaged or washed away [179].	Agricultural workers Farmers Low-income households	Protecting and managing agricultural land sustainably will help mitigate soil erosion from flooding [177]. Flood embankments could be used to protect agricultural land. Additionally, more flood-tolerant varieties and species of crops could be planted in areas at risk of flooding [177]. Longer term food provision through food distribution organisations and charities may be needed for low-income households if there are significant increases in food costs. Support and investment in local farmers and the local food economy may create more diversity and resilience and therefore increase access to nutritional healthy food for communities [177]. Shifts in diet away from processed foods and towards more vegetables, legumes, whole grains and fruit are likely to have health and wider environmental co-benefits [180, 181]-However, it is critical to account for and enable indigenous rights to food, for example mahinga kai.
Coastal barriers, stop banks and flood management infrastructure		Areas of lower socioeconomic status and rural areas with a smaller population may struggle to afford flood protection, despite potentially higher levels of exposure. This leads to further inequity and compounding issues, as communities do not have the financial ability to adapt by moving away or building flood protections [182]. Flood protection in Aotearoa New Zealand is already short by an estmated $150m per year. Increased risk of flooding may increase political and social tensions around who is responsible for the ongoing and increasing costs of flood protection [183, 184].	People living in a flood zone Small and rural communities	Pro-active investment into flood protection is needed to avoid the worst health and wellbeing impacts of flooding on the community. Any investment and plans should be carefully considered to ensure protections put in place are not mal-adaptive.

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Landfills and contaminated land	Landfills and areas of contaminated land are at risk of being flooded and exposed. This can mean that nearby areas and ecosystems are polluted with waste, impacting Māori physical, social, spiritual, cultural and economic wellbeing [151].	Landfills and areas of contaminated land are at risk of being flooded and exposed. This can mean that nearby areas and ecosystems are polluted with waste, impacting the community's physical health and wellbeing. For example, in a flooding event in 2019, a disused landfill was exposed and 135, 000 kg of waste was washed downstream into the Tasman Sea [151]. Within Canterbury, there is a total of 112 former or current town landfills, and an additional 85 smaller private landfills (for example a private farm pit) are within 100m of the coast or a river and therefore vulnerable to flooding or sea level rise [185]. Flooding can result in an increase in waste being sent to landfills. For example, the Buller flooding in 2021 resulted in twice the amount of waste in landfills than Westport usually produced in a year [186].		Landfills and contaminated land at risk of being exposed from flooding need to be proactively remediated [151]. Actively encouraging and rewarding households and community initiatives that focus on waste reduction, waste minimisation and recycling will reduce the need for landfills. Planning how to manage waste and where waste can be disposed safety after a flood event is critical. Additionally, consideration around how to save or recycle items affected by flooding is needed, to help reduce the amount of waste being put in landfills.
Direct impacts		Flooding can directly result in drowning, traumatic injury, including injury from debris or falls, hypothermia, trauma, stress, and shock [123, 172]. Flooding can also result in reduced physical activity and recreation due to lack of access or damage to facilities and impact individual health and wellbeing [4]. Flooding can exacerbate existing chronic diseases due to lack of access to medications [153]. Storms result in an increase of particulate matter, particularly airborne pollens, that can exacerbate asthma and other respiratory conditions [43]. Storms can result in Epidemic Thunderstorm Asthma, which can increase presentations to hospital and overwhelm the health system [187]. Climate change has significant impacts on mental health and wellbeing, from both the impacts of climate change events, such as a storm or flood event, and from the incremental changes and losses that communities may experience due to climate change. Additionally, the overall threat of climate change and	People living in a flood zone Emergency response workers and volunteers Children Young People Older Adults People with physical health needs People with mental health needs Disabled People Low-income households People without access to internet People without access to phone	Early warning systems are critical to ensure that individuals, families, businesses, and communities can prepare themselves for flood events and evacuate areas if needed [189]. Planning responses to the mental health impacts and consequences of climate change is critical as climate change magnifies risks to mental health. Responses need to consider both direct mental health impacts, for example from a flooding event, and indirect impacts that relate to damaged infrastructure or loss of employment due to climate change. Further, responses are needed for the potential and pervasive threat of climate change that can contribute to eco-anxiety, hopelessness, and despair, particularly for children and young people [188].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		climate events can create feelings of hopelessness and despair, due to the magnitude and complexity of the threat of climate change [188].		

Sea Level Rise

The impacts of climate-related hazards on human health and wellbeing are complex and compounding, with many inter-related causal pathways. Table 15 is focused on the impacts of sea level rise. The infrastructure, economic, biodiversity and direct impacts of sea level rise are noted in the first column (e.g. housing and communities). These impacts are used to inform the focus of the content explored in 'Te Ao Māori lens' and the 'Health / Wellbeing Impact' columns. The 'Most Affected Population Groups' column outlines some of the population groups that are more likely to be impacted by the climate-related hazard. It is important to note that these population groups are largely similar across the hazards and impacts. Finally, possible adaptive and mitigating responses can be found in the last column, all of which are directly or indirectly beneficial to health and wellbeing.

Note and Acknowledgement – The 'Te Ao Māori lens' column of the table below draws on the report: He huringa āhuarangi, he huringa ao: a changing climate, a changing world*, prepared for Ngā Pae o te Māramatanga by Manaaki Whenua - Landcare Reaseach.*

Table 15: Impacts, population groups and responses – Sea Level Rise

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Housing and communities	Loss of coastal land, urupā, Marae and other sites of cultural significance due to sea level rise may impact Māori cultural, spiritual, and mental wellbeing [98]. Māori are likely to be disproportionately affected by housing shortages and overcrowding due to housing shortages [190]. Māori are employed in relatively high numbers within the construction industry and therefore may have higher job security due to sea level rise remediation and relocation [151].	Coastal communities' wellbeing and mental health will likely be impacted through the physical insecurity of sea level rise [191, 192]. Sea level rise increases the financial insecurity for homeowners as insurance companies become more risk-averse to insuring flood-prone areas or areas experiencing coastal erosion; some properties may become uninsurable [147]. Insurance partial retreat and complete retreat is anticipated in coastal areas due to flooding and coastal erosion caused by sea level rise around Aotearoa. Insurance retreat will trigger default on mortgages, creating significant financial stress and potential home loss [59]. Displacement due to sea level rise and coastal erosion from sea level rise is associated with higher rates of anxiety, depression, and Post Traumatic Stress Disorder [144]. Displacement and relocation of housing due to sea level rise and coastal erosion may result in loss of community belonging, sense of connection to others, and connection to local history and traditions [191]. The process and decision making around public compensation for households impacted by sea level rise will likely create social and political tensions. Deciding and agreeing upon who is responsible for moving households away from hazards, and the process of funding	People living on the coast Emergency response workers and volunteers Children Older adults People with physical health needs People with mental health needs Disabled people Low-income households Homeowners without insurance/ under-insured Business owners Displaced residents	Adapting or relocating existing Māori cultural infrastructure will be necessary to protect these cultural places, and the overall cultural, spiritual, and mental wellbeing of Māori [151]. Relocation or managed retreat of communities impacted by sea level rise needs to involve extensive and meaningful community engagement and consultation to support and protect community agency [142]. Adaptation responses to protect a community from sea level rise can cause disruption and loss to community identity, sense of belonging, and community connections. Acknowledging the difficulty of adaptation policies to community wellbeing is important to ensure that residents and communities

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		and administrating funds for community or household relocation is complex and currently unclear. The process of community relocation/ managed retreat may also potentially create further inequities depending on the compensation model applied [193]. Due to sea level rise and other climate change events, it is likely that immigrants and refugees will arrive in New Zealand. This may exacerbate housing shortages and lead to overcrowding and an increased risk of infectious diseases. [68].		impacted are supported appropriately [142]. Encouraging and enhancing social connectedness, social cohesion, and social networks in a community ensures greater community resilience and protects against the worst health and wellbeing outcomes from climate change. Strong community ties can provide closer monitoring, assistance, and support to community members who will be most affected by climate change [67]. New housing and infrastructure needs to be designed to be resilient to the changing climate. This may mean changes to land-use policies as well as consideration of materials used in building new housing [152]. In response to sea level rise and increased migration from climate change refugees in the Pacific, Aotearoa New Zealand needs to rapidly build and enable extended-family houses and increase the supply of low-income housing overall in order to avoid over-crowding. Over-crowding and unsuitable, poor-quality housing can increase the risk of infectious diseases [106].
Transport infrastructure	Damage to transport infrastructure may impact access to marae, urupā, and other places of cultural significance.	Damage to transport infrastructure from sea level rise and coastal erosion impacts the accessibility of locations for residents, emergency services, businesses, tourism, and recreational visitors [158].	Children Young people Older adults People with physical health needs	Changing climate has widespread implications for transport planning, operation, maintenance, network, and vehicle function. Within the context of Canterbury, it is

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		Damage to transport infrastructure may particularly impact small rural communities who may not have the funding to easily repair the roads or bridges impacted by climate change [160]. Transport infrastructure damage from sea level rise and coastal erosion can impact access to critical healthcare services including hospitals, pharmacies, and local general practitioners [142, 159]. Food, fuel, and medicine supply lines often follow a 'just-in-time' supply process for the purposes of economic efficiency. This means that there are often limited reserves available and access to these critical items can be felt quickly by community members if they do not have their own emergency supplies. For example, on the West Coast, there are sufficient food supplies for two days in reserve in the supermarkets [163]. Damage to transport infrastructure can result in school closures, impacting the education and important social connections of children and young people [161]. Lack of access to crucial services and businesses can also impact the local economy, causing businesses and services to close or need to relocate due to lack of financial viability [142]. Isolation or lack of access to communities due to damaged transport infrastructure will create supply chain issues and mean shortages and lack of access to food, healthcare supplies, fuel and other basic household needs [158]. Sea level rise could have an impact on access to some recreational spaces and facilities in Canterbury, impacting people's physical activity and their community connectedness. Damage to ports could prevent the movement of exports and imports, causing delays and further disrupting the supply chain [158]. Ongoing economic cost to maintain, repair, or retreat transport infrastructure is likely to increase. The general maintenance and quality of roads may deteriorate over time due to this, leading to more economic cost to individuals as the road quality damages their vehicles and limits transport options [164].	People with mental health needs Disabled people Low-income households People who commute for work or study People living in remote communities Business owners	important to consider the implications of climate events on transport infrastructure within the local environment and address or plans to address the key vulnerabilities of that place. Pro-active investment in adaptation and planning is necessary to prevent the worst impacts of climate change on transport infrastructure [165]. De-carbonising the transport system is an important and necessary way to reduce emissions and mitigate the climate change [165]. Collaborative and integrated processes and policies are needed to reduce the risks of climate change events. For example, climate change impacts and planning need to be integrated into transportation policies and long-term plans [165].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Water quality and infrastructure	Access to indigenous biodiversity and kai moana is important for Māori intergenerational transmission of knowledge, nurturing whakapapa connections and whenua connections. The relationship between Māori and the environment is also important for kaitiakitanga [151].	Sea level rise could introduce saline water into drinking and groundwater supplies which can lead to an increased risk of communicable diseases including diarrhoea, rashes, skin infections, and eye infections [194].		
Coastal barriers, stop banks and flood management infrastructure		There is increasing political tension between local and central government regarding the cost and responsibility of flood management and flood protection [184]. In Aotearoa, it is estimated that flood protection costs are short by $150m per year [183]. Poorer areas and rural areas with a smaller population may struggle to afford flood protection, despite potentially higher levels of exposure. This leads to further inequity and compounding issues, as communities do not have the financial ability to adapt by moving away or building flood protections [182]. The ongoing cost of repairing and strengthening sea walls can become challenging and be disputed. Previously built sea walls around Aotearoa are already proving to be an inadequate defence to rising sea level [182].		Investing in sea walls, stop banks and levees can help protect communities for longer and delay the need for communities to relocate, however, these measures can also encourage more development in unsafe areas creating greater risks of loss if the flood protection measures are breached or damaged [59].
Landfills and contaminated land	Landfills and areas of contaminated land are at risk of being flooded and exposed. This can mean that nearby areas and ecosystems are polluted with waste, impacting Māori physical, social, spiritual, cultural and economic wellbeing [151].	Landfills and areas of contaminated land are at risk of being flooded and exposed. This can mean that nearby areas and ecosystems are polluted with waste, impacting the community's physical health and wellbeing [151]. Within Canterbury, there is a total of 112 former or current town landfills, and an additional 85 smaller private landfills (for example a private farm pit) are within 100m of the coast or a river and therefore vulnerable to flooding or sea level rise [185]. Flooding and coastal erosion can result in an increase in waste being sent to landfills. For example, the Buller flooding in 2021 resulted in twice the amount of waste in landfills than Westport usually produced in a year [186].		Landfills and contaminated land at risk of being exposed from flooding need to be proactively remediated [151]. Actively encouraging and rewarding households and community initiatives that focus on waste reduction, waste minimisation and recycling will reduce the need for landfills. Planning how to manage waste and where waste can be disposed safety after a flood or coastal erosion event is critical. Additionally, consideration around how to save or recycle items affected by flooding is needed, to help reduce the

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
				amount of waste being going to landfills.
Direct	Sea level rise could have an impact on popular surf breaks and cause flooding to recreational spaces and facilities that many whānau use, influencing levels of physical activity [151]. Important coastal land, urupā, marae and other sites of cultural significance important for Māori identity may be flooded and damaged due to sea level rise, impacting Māori cultural, spiritual, and mental wellbeing [68].	Climate change has significant impacts on mental health and wellbeing, from both the impacts of climate change events, such as a storm or flood event, and from the incremental changes and losses that communities may experience due to climate change. Additionally, the overall threat of climate change and climate events can create feelings of hopelessness and despair, due to the magnitude and complexity of the threat of climate change [188].	People living in a flood zone Emergency response workers and volunteers Children Older adults People with physical health needs People with mental health needs Disabled people Low-income households Homeowners without insurance/ under-insured Business owners Displaced residents	Planning responses to the mental health impacts and consequences of climate change is critical, as climate change magnifies risks to mental health. Additionally, responses need to consider both direct mental health impacts, for example from a flooding event, as well as indirect impacts that relate to damaged infrastructure or loss of employment due to climate change. Further, responses are needed for the potential and pervasive threat of climate change that can contribute to eco-anxiety, hopelessness, and despair, particularly for children and young people [188].

Temperature Rise

The impacts of climate-related hazards on human health and wellbeing are complex and compounding, with many inter-related causal pathways. Table 16 is focused on the impacts of temperature rise. The infrastructure, economic, biodiversity and direct impacts of temperature rise are noted in the first column (e.g. housing and communities). These impacts are used to inform the focus of the content explored in 'Te Ao Māori lens' and the 'Health / Wellbeing Impact' columns. The 'Most Affected Population Groups' column outlines some of the population groups that are more likely to be impacted by the climate-related hazard. It is important to note that these population groups are largely similar across the hazards and impacts. Finally, possible adaptive and mitigating responses can be found in the last column, all of which are directly or indirectly beneficial to health and wellbeing.

Note and Acknowledgement – The 'Te Ao Māori lens' column of the table below draws on the report: He huringa āhuarangi, he huringa ao: a changing climate, a changing world*, prepared for Ngā Pae o te Māramatanga by Manaaki Whenua - Landcare Reaseach.*

Table 16: Impacts, population groups and responses – Temperature Rise

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Housing and communities	Māori are over-represented in poor quality housing which may mean greater health impacts from heat [68].	Increased heat can lead to a greater risk of heat-related illnesses, including heat stress, heat stroke, as well as heat-related mortality, and will have negative impacts for people with existing health conditions [123, 195]. Urban communities are at risk of the urban heat island effect as many of the material used in urban settings – brick, concrete, steel – trap heat and increase the overall temperature experienced in urban environments. The urban heat island effect can cause up to 10 degrees increase in air temperature. Heat island effects are more likely to be experienced in areas of socioeconomic disadvantage as there is less natural vegetation and fewer trees in those areas to help reduce and prevent the heat island effect [123]. Residents living in high rise buildings or on the upper floor of buildings are more likely to experience heat stress and heat-related health risks [123]. Increased temperature in communities is likely to put pressure on healthcare services [123].	Older people Children Pregnant people People living in high-rise housing People with physical health needs People with mental health needs Disabled people Low-income households	To reduce the potential of heat-related illness and mortality it is critical that trees, green spaces, and natural vegetation are protected [196]. Hard surfaces like roads and footpaths in cities can reach up to 50 degrees in temperature on a 30-degree day. However, shade from trees can mean that roads and footpaths are nearly 20 degrees cooler [197]. In communities where there is limited vegetation and trees, planting should be done. Roof-top gardens and creative green spaces in urban settings should be encouraged [196]. Roof-top gardens and places of biodiversity can play a part in decolonising cities, by showcasing local ecology and culture [198]. Changes to the Building Code may be needed

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
				to better enable and support roof-top gardening. An equitable approach to green space and tree-planting needs to be applied across community and urban planning in order to reduce the heat island effect and negative health impacts of increased heat [196]. New housing and infrastructure needs to be designed to be resilient to the changing climate, including increased temperatures and heatwaves. This may mean changes to land-use policies (for example maintaining trees on properties) as well as consideration in materials used in building new housing [152]. Housing can be designed or retrofitted to passively cool using cross ventilation systems or external shade. White or light covered roof-tops can also help reduce temperatures and prevent the heat island effect in urban areas [199]. Existing housing stock, particularly social housing and council-owned housing, may require increased maintenance costs and funding to upgrade these properties to be resilient to increased temperatures [152]. Ensure dedicated cooling centres where people can seek shelter and assistance – as well

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
				as access to other public spaces that provide respite [200]. Encouraging and enhancing social connectedness, social cohesion, and social networks in a community ensures greater community resilience and protects against the worst health and wellbeing outcomes from climate change. Strong community ties can provide closer monitoring, assistance, and support to community members who will be most affected by climate change [67].
Transport infrastructure	Damage to transport infrastructure may impact access to marae, urupā, and other places of cultural significance.	Increased temperature can cause roads to melt and rail buckling. In 2006, a rail line buckled by heat caused 27 wagons to tumble from the Selwyn River Bridge in Mid-Canterbury [201]. Damage to transport infrastructure impacts the accessibility of locations for residents, emergency services, businesses, tourism and recreational visitors [158]. Softened and melting road surfaces create safety issues for road users, as coming to a halt takes longer, increasing the risk of serious crashes on roads [202]. Ongoing economic cost to maintain, repair, or retreat transport infrastructure likely to increase; general maintenance and quality of roads may deteriorate leading to more economic cost to individuals as the road quality damages their vehicles and limits transport options [164].	Children Young people Older adults People with physical health needs People with mental health needs Disabled people Low-income households People who commute for work or study People living in remote communities Business owners	Changing climate has widespread implications for transport planning, operation, maintenance, network, and vehicle function. Within the context of Canterbury, it is important to consider the implications of climate events on transport infrastructure within the local environment and address or plans to address the key vulnerabilities of that place. Pro-active investment in adaptation and planning is necessary to prevent the worst impacts of climate change on transport infrastructure [165]. De-carbonising the transport system is an important and necessary way to reduce emissions and mitigate the climate change [165]. Collaborative and integrated processes and policies are

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
				needed to reduce the risks of climate change events. For example, climate change impacts and planning need to be integrated into transportation policies and long-term plans [165].
Water quality and infrastructure	Increased temperature can increase the risk of toxic algae blooms in freshwater environments which may have an impact on Māori taonga species for example pāua and kina [105]. Increased temperatures may also lead to localised extinction of some taonga species, and change their breeding, and migration patterns: Longfin eels, lamprey (piharau, kanakana), īnanga, kōaro, banded kōkopu, the shortfin eel and the freshwater mussel are highly vulnerable species [105]. The impact of increased temperature on taonga freshwater and marine species and decrease to kaimoana is likely to negatively impact Māori cultural identity and wellbeing and increase food insecurity. For example, in 2017/2018 a marine heatwave caused the complete loss of rumurapa (bull kelp) around certain areas of Whakaraupō Lyttleton harbour. This species of kelp is used to make pōhā (food storage containers) used for transporting and steaming food. The loss of rumurapa has also had an impact on the mussel population of those areas [105]. Damage to ocean environments could have an impact on Māori income, investments and financial security. Māori have significant investments in tourism and the fishing industry, which could be	Increased temperature can increase the risk of toxic algae blooms in freshwater environments. Exposure to algal blooms can cause skin rashes, stomach cramps, nausea, and numbness or tingling around mouth and fingertips [203]. Increases in algal blooms can also impact recreation, tourism, fishery, aquaculture, and the wider ecosystem [43]. Increased temperature can also increase the risk of vector-borne diseases such as tick- and mosquito-borne diseases including Chikungunya, Dengue Fever, Ross River Virus and Zika [43]. Increased temperature can also increase the concentration of campylobacteriosis and salmonellosis in freshwater [43]. Changes and damage to the ocean environment and biodiversity could impact supply and affordability of fish which subsequently may impact the nutrition and wellbeing of communities. Fishing, tourism, diving, and other recreational activities that rely on our ocean environment may be negatively impacted causing financial stress and mental distress to communities who rely on the ocean and natural environment for their income and recreation [151].	Older people Children Pregnant people People with physical health needs People with mental health needs Disabled people	Marine and freshwater environments would benefit from greater protections and the introduction of new protected areas and managed resource protected zones [152]. Move the swim leg of multi-sport events to swimming pools or alternative sites with cleaner water to manage health risks associated with climate-induced low water flows and toxic algal blooms [151]. Increased and effective riparian planting is recommended as it an effective measure providing many benefits, including: filtering water before it enters waterways, providing increased stability for riverbanks, creating habitats for wildlife and providing shade for the cooling of rivers and streams [204].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
	damaged by changing coastal and ocean water quality and damage to marine and freshwater biodiversity [151].			
Energy supply and infrastructure		Increased demand on the energy system due to air conditioning can overload the electric lines and transformers resulting in power cuts. Sustained demand on energy can also cause transformers to overheat and become damaged. Damage to energy infrastructure and power cuts can result in lack of electricity needed for cooling and cooking, to power computers and home appliances, lighting, and for medical supplies and equipment [171]. Lack of power can disrupt critical services including healthcare services and hospitals, as well as the supply of power to critical care devices for people with existing health conditions [123].		Government rebates for domestic solar panels or other small scale renewable energy system (wind, hydro, or hot water system) such as the Australian Small-scale Renewable Energy Scheme (SRES).
Crops and livestock	Increased temperatures could mean an increase in invasive pests and diseases affecting monocultural agriculture and forestry. This could disproportionately impact Māori investment, economy, and food security [151]. Certain crops may benefit from the increased temperature and therefore have a longer growing season. Additionally, warming temperatures may mean that certain crops can be grown in different areas of the country [151]. The increasing cost of food may also affect Māori communities, who already experience higher levels of food insecurity [68].	Increased temperatures could change the growing of crops and distributions of productive land around Aotearoa which may lead to food price increases and compound existing food insecurity. Increased temperature could create serious health risk to livestock through heat stress, and through an increase in parasites or introduction of new parasites that effect the health of livestock. This will likely increase the costs of animal products and increase food insecurity [151]. Managing the impact of increased temperature could create a significant financial burden and stress for farmers and agricultural workers, who may lose their income or need to adapt their growing times and crops, as well as adapt work procedures. Increased temperatures could also have a positive impact on food security due to the increased growing season of certain crops [205].	Farmers Agricultural workers Children Older adults People with physical health needs People with mental health needs Disabled people Low-income households	In order to support and cultivate food security, growing food should be encouraged in other spaces including in urban settings. Food security can also be supported through appropriate irrigation and prioritising water use. Land-use policies need to protect existing land good for growing food. Areas of shade and shelter for livestock need to be provided to protect them from heat stress. Shifts in diet away from processed foods and towards more vegetables, legumes, whole grains and fruit are likely to have health and wider environmental co-benefits

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
				[180, 181]-However, it is critical to account for and enable indigenous rights to food, for example mahinga kai.
Biodiversity and ecosystems	Increased temperatures can result in the loss of indigenous flora and fauna due to changes to the habitable environment and potential increase in predators and weeds. The loss of these habitats may impact Māori businesses including in honey production from pōhutukawa and manuka [151]. The loss of indigenous biodiversity may have adverse impacts on Māori cultural practices, Māori cultural identity, and overall spiritual and mental wellbeing [151].	Biodiversity loss has both direct and indirect consequences on human health, for example, biodiversity is essential for soil health and agriculture, fresh water, clear air, and naturally-sourced medicines [206]. Climate change impacts to biodiversity are likely to have negative impacts to wellbeing, physical and mental health. Engaging with natural environments has been shown to reduce stress, restore attention, increase positive feelings and mood, and reduce depressive symptoms [207]. Access to natural environments also increases physical and recreational activities. The natural environment also provides food, fresh water and can help regulate air quality, pollination, and pests and vector-borne and fungal diseases; damage to ecosystems can have harmful consequences to human health [207].		Protecting and conserving biodiversity is an essential strategy for protecting human health and wellbeing. New planting areas, including public spaces such as streets and parks, should be planned with the changing climate in mind. This includes the careful selection of plant varieties which will tolerate and be suitable for warmer temperatures and droughts [208].
Direct	Māori health outcomes are more likely to be impacted by increasing heat as Māori have a higher burden of chronic diseases such as diabetes, which means they are at a greater risk of heat-related illness and death [68]. Māori are more likely to work outdoors and are therefore more at risk from heat-related illness and death [68].	Increased temperature can cause adverse health impacts including heat stress, heat stroke, nausea, dehydration, sleep deprivation, and increased risk of hospitalisation [209]. People with chronic health conditions such as diabetes, cardiovascular disease, and kidney disease are at a higher risk from increased temperatures. People with chronic health conditions are more likely to experience higher incidence of dehydration, hospitalisation, and mortality [151, 210]. Increased temperatures can cause risks during pregnancy, including reduced birth weight, premature delivery, stillbirth, and cardiovascular stress during delivery [211]. Increased temperature can cause heat stress and reduce labour capacity and concentration, reducing the overall productivity of the labour market, but especially for people working outdoors [212]. Increased temperature may limit participation in sports and physical activities, as these activities can increase the risk of heat-related illnesses. Additionally, there may be fewer hours in the day where people can exercise or participate in physical activity safely [151, 212].	Older people Children Young people Pregnant people People living in high-rise housing People with physical health needs People with mental health needs Disabled people Low-income households	To reduce the health impacts of higher temperature, community education and communication will be necessary to help people understand how to protect themselves in the higher temperatures. To reduce the potential of heat-related illness and mortality it is critical that trees, green spaces, and natural vegetation are protected [196]. Community facilities need to be available to manage extreme heat such as accessible drinking water, sunscreen, cooling stations, and shade. An equitable approach to green space and tree planting needs

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		Warmer temperatures may change behaviours in relation to spending time outdoors, which could mean that people have higher exposure to ultra-violet (UV) radiation with impacts on skin cancer [67]. Increased temperatures can cause significant health impacts to outdoor workers leading to heat stress, heat stroke, fatigue, dehydration, loss in productivity, increased morbidity, and fatality. Outdoor workers in sectors such as agriculture and construction will be among the first to feel the health impacts of climate change [213]. Increased temperatures can result in a longer period of pollination and aeroallergen production which can increase the health risks for people with respiratory issues and asthma [98]. Increased temperatures can pose issues with food safety, increasing the risk of food spoilage and incidence of diseases such as salmonella infection [43]. Increased temperature can also influence mood and mental health and can result in higher incidence of aggressive behaviour, violence and suicide [151]. Increased temperatures can have a positive impact in reducing winter illness, such as influenza, and mortality due to cold temperatures [151]. Climate change has significant impacts on mental health and wellbeing, from both the impacts of climate change events, such as a storm or flood event, and from the incremental changes and losses that communities may experience due to climate change. Additionally, the overall threat of climate change and climate events can create feelings of hopelessness and despair, due to the magnitude and complexity of the threat of climate change [188].		to be applied across community and urban planning in order to reduce the heat island effect, provide shade and reduce the negative health impacts of increased heat [196]. Sports and outdoor recreational activities may have to be played earlier in the morning or late in the evening to avoid the highest temperatures of the day. Additionally, more breaks may be needed for people to drink water and rest in the shade. Outdoor work, for example construction or agricultural work, may need to be done early in the morning or late in the evening to avoid the highest temperatures of the day and reduce the risk of heat stress on workers. Additionally, workers will need more breaks to drink water and rest in the shade. To address increased risk of food safety issues, and associated diseases, regulations, audits and education about the correct preparation and storage of food is required for both food producers and the public [214]. Public campaigns and education can support public knowledge about SunSmart-approaches. Organisational SunSmart Policies also ensure the running of SunSmart public

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
				events. SunSmart events consider: the timing of the event, the use of shade, sunscreen availability, use of the SunSmart steps (slip, slop, slap and wrap) and the overall promotion of SunSmart at the event [215]. Adequate shaded areas should be ensured in public spaces, especially in places with seating and in dedicated play spaces [216]. Public drinking fountains should be available in spaces where people live, work and play. Additionally, the provision of water should be ensured at public events such as sports and cultural events [217]. Planning responses to the mental health impacts and consequences of climate change is critical as climate change magnifies risks to mental health. Additionally, responses need to consider both direct mental health impacts, for example from a flooding event, as well as indirect impacts that relate to damaged infrastructure or loss of employment due to climate change. Further, responses are needed for the potential and pervasive threat of climate change that can contribute to eco-anxiety, hopelessness, and despair, particularly for children and young people [188].

Heatwaves

The impacts of climate-related hazards on human health and wellbeing are complex and compounding, with many inter-related causal pathways. Table 17 is focused on the impacts of heatwaves. The infrastructure, economic, biodiversity and direct impacts of heatwaves are noted in the first column (e.g. housing and communities). These impacts are used to inform the focus of the content explored in 'Te Ao Māori lens' and the 'Health / Wellbeing Impact' columns. The 'Most Affected Population Groups' column outlines some of the population groups who are more likely to be impacted by the climate-related hazard. It is important to note that these population groups are largely similar across the hazards and impacts. Finally, possible adaptive and mitigating responses can be found in the last column, all of which are directly or indirectly beneficial to health and wellbeing.

Note and Acknowledgement – The 'Te Ao Māori lens' column of the table below draws on the report: He huringa āhuarangi, he huringa ao: a changing climate, a changing world*, prepared for Ngā Pae o te Māramatanga by Manaaki Whenua - Landcare Reaseach.*

Table 17: Impacts, population groups and responses – Heatwaves

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Housing and communities	Māori are over-represented in poor quality housing which may mean greater health impacts from heat [98].	Increased heat can lead to a greater risk of heat-related illnesses including heat stress, heat stroke, as well as heat-related mortality and can cause negative impacts for people with existing health conditions [123]. Urban communities are at risk of the urban heat island effect as many of the materials used in urban settings – brick, concrete, steel – trap heat and increase the overall temperature experienced in urban environments. The urban heat island effect can cause 3 – 5 degrees Celsius increase in air temperature. Heat island effects are more likely to be experienced in areas of socioeconomic disadvantage as there is less natural vegetation and trees in those areas to help reduce and prevent the heat island effect [123]. Residents living in high rise buildings or on the upper floor of buildings are more likely to experience heat stress and heat-related health risks [123]. Increased temperature in communities is likely to put pressure on healthcare services [123].		Ensure dedicated cooling centres where people can seek shelter and assistance – as well as access to other public spaces that provide respite [200]. To reduce the potential of heat-related illness and mortality, it is critical that trees, green spaces, and natural vegetation are protected [196]. In communities where there is limited vegetation and trees, planting should be done. Roof-top gardens and creative green spaces in urban settings should be encouraged [196]. An equitable approach to green space and tree-planting needs to be applied across community and urban planning in order to reduce the heat island effect and negative health impacts of increased heat [196].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
				New housing and infrastructure needs to be designed to be resilient to the changing climate, including increased temperatures and heatwaves. This may mean changes to land-use policies (for example maintaining trees on properties) as well as consideration of materials used in building new housing [152]. Existing housing stock, particularly state housing, may require increased maintenance costs and funding to upgrade these properties to be resilient to increased temperatures [152]. Air conditioning is not always available or recommended as the energy demands may exceed the system capacity, additionally some households will not have access or be able to afford air conditioning costs. A ceiling fan or electric fan can be a helpful alternative, to help circulate the air. Ceiling fans can reduce the air temperature by 3-4 degrees Celsius [181]. Building codes may need to be adapted to encourage the inclusion of ceiling fans in building new homes and retrofitting homes. Within households, changes in behaviour can help reduce heat, for example, closing window blinds can reduce indoor temperature. Public Health campaigns to promote

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
				sustainable and accessible ways for keeping cool during extreme heat can help reduce the risk of heat-related illness and morbidity. Encouraging and enhancing social connectedness, social cohesion, and social networks in a community ensures greater community resilience and protects against the worst health and wellbeing outcomes from climate change. Strong community ties can provide closer monitoring, assistance, and support to community members who will be most affected by climate change [67].
Transport Infrastructure	Damage to transport infrastructure may impact access to marae, urupā, and other places of cultural significance.	Increased temperature can cause roads to melt and rail buckling. In 2006, a rail line buckled by heat caused 27 wagons to tumble from the Selwyn River Bridge in Mid-Canterbury [201]. Damage to transport infrastructure impacts the accessibility of locations for residents, emergency services, businesses, tourism and recreational visitors [158]. Softened and melting road surfaces create safety issues for road users, as coming to a halt takes longer, increasing the risk of serious crashes on roads [202].		Changing climate has widespread implications for transport planning, operation, maintenance, network, and vehicle function. Within the context of Canterbury, it is important to consider the implications of climate events on transport infrastructure within the local environment and address or plans to address the key vulnerabilities of that place. Pro-active investment in adaptation and planning is necessary to prevent the worst impacts of climate change on transport infrastructure [165]. De-carbonising the transport system is an important and necessary way to reduce emissions and mitigate the climate change [165].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
				Collaborative and integrated processes and policies are needed to reduce the risks of climate change events. For example, climate change impacts and planning need to be integrated into transportation policies and long-term plans [165].
Water quality and infrastructure	Increased temperature can increase the risk of toxic algae blooms in freshwater environments which may have an impact on Māori taonga species for example pāua and kina [105]. Increased temperatures may also lead to localised extinction of some taonga species, and change their breeding, and migration patterns: Longfin eels, lamprey (piharau, kanakana), īnanga, kōaro, banded kōkopu, the shortfin eel and the freshwater mussel are highly vulnerable species[105]. The impact of increased temperature on taonga freshwater and marine species and decrease to kaimoana is likely to negatively impact Māori cultural identity and wellbeing and increase food insecurity. For example, in 2017/2018 a marine heatwave caused the complete loss of rumurapa (bull kelp) around certain areas of Whakaraupō Lyttleton harbour. This species of kelp is used to make pōhā (food storage containers) used for transporting and steaming food. The loss of rumurapa has also had an impact on the mussel population of those areas [105].	Increased demand for water may lead to reduced water supply, affecting drinking water access and increase the risk of pathogen contamination from water sources and through disruption of hygiene practices in households (for example, acute respiratory and gastrointestinal illnesses) [67, 123]. Lack of water access can also contribute to household costs and the stress of managing a household, as families must negotiate childcare and caregiving responsibilities with limited water supplies [218]. Lack of safe water can disrupt the functioning and operations of healthcare and aged care facilities.		Water reuse and greywater and rainwater storage would support households to have greater resilience to droughts and heatwaves [123]. Water supply and water management planning and development is needed to provide immediate health protection and gains to communities most likely to be affected by drought and heatwaves [151]. Clear, empathetic communication and recommendations for water use during times of heatwaves will be needed. Households need to have access to a minimum amount of water, at no charge, to allow for general cleanliness and hygiene, and protect the household and community from the spread of infectious disease [152]. Greater planting over rivers should be planned to help cool and protect waterways.

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Crops and livestock	Increased temperatures could mean an increase in invasive pests and diseases affecting monocultural agriculture and forestry. This could disproportionately impact Māori investment, economy, and food security [151]. The increasing cost of food may also affect Māori communities, who already experience higher levels of food insecurity [68].	Increased temperatures could change the growing of crops and distributions of productive land around Aotearoa which may lead to food price increases and compound existing food insecurity. Increased temperature could create serious health risk to livestock through heat stress, and through an increase in parasites or introduction of new parasites that affect the health of livestock. This will likely increase the costs of animal products and increase food insecurity [151]. Managing the impact of increased temperature could create a significant financial burden and stress for farmers and agricultural workers, who may lose their income or need to adapt their growing times and crops, as well as adapting work procedures. Increased temperatures could also have a positive impact on food security due to the increased growing season of certain crops [85].		In order to support and cultivate food security, growing food should be encouraged in other spaces including in urban settings. Food security can also be supported through appropriate irrigation and prioritising water use. Land-use policies need to protect existing land good for growing food. Areas of shade and shelter for livestock need to be provided to protect them from heat stress. Shifts in diet away from processed foods and towards more vegetables, legumes, whole grains and fruit are likely to have health and wider environmental co-benefits [180, 181]-However, it is critical to account for and enable indigenous rights to food, for example mahinga kai.
Biodiversity and ecosystems	Increased temperatures can result in the loss of indigenous flora and fauna due to changes to the habitable environment and potential increase in predators and weeds. The loss of these habitats may impact Māori businesses including in honey production from pōhutukawa and manuka [151]. The loss of indigenous biodiversity may have adverse impacts on Māori cultural practices, Māori cultural identity, and overall spiritual and mental wellbeing [151].	Biodiversity loss has both direct and indirect consequences on human health, for example, biodiversity is essential for soil health and agriculture, fresh water, clear air, and naturally-sourced medicines [206]. Climate change impacts to biodiversity are likely to have negative impacts to wellbeing, physical and mental health. Engaging with natural environments has been shown to reduce stress, restore attention, increase positive feelings and mood, and reduce depressive symptoms [207]. Access to natural environments also increases opportunities for physical and recreational activities. The natural environment also provides food, fresh water and can help regulate air quality,		Protecting and conserving biodiversity is an essential strategy for protecting human health and wellbeing. New planting areas, including public spaces such as streets and parks, should be planned with the changing climate in mind. This includes the careful selection of plant varieties which will tolerate and be suitable for warmer temperatures and droughts [208].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		pollination, and pests and vector-borne and fungal diseases; damage to ecosystems can have harmful consequences to human health [207].		
Energy supply and infrastructure		Increased demand on the energy system due to air conditioning can overload the electric lines and transformers resulting in power cuts. Sustained demand on energy can also cause transformers to overheat and become damaged. Damage to energy infrastructure and power cuts can result in lack of electricity needed for cooling and cooking, to power computers and home appliances, lighting, and for medical supplies and equipment [171]. Lack of power can disrupt critical services including healthcare services and hospitals, as well as the supply of power to critical care devices for people with existing health conditions [123].		Clear, empathetic communication and recommendations for energy use during times of heatwaves will be needed. Government rebates for domestic solar panels or other small scale renewable energy system (wind, hydro, or hot water system) such as the Australian Small-scale Renewable Energy Scheme (SRES).
Direct	Māori will likely be disproportionately affected by heat-related illness or mortality during a heatwave as Māori have higher rates of cardiovascular disease and other chronic health conditions that are exacerbated by increased temperature [209].	Heatwaves can cause adverse health impacts including heat stress, heat stroke, nausea, dehydration, sleep deprivation, and increased risk of hospitalisation [209]. People with chronic health conditions such as diabetes, cardiovascular disease, and kidney disease are at a higher risk from increased temperatures during a heatwave. People with chronic health conditions are more likely to experience higher incidence of dehydration, hospitalisation, and mortality [105, 210]. Increased temperatures during a heatwave can cause risks during pregnancy, including reduced birth weight, premature delivery, stillbirth, and cardiovascular stress during delivery [211]. Increased temperatures during a heatwave can cause heat stress and reduce labour capacity and concentration, reducing the overall productivity of the labour market, but especially for people working outdoors [212]. Increased temperatures during a heatwave may limit participation in sports and physical activities, as these activities can increase the risk of heat-related illnesses. Additionally, there may be fewer hours in the day where people can exercise or participate in physical activity safely [151, 212].	Older people Children Pregnant people Women People living in high-rise housing People with physical health needs People with mental health needs Disabled people Low-income households	To reduce the health impacts of higher temperature, community education and communication will be necessary to help people understand how to protect themselves in the higher temperatures. To reduce the potential of heat-related illness and mortality it is critical that trees, green spaces, and natural vegetation are protected [196]. Community facilities need to available to manage extreme heat such as accessible drinking water, sunscreen, cooling stations, and shade. An equitable approach to green space and tree planting needs to be applied across community and urban planning in order to reduce the heat island effect,

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		Increased temperatures during a heatwave can cause significant health impacts to outdoor workers leading to heat stress, heat stroke, fatigue, dehydration, loss in productivity, increased morbidity, and fatality. Outdoor workers in sectors such as agriculture and construction will be among the first to feel the health impacts of climate change [213]. A heatwave can cause elevated levels of ozone pollution, which can be harmful to people with asthma, and respiratory illnesses [43]. Climate change has significant impacts on mental health and wellbeing, from both the impacts of climate change events, such as a storm or flood event, and from the incremental changes and losses that communities may experience due to climate change. Additionally, the overall threat of climate change and climate events can create feelings of hopelessness and despair, due to the magnitude and complexity of the threat of climate change [188].		provide shade and negative health impacts of increased heat [196]. Sports and outdoor recreational activities may have to occur earlier in the morning or late in the evening to avoid the highest temperatures of the day. Additionally, more breaks may be needed for people to drink water and rest in the shade. Outdoor work, for example construction or agricultural work, may need to be done early in the morning or late in the evening to avoid the highest temperatures of the day and reduce the risk of heat stress on workers. Additionally, workers will need more breaks to drink water and rest in the shade. To address increased risk of food safety issues, and associated diseases, regulations, audits and education about the correct preparation and storage of food is required for both food producers and the public [214]. Public campaigns and education can support public knowledge about SunSmart- approaches. Organisational SunSmart Policies also ensure the running of Sun Smart public events. SunSmart events consider: the timing of the event, the use of shade, sunscreen availability, use of the SunSmart steps (slip, slop, slap and wrap) and the overall

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
				promotion of SunSmart at the event [215]. Adequate shaded areas should be ensured in public spaces, especially in places with seating and in dedicated play spaces [216]. Public drinking fountains should be available in spaces where people live, work and play. Additionally, the provision of water should be ensured at public events such as sports and cultural events [217]. Planning responses to the mental health impacts and consequences of climate change is critical as climate change magnifies risks to mental health. Additionally, responses need to consider both direct mental health impacts, for example from a flooding event, as well as indirect impacts that relate to damaged infrastructure or loss of employment due to climate change. Further, responses are needed for the potential and pervasive threat of climate change that can contribute to eco-anxiety, hopelessness, and despair, particularly for children and young people [188].

Drought

The impacts of climate-related hazards on human health and wellbeing are complex and compounding, with many inter-related causal pathways. Table 18 is focused on the impacts of drought. The infrastructure, economic, biodiversity and direct impacts of drought are noted in the first column (e.g. housing and communities). These impacts are used to inform the focus of the content explored in 'Te Ao Māori lens' and the 'Health / Wellbeing Impact' columns. The 'Most Affected Population Groups' column outlines some of the population groups who are more likely to be impacted by the climate-related hazard. It is important to note that these population groups are largely similar across the hazards and impacts. Finally, possible adaptive and mitigating responses can be found in the last column, all of which are directly or indirectly beneficial to health and wellbeing.

Note and Acknowledgement – The 'Te Ao Māori lens' column of the table below draws on the report: He huringa āhuarangi, he huringa ao: a changing climate, a changing world*, prepared for Ngā Pae o te Māramatanga by Manaaki Whenua - Landcare Reaseach.*

Table 18: Impacts, population groups and responses – Drought

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Housing and Communities		Drought can cause land movement and unstable ground, which may cause damage to housing, buildings and infrastructure [219].		Encouraging and enhancing social connectedness, social cohesion, and social networks in a community ensures greater community resilience and protects against the worst health and wellbeing outcomes from climate change. Strong community ties can provide closer monitoring, assistance, and support to community members who will be most affected by climate change [67].
Water quality and infrastructure	Lack of water availability may impact marae, especially those that are using reticulated water supply systems [151].	During times of drought there is a greater risk that the groundwater is contaminated with nitrates, orthophosphates, chlorides and sulphates due to reduced water flow and increased soil erosion [220]. In a 2021 survey of wells across the Canterbury region, Environment Canterbury found that 10% of the 327 wells sampled had nitrate concentrations over the maximum acceptable value [221]. Nitrate concentration is continuing to rise and drought could further increase this risk. Increased levels of nitrates in the water can cause methaemoglobinaemia (blue-baby syndrome) in bottle-fed infants. Children under six months and pregnant people can be most affected by this [222].	Children Pregnant People Older Adults People with physical health needs People with mental health needs Disabled people Farmers Low-income households Business owners Healthcare services	Water reuse, greywater and rainwater storage would support households to have greater resilience to droughts [123]. Water supply and water management planning and development is needed to provide immediate health protection and gains to communities most likely to be affected by drought [151].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		Drought can reduce the size of waterbodies and create more stagnant water which are breeding grounds for mosquitoes, increasing the risk of infectious disease [223]. Reduced water supply may affect drinking water access and increase the risk of pathogen contamination from water sources and through disruption of hygiene practices in households (for example, acute respiratory and gastrointestinal illnesses) [67, 123]. There is a greater risk of water-borne diseases when there in a drought due to compacted, dry soil being more likely to cause run-off in a subsequent heavy rain event, resulting in water contamination [220]. Lack of water access can also contribute to household costs and the stress of managing a household, as families must negotiate childcare and caregiving responsibilities with limited water supplies [218]. Lack of safe water can disrupt the functioning and operations of healthcare and aged care facilities. Water scarcity can also contribute to increased social and political tensions between urban and rural communities, regarding appropriate water use and perceived wasted water.		Clear, empathetic communication and recommendations for water use during times of drought will be needed. Households need to have access to a minimum amount of water, at no charge, to allow for general cleanliness and hygiene, and protect the household and community from the spread of infectious disease [152].
Energy supply and infrastructure		Reduced water supply and increased demands for water can mean that there is disruption to power supplies especially if there is a reliance on hydroelectric power. Lack of power can disrupt critical services including healthcare services and hospitals, as well as the supply of power to critical care devices for people with existing health conditions [123]. Storms and wind can damage energy infrastructure resulting in lack of heating, electricity needed for warmth and cooking, and for medical supplies and equipment. Damaged energy infrastructure can cause electrical burns and electrical injuries.	Healthcare services	Water supply and water management planning can prevent the worst impact to energy transmission through drought. Diversification of energy sources to include renewable and localised energy, can create more resilience to climate change events [173]. Improving the affordability of renewable energy sources for communities can strengthen local resilience to climate change events [171].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Crops and livestock	Drought will have an impact on horticulture and livestock, which will impact Māori financially, as Māori have placed significant investment into farming [151]. Ngāi Tahu manage more than 10,000 ha of farm and forestry land in Te Waipounamu, including 9,407 ha of land for beef farming and 6,757 ha of land for dairy farming in Waitaha Canterbury [224]. The increasing cost of food may also affect Māori communities, who already experience higher levels of food insecurity [68].	Drought will impact the productivity of land putting farmers, agricultural workers and rural communities under financial stress [43]. Water insecurity and drought have been shown to have considerable impact on mental health (including depression, anxiety, and increased risk of suicide), particularly in rural communities, and for families and farmers whose livelihoods are dependent on water for growing crops [43]. Drought can increase the cost of food, especially fresh nutritious food. The increasing costs and food insecurity can make fresh foods less available to low-income households, further impacting the health outcomes and health inequities of communities [68]. Drought can also increase pests and mould on crops, which can lead to an increased use in toxic chemicals to manage the pests. The increased use of toxic chemicals such as herbicides, fungicides and insecticides can be harmful to the health of agricultural workers, farmers, and their families, particularly children exposed to the chemicals [167].	Farmers Agricultural workers Low-income households	Growing drought resistant crops may support food security and local economies [123]. Shifts in diet away from processed foods and towards more vegetables, legumes, whole grains and fruit are likely to have health and wider environmental co-benefits [180, 181]- however important to be aware of indigenous rights to food, for example mahinga kai. Support and investment in local farmers and the local food economy may create more diversity and resilience and therefore increase access to nutritional healthy food for communities [167].
Biodiversity and ecosystems	The loss of indigenous biodiversity will likely have adverse impacts on Māori cultural practices, Māori cultural identity, and overall spiritual and mental wellbeing [151]. Access to indigenous biodiversity is important for Māori intergenerational transmission of knowledge, nurturing whakapapa connections and whenua connections. The relationship between Māori and the environment is also important for kaitiakitanga [151].	Biodiversity loss has both direct and indirect consequences on human health, for example, biodiversity is essential for soil health and agriculture, fresh water, clear air, and naturally-sourced medicines [206]. Climate change impacts to biodiversity are likely to have negative impacts to well-being, physical and mental health. Engaging with natural environments has been shown to reduce stress, restore attention, increase positive feelings and mood, and reduce depressive symptoms [207].		Protecting and conserving biodiversity is an essential strategy for protecting human health and wellbeing. New planting areas, including public spaces such as streets and parks, should be planned with the changing climate in mind. This includes the careful selection of plant varieties which will tolerate and be suitable for warmer temperatures and droughts [208].
Direct	Changing water flow in rivers may also impact Māori recreational activities including sporting events such as Waka Ama [151].	Drought can directly contribute to respiratory health issues and exacerbate existing ear, eye, or throat conditions through dry conditions and wind causing dust storms [43]. Drought results in more airborne dust and particulate pollution which has negative cardiovascular outcomes, especially in adults over the age of 65 [167].	Children Older Adults People with physical health needs People with mental health needs Disabled People Farmers	Development of drought risk reduction policies and drought preparedness plans can help reduce the health and wellbeing impacts of drought [226]. Understanding the social impacts of drought can enable more

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		Poor air quality due to drought can lead to an increase in emergency department visits and hospitalisations for people with asthma or other respiratory diseases [167]. Drought can also impact the wellbeing of individuals and communities by impacting their recreational activities for example gardening or water sports [225]. The drying of the land is also associated with mental distress, especially for communities or individuals that have a strong attachment to the land [220]. Climate change has significant impacts on mental health and wellbeing, from both the impacts of climate change events, such as a storm or flood event, and from the incremental changes and losses that communities may experience due to climate change. Additionally, the overall threat of climate change and climate events can create feelings of hopelessness and despair, due to the magnitude and complexity of the threat of climate change [188].	Gardeners Healthcare services People without access to internet People without access to phone	targeted messaging to vulnerable communities and groups to support drought education and behaviour changes [227]. Clear, empathetic communication and recommendations for water use during times of drought will be needed. Public education and support on managing and planning for drought (for example, recycling grey water) also needs to be provided to reduce the worst impacts of drought. Ongoing monitoring of water quality during times of drought is required as well as provision of health warnings when necessary [220]. Pro-active and protective actions regarding efficient and effective water use by industry are also necessary to mitigate the potential impacts of drought and to ensure sufficient water access for the population of Waitaha. Planning responses to the mental health impacts and consequences of climate change is critical as climate change magnifies risks to mental health. Additionally, responses need to consider both direct mental health impacts, for example from a flooding event, as well as indirect impacts that relate to damaged infrastructure or loss of employment due to climate change. Further, responses are

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
				needed for the potential and pervasive threat of climate change that can contribute to eco-anxiety, hopelessness, and despair, particularly for children and young people [188].

Fires

The impacts of climate-related hazards on human health and wellbeing are complex and compounding, with many inter-related causal pathways. Table 19 is focused on the impacts of fires. The infrastructure, economic, biodiversity and direct impacts of fires are noted in the first column (e.g. housing and communities). These impacts are used to inform the focus of the content explored in 'Te Ao Māori lens' and the 'Health / Wellbeing Impact' columns. The 'Most Affected Population Groups' column outlines some of the population groups who are more likely to be impacted by the climate-related hazard. It is important to note that these population groups are largely similar across the hazards and impacts. Finally, possible adaptive and mitigating responses can be found in the last column, all of which are directly or indirectly beneficial to health and wellbeing.

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Table 19: Impacts, population groups and responses – Fires

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Housing and communities	Wildfires can damage or destroy important cultural infrastructure, including marae and kainga [151].	In Aotearoa there are 3000-4000 wildfires per year, and the Canterbury region over 2020-2022 has had one of the highest rates of wildfire in the country. Wildfires are most likely to take place in areas of rural-urban interface, areas where there are pockets of housing surrounded by bush, farmland or lifestyle blocks, such as the area around the Port Hills impacted by the wildfire in 2017. The Port Hills wildfire resulted in loss of nine houses, damage to five lifestyle blocks, and the burning of 1661 hectares of land [228, 229]. More housing at the urban fringe could result in higher losses of life and loss of property from wildfires in the future [229]. Communities in Canterbury are at a high risk of negative health and wellbeing impacts of wildfire including acute burns, mortality, loss of housing and important community infrastructure and loss of essential services [230]. The mental health of residents living in wildfire-prone areas or who have lost their home to a wildfire can experience negative mental health outcomes, including higher levels of mental distress, anxiety, general anxiety disorder, and post-traumatic stress disorder [231]. Lack of emergency planning or shelter for family animals and pets can negatively impact wellbeing and also strongly influence decision-making of households. In New Zealand, 64% of households	Emergency response workers and volunteers Children Older adults People with physical health needs People with mental health needs Disabled people Low-income households Homeowners without insurance/ under-insured Business owners Displaced residents	Strong community networks and relationships can reduce the risk and harms caused by wildfires. Local knowledge and community networks increase the adaptive capacity and response to wildfire events [232]. Community engagement needs to be prioritised in reduction, readiness, response, and recovery of wildfire events [233]. Clear and regular communications are reassuring and helpful to community members, especially during a wildfire event [233]. Fire risk awareness, experience of fire, and community education around wildfires can protect against

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		have at least one companion animal [145], and often emergency accommodation or temporary accommodation post-flood event may not allow pets. Separating pets from families can cause mental distress and adds to further loss experienced by families. During Hurricane Katrina, 44% of people who remained in their home, even after being encouraged to evacuate, did so in part because they were not allowed to take their animal companions with them [146] Similarly, in Victoria Australia in 2009, family members returned to protect or save their animals from wildfire and in some cases tragically died from taking this risk.		the harmful health impacts of wildfires [229]. Encouraging and enhancing social connectedness, social cohesion, and social networks in a community ensures greater community resilience and protects against the worst health and wellbeing outcomes from climate change. Strong community ties can provide closer monitoring, assistance, and support to community members who will be most affected by climate change [67]. Allocating emergency funding that supports families with fewer resources to keep their companion animals with them or in a temporary shelter will support mental health and wellbeing and ensure that households do not suffer the additional loss of their companion animal. Additionally, encouraging landlords to allow pets can make it easier for families and households with pets to find accommodation after a flood event.
Transport infrastructure		Active wildfire can reduce accessibility to critical services and make transportation difficult due to poor visibility from the smoke [234]. Lack of accessibility to roads due to wildfire can impact evacuation efforts [234].		Prior emergency planning and preparation with key Emergency Services and Civil Defence are essential, especially for communities which have limited evacuation routes [235].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Water quality and infrastructure		There is a risk of ash and fire debris contaminating water supplies, equally there can be a reduction in available water that can be accessed due to a wildfire [43]. Water infrastructure can also be directly destroyed or damaged by fire leading to health issues associated with lack of water [43]. Lack of water access or contaminated water in households due to damaged wastewater treatment processes can lead to an increased risk of gastrointestinal illnesses and infectious diseases [168]. Lack of water access can also contribute to household costs and the stress of managing a household, as families must negotiate childcare and caregiving responsibilities with limited water supplies [218]. Lack of safe water can disrupt the functioning and operations of healthcare and aged care facilities [168] .		Water supply and water management planning and development are needed to provide immediate health protection and gains to communities most likely to be affected by a wildfire event [151]. Clear, empathetic communication and recommendations for water use during a wildfire event will be needed. Households need to have access to a minimum amount of water, at no charge, to allow for general cleanliness and hygiene, and protect the household and community from the spread of infectious disease [152].
Energy supply and infrastructure		Wildfires can damage energy infrastructure, resulting in power cuts. Lack of power can disrupt critical services including healthcare services and hospitals, as well as the supply of power to critical care devices for people with existing health conditions [123]. Damage to energy infrastructure and power cuts can result in lack of electricity needed for cooling and cooking, to power computers and home appliances, lighting, and for medical supplies and equipment [123, 171].		
Crops and livestock	The increasing cost of food may affect Māori communities, who already experience higher levels of food insecurity [68].	Crops could be destroyed, and livestock killed from a wildfire, potentially resulting in increased costs of animal products and increase food insecurity [151]. Additionally, the loss of livelihood could have significant consequences on wellbeing, health, and financial security of farmers, agricultural workers, and rural communities.		Shifts in diet away from processed foods and towards more vegetables, legumes, whole grains and fruit are likely to have health and wider environmental co-benefits [180, 181]-However, it is critical to account for and enable indigenous rights to food, for example mahinga kai.

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
Biodiversity and ecosystems	Wildfires could destroy areas of biodiversity and taonga species, which could have significant cultural, spiritual, and economic wellbeing implications for Māori.	Wildfires can damage or destroy significant areas of biodiversity. Negative impacts to biodiversity are likely to have negative impacts to wellbeing, as well as to physical and mental health. Engaging with natural environments has been shown to reduce stress, restore attention, increase positive feelings and mood, and reduce depressive symptoms [207]. Due to damage from wildfires, access to natural environments may be impacted, reducing community access to physical and recreational activities [207]. The natural environment also provides food, fresh water and can help regulate air quality, pollination, and pests and vector-borne diseases; damage to ecosystems can have harmful consequences to human health [207].		Fire-resistant planting, including some native planting, can help to reduce risk of fires and prevent the spread of fires [236].
Landfills and contaminated land	Landfills and areas of contaminated land are at risk of fires. This can mean that nearby areas and ecosystems are polluted with waste, impacting Māori physical, social, spiritual, cultural and economic wellbeing [151].	Landfill fires pose serious health impacts as they can emit toxic smoke and gases from the combustion of the wide range of materials contained within the landfill. In particular, carbon monoxide, hydrogen sulphide, volatile organics can aggravate pre-existing pulmonary conditions, cause respiratory distress and contribute to the development of long-term health conditions [237].	Emergency response workers and volunteers	To reduce the risk of fires in landfills, it is important that landfill sites are engineered with fire suppression technology and have fire management equipment on site. It is also important that landfills are closely monitored to prevent fire and manage any potential fire sources [238].
Direct	Wildfire smoke is more likely to negatively impact Māori health and communities as Māori have higher rates of asthma and respiratory or cardiovascular illness [98, 151].	Wildfire care result in acute burns and injury, mortality, loss of housing and damage to important community infrastructure and essential services [230]. The smoke from wildfires can impact air quality and therefore the health of communities. Wildfire smoke has a significant amount of particulate matter and toxic gases within it which are especially harmful to those with respiratory and cardiovascular conditions. This will also likely result in an increase in hospitalisations and presentations to emergency departments [239, 240]. Smoke from wildfires can also increase the risk of cancer developing in the long-term in individuals who have been exposed to toxic compounds in the air [241].	Emergency response workers and volunteers Children Pregnant people Older Adults People with physical health needs People with mental health needs Disabled people Low-income households Homeowners without insurance/ under-insured Business owners Displaced residents	The Port Hills Independent Operational Review highlighted several key recommendations and actions for managing a wildfire response including the need for emergency services to have good inter-operability with a single incident management system that is well practiced and ensuring that community is at the centre of emergency management and response [233].

Infrastructure / Economic / Biodiversity Impact	Te Ao Māori Lens	Health / Wellbeing Impact	Most Affected Population Groups	Responses
		Wildfire smoke can also cause eye irritation and scratches on the cornea, as well as reduced visibility overall which has led to car accidents in wildfire events [239]. Climate change has significant impacts on mental health and wellbeing, from both the impacts of climate change events, such as a storm or flood event, and from the incremental changes and losses that communities may experience due to climate change. Additionally, the overall threat of climate change and climate events can create feelings of hopelessness and despair, due to the magnitude and complexity of the threat of climate change [188].		Early warning systems are essential to identify fires and reduce health risks of exposure to wildfire and smoke. Planning responses to the mental health impacts and consequences of climate change is critical as climate change magnifies risks to mental health. Additionally, responses need to consider both direct mental health impacts, for example from a flooding event, as well as indirect impacts that relate to damaged infrastructure or loss of employment due to climate change. Further, responses are needed for the potential and pervasive threat of climate change that can contribute to eco-anxiety, hopelessness, and despair, particularly for children and young people [188].

Conclusions

Climate change impacts health and wellbeing

Climate change is a global and local public health emergency. It poses both a major threat and a major opportunity for planetary health and health equity. Addressing the threat and realising the opportunity to improve health requires action by governments and non-government organisations at all levels and will only be achieved in close collaboration with the community. More progress is needed to ensure that action is delivered at the scale and pace required to prevent the most significant impacts that could arise as a result of climate change. Figure 15 outlines the main categories of climate hazards and health and wellbeing impact pathways, including those that are direct, indirect, and those that affect (or act through) the social determinants of health and wellbeing.

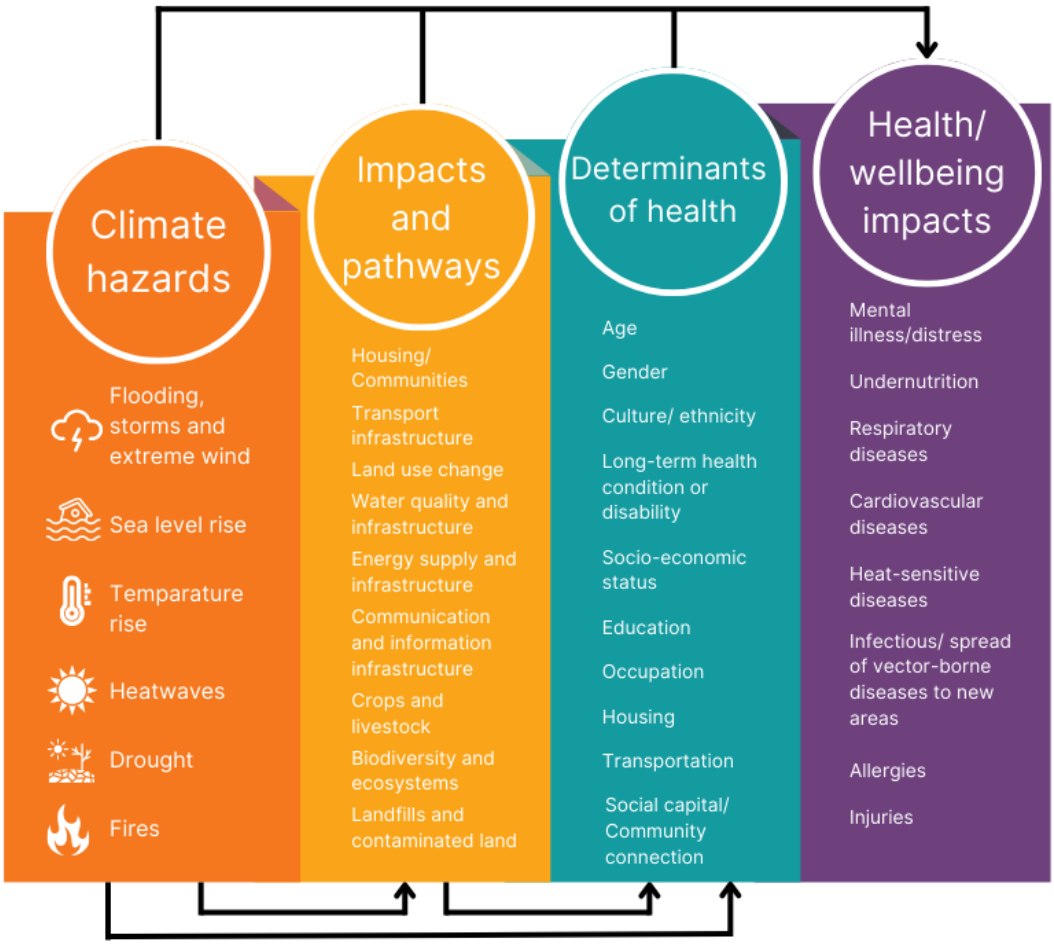


Figure 15: Direct and indirect effects of climate change on health and wellbeing

The figure shows how climate change poses a range of threats to human health and survival in multiple, interacting ways. Impacts can be direct (e.g., injuries during extreme weather events such as a storms and floods) or indirectly mediated through the effects of climate change on ecosystems (e.g., agricultural losses/undernutrition and changing patterns of disease) [37, 40].

People will experience the impacts of climate change in different ways

Across Waitaha Canterbury, people and communities differ in their exposures, their inherent sensitivity, and their adaptive capacity to respond to and cope with climate change-related health and wellbeing threats. In many cases, the most affected people are those who already experience inequitable health and wellbeing outcomes, including those with physical and mental health needs, disabled people, older adults, children, low-income households, and Māori. Generally, those who have historically contributed the least to current climate change (in terms of emissions) are disproportionately affected.

Response Priorities

Climate change responses, including both mitigation and adaptation planning, need to be focused on health, wellbeing, and equity to achieve the best outcomes for communities and populations in Waitaha Canterbury. Summarised below are several key climate responses which, if prioritised, will contribute to improved and more equitable health and wellbeing outcomes.

Working Collaboratively with Communities

Plans, processes and policies must be collaborative and integrated, as the responsibility for reducing the risks of climate change falls across a range of organisations, agencies and roles. Utilising an approach such as Health in All Policies enables public policies to systematically account for the health and equity impacts of processes and plans.

In addition, climate-related plans, processes and policies must incorporate community-led climate change adaptation and mitigation, which supports community wellbeing, agency, and resilience. Decision-makers and policymakers need to work with communities to strengthen communities, build trust and cohesion, and avoid top-down decision making. Working in partnership enables the context and values of communities to be represented, and allows communities to better engage in and influence local and regional decision making.

Equity and Te Ao Māori

Climate responses must embed Te Ao Māori values, realities, and practices to honour and uphold Te Tiriti o Waitangi. Significantly, this involves maintaining and promoting relational links with whenua, enhancing tūrangawaewae and tino rangatiratanga, as well as enabling the transmission of mātauranga Māori. This 'embedding' can only be achieved through meaningful partnership with Māori and a full understanding of kaitiakitanga, and the rights and reponsibilities of guardianship and stewardship. Embedding these fundamentals must be enacted at all levels of planning and decision making.

Social Connectedness and Mental Health

Encouraging and enhancing social connectedness, social cohesion, and social networks in a community ensures greater community resilience and protects against the worst health and wellbeing outcomes from climate change. Strong community ties can provide closer monitoring, assistance, and support to community members who will be most affected by climate change.

Planning responses to the mental health impacts and consequences of climate change is critical as climate change magnifies risks to mental health. Responses need to consider both direct mental health impacts, for example from a flooding event, as well as indirect impacts that relate to damaged infrastructure or loss of employment due to climate change. Further, responses are needed for the potential and pervasive threat of climate change that can contribute to eco-anxiety, and hopelessness and despair, particularly for children and young people.

Urban Infrastructure and Housing

New housing and infrastructure needs to be designed to be resilient to the changing climate. This may mean changes to land-use policies as well as consideration of materials used in building new housing. Similarly, urban infrastructure and environment planning and design must be informed by likely climate impacts. Responses considering urban design and infrastructure provide the potential to provide significant, long-term and immediate benefits to health and wellbeing of communities.

Natural Environments, Green Spaces and Biodiversity

Responses that focus on protecting and restoring natural environments, the creation of green spaces, and enhancing biodiversity will co-benefit human health and wellbeing. Human health and wellbeing is dependent on environmental health, and the understanding of this crucial relationship must be evidenced in all responses, plans and policies.

Transport

De-carbonising the transport system is an important and necessary way to reduce emissions and mitigate climate change [165]. Critically, this involves pro-active investment in infrastructure and programmes to support the increase in active and public transport options.

Next Steps

This scoping and profiling interim report is not a completed Health Impact Assessment (HIA), as the assessment/quantification of the identified impacts is yet to be undertaken for Waitaha Canterbury. However, the report collates and summarises key information to help local planners and decision makers plan for health and wellbeing risks of climate change in Waitaha Canterbury.

Following this report, the next steps include the development of a report summary and summarised versions of tables 14-19: which outline the impacts, population groups and responses related to climate hazards. In addition, infographics based on the information explored in this report will be developed to display this information in an alternative and accessible way. Further, opportunities for future work will be discussed with local councils and organisations to inform the priorities for next steps.

References

1. Christchurch City Council (2021) What's climate change? Why did the Council declare a climate emergency? Christchurch.
2. Public Health England (1999) Gothenburg Consensus paper available at HIA Gateway: Public Health England.
3. The Royal Australasian College of Physicians (2016) *Climate Change and Health Position Statement*. Sydney NSW 2000, Australia: The Royal Australasian College of Physicians.
4. Department of Health and Human Services (2020) *Tackling climate change and its impacts on health through municipal public health and wellbeing planning:Guidance for local government, 2020* State of Victoria, Australia: Health Protection Branch, Department of Health and Human Services.
5. WHO. The Ottawa Charter for Health Promotion; 1986; Ottawa. World Health Organization.
6. Huber M, Knottnerus JA, Green L, Horst Hvd, Jadad AR, et al. (2011) How should we define health? *BMJ* 343: d4163.
7. Barton H,Grant M (2006) A health map for the local human habitat. *The Journal of the Royal Society for the Promotion of Health* 126: 252-253.
8. Dahlgren G,Whitehead M (1991) Policies and strategies to promote social equity in health. Stockholm: Institute for Future Studies.
9. Barton H,Grant M (2006) A health map for the local human habitat: developed from the model by Dahlgren and Whitehead, 1991. *The Journal for the Royal Society for the Promotion of Health* 126: 252-253.
10. Macintyre S (1994) Understanding the social patterning of health: the role of the social sciences. *Journal of Public Health Medicine* 16: 53-59.
11. Marmot M,Wilkinson R, editors (2006) Social Determinants of Health. 2 ed. Oxford: Oxford University Press. 376 p.
12. Wilkinson R,Marmot M, editors (2003) Social determinants of health: The solid facts. 2 ed. Copenhagen: World Health Organization.
13. Marmot M (2004) Social Causes of Social Inequalities in Health In: Anand, S, Peter, F,Sen., AK, editors. *Public health, ethics, and equity*. Oxford: Oxford University Press on Demand.
14. Marmot M, Allen J, Bell R, Bloomer E,Goldblatt P (2012) WHO European review of social determinants of health and the health divide. *Lancet* 380: 1011-1029.
15. Marmot M,Bell R (2012) Fair society, healthy lives. *Public Health* 126: S4-10.
16. Diderichsen F, Evans T,Whitehead M (2001) 12The Social Basis of Disparities in Health. Challenging Inequities in Health: From Ethics to Action: Oxford University Press. pp. 0.
17. Dahlgren Gr, Whitehead M,World Health Organization. Regional Office for E (2006) Levelling up (part 2) : a discussion paper on European strategies for tackling social inequities in health / by Göran Dahlgren and Margaret WHitehead. Copenhagen : WHO Regional Office for Europe.
18. Diderichsen F, Andersen I, Manuel C, Andersen AM, Bach E, et al. (2012) Health inequality--determinants and policies. *Scand J Public Health.* 40: 12-105. doi: 110.1177/1403494812457734.
19. Diderichsen F,Hallqvist JJIihaSpSSCfSR (1998) Social inequalities in health: some methodological considerations for the study of social position and social context. 25-39.
20. Rockstrom J, Steffen W, Noone K, Persson A, Chapin FS, 3rd, et al. (2009) A safe operating space for humanity. *Nature* 461: 472-475.
21. IPCC (2014) *Summary for policy makers. Contribution of working group II to the fifth assessment report of the Intergovernmental Panel on Climate Change: impacts, adaptation, and vulnerability*.
22. Lee K, Yach D,Kamradt-Scott A (2012) Global health diseases, programs, systems and policies. In: Merson, MH, Black, RE,Mills, AJ, editors. *Globalization and health*. Burlington, MA: Jones and Bartlett Learning. pp. 885-913.
23. Stern N (2006) *Stern review on the economics of climate change*. London: Blackwell Publishing.
24. Hibbard KA, Crutzen P,Lambin EF (2007) The great acceleration. In: Costanza, R, Graumlich, LJ,Steffen, W, editors. *Sustainability or collapse? An integrated history and future of people on earth: Dahlem Workshop Report 96*. Cambridge, MA: MIT Press. pp. 417-446.

25. McNeill J,Engelke P (2014) The great acceleration: an environmental history of the anthropocene since 1945. In: Iriye, A, editor. *Global Interdependence: The world after 1945*. Cambridge: Harvard University Press.
26. Costello A, Abbas M, Allen A, Ball S, Bell S, et al. (2009) Managing the health effects of climate change: Lancet and University College London Institute for Global Health Commission. *Lancet* 373: 1693-1733.
27. IPCC (2014) *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)* Geneva, Switzerland. 151 p.
28. Labonte R, Mohindra K,Schrecker T (2011) The growing impact of globalization for health and public health practice. *Annu Rev Public Health* 32: 263-283.
29. McMichael AJ (2013) Globalization, climate change, and human health. *N Engl J Med* 368: 1335-1343.
30. McMichael AJ,Lindgren E (2011) Climate change: present and future risks to health, and necessary responses. *J Intern Med* 270: 401-413.
31. Shindell DT (2015) The social cost of atmospheric release. *Clim Change* 130.
32. The Royal Society of New Zealand (2016) *Climate change implications for New Zealand*. Wellington: The Royal Society of New Zealand.
33. WHO,Health Care Without Harm (2009) *Healthy hospitals, healthy planet, healthy people. Addressing climate change in health care settings*. Geneva: World Health Organization.
34. IPCC (2022) *Sixth Assessment Report: contributions of the Working Group I (the physical science basis), Working Group II (impacts, adaptation and vulnerability) and Working Group III (mitigation) to the Sixth Assessment Report (AR6) of the IPCC*: IPCC.
35. IPCC, H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, et al. (2022) Summary for Policymakers. In: H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, et al., editors. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK and New York NY, USA: Cambridge University Press. pp. 3–33.
36. IPCC (2018) *Global warming of 1.5°C. An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. In Press.*
37. IPCC (2023) *Synthesis reoprt of the IPCC sixth assessment report (AR6): Summary for Policymakers*: IPCC.
38. IPCC (2018) *IPCC special report on global warming of 1.5º C, summary for policymakers. 48th Session of the IPCC*. Incheon, South Korea: IPCC.
39. Watts N, Adger WN, Agnolucci P, Blackstock J, Byass P, et al. (2015) Health and climate change: policy responses to protect public health. *Lancet* 386: 1861-1914.
40. NIWA Taihoro Nukurangi (2022) Annual Climate Summary 2022.
41. Thomas R, Graven H, Hoskins B,Prentice IC (2016) *What is meant by 'balancing sources and sinks of greenhouse gases' to limit global temperature rise? Grantham Institute Briefing Note No 3*. Grantham Institute.
42. Watts N, Amann M, Ayeb-Karlsson S, Belesova K, Bouley T, et al. (2018) The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. *The Lancet* 391: 581-630.
43. Weeramanthri TS, Joyce S, Bowman F, Bangor-Jones R,Law C (2020) *Climate Health WA Inquiry: Final Report*: Department of Health, Government of Western Australia.
44. IPCC (2007) Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In: Parry, ML, Canziani, OF, Palutikof, JP, Linde, PJVD,Hanson, CE, editors. Cambridge, UK: Cambridge University Press.
45. IPCC (2012) Managing the risks of extreme events and disasters to advance climate change adaptation. In: Field CB, BV, Stocker TF, Qin D, Dokken DJ, Ebi KL, editor. *A special report of working groups I*

and II of the intergovernmental panel on climate change. Cambridge, United Kingdom and New York, USA: Cambridge University Press. pp. 582.
46. Cardona OD (2004) The need for rethinking the concepts of vulnerability and risk from a holistic perspective: A necessary review and criticism for effective risk management. In: Bankoff, G, Frerks, G,Hilhorst, D, editors. *Mapping Vulnerability: Disasters, Development and People*. London, UK,: Earthscan Publishers. pp. 37-51.
47. Cardona OD (2006) A system of indicators for disaster risk management in the Americas. In: Birkmann, J, editor. *Measuring Vulnerability to Hazards of Natural Origin: Towards Disaster Resilient Societies*. Tokyo, Japan: UNU Press. pp. 189-209.
48. Cardona OD (2011) Disaster risk and vulnerability: Notions and measurement of human and environmental insecurity. In: Brauch, HG, Spring, UO, Mesjasz, C, Grin, J, Kameri-Mbote, P, et al., editors. *Coping with Global Environmental Change, Disasters and Security – Threats, Challenges, Vulnerabilities and Risks*. Berlin, Germany: Springer Verlag. pp. 107-122.
49. Rising J, Tedesco M, Piontek F,Stainforth DA (2022) The missing risks of climate change. *Nature* 610: 643-651.
50. Simpson NP, Mach KJ, Constable A, Hess J, Hogarth R, et al. (2021) A framework for complex climate change risk assessment. *One Earth* 4: 489-501.
51. IPCC.,H.-O. Pörtner DCR, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama, editors (2022) Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA: Cambridge University Press. 3056 p.
52. Lawrence J, Mackey B,et al. (2021) *Chapter 11: Australasia. 2021 Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom.
53. Cradock-Henry NA (2017) New Zealand kiwifruit growers' vulnerability to climate and other stressors. *Regional Environmental Change* 17: 245-259.
54. Cradock-Henry NA, Connolly J, Blackett P,Lawrence J (2020) Elaborating a systems methodology for cascading climate change impacts and implications. *MethodsX* 7: 100893.
55. Lawrence J, Bell R,Stroombergen A (2019) A Hybrid Process to Address Uncertainty and Changing Climate Risk in Coastal Areas Using Dynamic Adaptive Pathways Planning, Multi-Criteria Decision Analysis & Real Options Analysis: A New Zealand Application. Sustainability.
56. Ministry for the Environmen (2020) *National Climate Change Risk Assessment for Aotearoa New Zealand: Main report – Arotakenga Tūraru mō te Huringa Āhuarangi o Āotearoa: Pūrongo whakatōpū.* : Ministry for the Environment.
57. Glavovic BC. The 2004 Manawatu Floods, New Zealand: Integrating Flood Risk Reduction and Climate Change Adaptation; 2014.
58. Paulik R, Stephens SA, Bell RG, Wadhwa S,Popovich B (2020) National-Scale Built-Environment Exposure to 100-Year Extreme Sea Levels and Sea-Level Rise. Sustainability.
59. Storey B, Owen S, Noy I,Zammit C (2020) *Insurance Retreat: Sea level rise and the withdrawal of residential insurance in Aotearoa New Zealand. Report for the Deep South National Science Challenge, December 2020*: Deep South National Science Challenge.
60. Roy J, Prakash A, Some S, Singh C, Bezner Kerr R, et al. (2022) Synergies and trade-offs between climate change adaptation options and gender equality: a review of the global literature. *Humanities and Social Sciences Communications* 9: 251.
61. Smith KR, Woodward A, Campbell-Lendrum D, Chadee DD, Honda Y, et al. (2014) Human health: impacts, adaptation, and co-benefits In: Field, CB, Barros, VR, Dokken, DJ, Mach, KJ, Mastrandrea, MD, et al., editors. *Climate change 2014: impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change*. Cambridge, United Kingdom and New York, USA: Cambridge University Press. pp. 709–754.
62. McMichael A, Campbell-Lendrum D, Kovats S, Edwards S, Wilkinson P, et al. (2014) Comparative quantification of health risks: global and regional burden of disease due to selected major risk

factors. In: Ezzati M, LA, Rodgers A, Murray CJL, editor. *Global climate change*. Geneva, Switzerland: World Health Organization.
63. Vardoulakis S, Dear K, Hajat S, Heaviside C, Eggen B, et al. (2014) Comparative assessment of the effects of climate change on heat- and cold-related mortality in the United Kingdom and Australia. *Environ Health Perspect.* 122: 1285-1292. doi: 1210.1289/ehp.1307524. Epub 1302014 Sep 1307515.
64. Marmot M (2005) Social determinants of health inequalities. *Lancet.* 365: 1099-1104. doi: 1010.1016/S0140-6736(1005)71146-71146.
65. Patz JA, Gibbs HK, Foley JA, Rogers JV,Smith KR (2007) Climate Change and Global Health: Quantifying a Growing Ethical Crisis. *EcoHealth* 4: 397-405.
66. Commission on Social Determinants of Health (2008) *Commission on Social Determinants of Health 2008. Closing the gap in a generation: health equity through action on the social determinants of health. Final Report of the Commission on Social Determinants of Health*. Geneva: World Health Organization.
67. Bennett H, Jones R, Keating G, Woodward A, Hales S, et al. (2014) Health and equity impacts of climate change in Aotearoa-New Zealand, and health gains from climate action. *NZM J* 127.
68. Jones R, 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: 54-68.
69. World Health Organization (2012) Atlas of health and climate.
70. Burke M, Hsiang SM,Miguel E (2015) Global non-linear effect of temperature on economic production. *Nature* 527: 235-239.
71. Venn A (2019) 24 - Social justice and climate change☆. In: Letcher, TM, editor. *Managing Global Warming*: Academic Press. pp. 711-728.
72. United Nations (1992) *Framework Convention on Climate Change (UNFCCC). The Parties 9/5/1992, the United Nations Conference on Environment and Development (UNCED), the Earth Summit*. Rio de Janeiro from 3 to 14 June 1992.
73. United Nations (2015) *Framework Convention on Climate Change: Paris Agreement. Adoption of the Paris Agreement Conference of the Parties 12/12/2015. Paris, UNFCCC*.
74. IPCC (2014) *Climate Change: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Field, CB, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, et al., editors. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. 1132 p.
75. Reisinger A, Kitching RL, Chiew F,et al. (2014) *Australasia. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom.
76. Howden-Chapman P, Chapman R, Hales S, Britton E,Wilson N (2010) Climate Change and Human Health: Impact and Adaptation Issues for New Zealand. In: Nottage, R, Wratt, D, Bornman, J,Jones, K, editors. *Climate Change Adaptation in New Zealand: Future Scenarios and Some Sectoral Perspectives*. Wellington: New Zealand Climate Change Centre.
77. Friel S, Chopra M,Satcher D (2007) Unequal weight: equity oriented policy responses to the global obesity epidemic. *BMJ* 335: 1241-1243.
78. Marmot M, Friel S, Bell R, Houweling TA,Taylor S (2008) Closing the gap in a generation: health equity through action on the social determinants of health. *Lancet* 372: 1661-1669.
79. Climate Change Adaptation Technical Working Group (2017) *Adapting to Climate Change in New Zealand: Stocktake Report from the Climate Change Adaptation Technical Working Group*. Wellington: Ministry for the Environment.
80. The Royal Society Te Apārangi (2017) *Human Health Impacts of Climate Change for New Zealand: Evidence Summary*. Wellington: The Royal Society Te Apārangi,.
81. Chapman R,Boston J (2007) The social implications of decarbonising the New Zealand economy. *Social Policy Journal of New Zealand* 31: 104-136.
82. Hassan FA (2009) Human agency, climate change, and culture: an archaeological perspective. In: Crate, SA, Nuttall, M, American Anthropological, A,Society for Applied, A, editors. *Anthropology and climate change: from encounters to actions*. Walnut Creek, Calif: Left Coast Press. pp. 39-69.

83. World Health Organization (2018) *COP24 special report: health and climate change*. Katowice, Poland: World Health Organization. 73 p.
84. Te Rūnanga o Ngāi Tahu (2022) *Te Kounga Paparangi*. Christchurch: Te Rūnanga o Ngāi Tahu | Ngāi Tahu Climate Change Action Plan.
85. Ministry for the Environment,Stats NZ (2020) New Zealand's Environmental Reporting Series: Our atmosphere and climate 2020.
86. Khan M, Abimbola S, Aloudat T, Capobianco E, Hawkes S, et al. (2021) Decolonising global health in 2021: a roadmap to move from rhetoric to reform. *BMJ Global Health* 6: e005604.
87. Chandanabhumma PP,Narasimhan S (2020) Towards health equity and social justice: an applied framework of decolonization in health promotion. *Health Promot Int.* 35: 831-840. doi: 810.1093/heapro/daz1053.
88. Jones R (2019) Climate change and Indigenous Health Promotion. *Glob Health Promot.* 26: 73-81. doi: 10.1177/1757975919829713.
89. Jones R, Macmillan A,Reid P (2020) Climate Change Mitigation Policies and Co-Impacts on Indigenous Health: A Scoping Review. *Int J Environ Res Public Health.* 17: 9063. doi: 9010.3390/ijerph17239063.
90. Wilson AW,Yellow Bird M, editors (2005) Beginning decolonization. Santa Fe, NM: School of American Research. 1–18 p.
91. Denzin N,Lincoln Y (2008) Introduction: critical methodologies and indigenous inquiry. In: Denzin, N, Lincoln, Y,Smith, LT, editors. *Handbook of critical and Indigenous methodologies*. Los Angeles, CA: Sage Publications. pp. 1–20.
92. Smith L (2012) *Decolonising methodologies: research and Indigenous peoples*. London, UK: Zed Books Ltd.
93. Came H (2012) Institutional racism and the dynamics of privilege in public health. (Unpublished doctorate). Hamilton, New Zealand: Waikato University.
94. Heke D, Came H, Birk M,Gambrell K (2022) Exploring anti-racism within the context of human resource management in the health sector in Aotearoa. *International Journal of Critical Indigenous Studies* 14: 114-132.
95. Berghan G, Came H, Coupe N, Doole C, Fay J, et al. (2017) *Tiriti-based health promotion practice*. Auckland, Aotearoa New Zealand: STIR: Stop Institutional Racism.
96. Ford JD (2012) Indigenous health and climate change. *Am J Public Health Res Pract* 102: 1260–1266.
97. Ford JD, Sherman M, Berrang-Ford L, Llanos A, Carcamo C, et al. (2018) Preparing for the health impacts of climate change in Indigenous communities: The role of community-based adaptation. *Global Environmental Change* 49: 129-139.
98. Jones R, Bennett H, Keating G,Blaiklock A (2014) Climate change and the right to health for Māori in Aotearoa/New Zealand. *Health Hum Rights.* 16: 54-68.
99. Nilsson C (2008) Climate change from an indigenous perspective: key issues and challenges. *Indigenous Affairs* 1-2: 8–15.
100. Ministry of Health (2015) *Tatau Kahukura: Māori Health Chart Book 2015*. Wellington, New Zealand.
101. Baker MG, Barnard LT, Kvalsvig A, Verrall A, Zhang J, et al. (2012) Increasing incidence of serious infectious diseases and inequalities in New Zealand: a national epidemiological study. *Lancet.* 379: 1112-1119. doi: 1110.1016/S0140-6736(1111)61780-61787. Epub 62012 Feb 61720.
102. Ministry of Health (2016) *Health loss in New Zealand1990–2013: a report from the New Zealand Burden of Diseases, Injuries and Risk Factors Study*. Wellington, New Zealand: Ministry of Health.
103. Royal Society Te Apārangi (2017) *Human health impacts of climate change for New Zealand: evidence summary*. Wellington, New Zealand: Royal Society Te Apārangi.
104. Davis P, Lay-Yee R, Dyall L, Briant R, Sporle A, et al. (2006) Quality of hospital care for Māori patients in New Zealand: retrospective cross-sectional assessment. *Lancet.* 367: 1920-1925. doi: 1910.1016/S0140-6736(1906)68847-68848.
105. Awatere S, King DN, Reid J, Williams L, Masters-Awatere B, et al. (2021) *He huringa āhuarangi, he huringa ao: A changing climate, a changing world. Contract Report: LC3948 Prepared for Ngā Pae o te Māramatanga*. Landcare Research.

106. Government of New Zealand (2019) *The Wellbeing Budget 2019*. Wellington: Treasury; Government of New Zealand.
107. Williams D, Garbutt B,Peters J (2015) Core Public Health Functions for New Zealand. *N Z Med J.* 128: 16-26.
108. Iorns Magallanes C (2019) *Treaty of Waitangi duties relevant to adaptation to coastal hazards from sea-level rise. Research Report for the Deep South National Science Challenge, 190*
109. Ihirangi (2021) *Exploring An Indigenous Worldview Framework for the National Climate Change Adaptation Plan: Brief Summary Document*. Wellington: Ihirangi.
110. Ministry for the Environment (2022) *Draft national adaptation plan*. Wellington: Ministry for the Environment Manatū Mō Te Taiao.
111. Ministry for the Environment (2022) *Aotearoa New Zealand's first national adaptation plan*. Wellington: Ministry for the Environment.
112. Kyoto Protocol (1997) *Kyoto Protocol to the United Nations Framework Convention on Climate Change. Secretary-General of the United Nations. Kyoto, Japan.* .
113. UNFCCC. (2015) Conference of the Parties, Twenty-first session, Paris, 30 November to 11 December 2015. Adoption of the Paris Agreement Conference of the Parties 12/12/2015. Paris: United Nations Framework Convention on Climate Change.
114. United Nations General Assembly (2015) *Resolution adopted by the General Assembly on 25 September 2015, Transforming our world: the 2030 Agenda for Sustainable Development*.
115. Saunders WSA, Kelly S, Paisley S,Clarke LB (2020) Progress Toward Implementing the Sendai Framework, the Paris Agreement, and the Sustainable Development Goals: Policy from Aotearoa New Zealand. *International Journal of Disaster Risk Science* 11: 190-205.
116. World Health Organization (1999) *London declaration on action in partnership. third ministerial conference on environment and health, London, 16-18 June 1999*. Copenhagen, Denmark: WHO Regional Office for Europe.
117. Fox M, Zuidema C, Bauman B, Burke T,Sheehan M (2019) Integrating Public Health into Climate Change Policy and Planning: State of Practice Update. *Int J Environ Res Public Health.* 16: 3232. doi: 3210.3390/ijerph16183232.
118. Dreaves HA (2016) How Health Impact Assessments (HIAs) Help Us to Select the Public Health Policies Most Likely to Maximise Health Gain, on the Basis of Best Public Health Science. *AIMS Public Health.* 3: 235-241. doi: 210.3934/publichealth.2016.3932.3235. eCollection 2016.
119. Harris-Roxas B,Harris E (2011) Differing Forms, Differing Purposes: A Typology of Health Impact Assessment. *Environmental Impact Assessment Review* 31: 396-403.
120. Patz J, Campbell-Lendrum D, Gibbs H,Woodruff R (2008) Health impact assessment of global climate change: expanding on comparative risk assessment approaches for policy making. *Annu Rev Public Health* 29:27-39.: 10.1146/annurev.publhealth.1129.020907.090750.
121. Brown H, Spickett J,Katscherian D (2014) A health impact assessment framework for assessing vulnerability and adaptation planning for climate change. *Int J Environ Res Public Health* 11.
122. Winkler MS, Furu P, Viliani F, Cave B, Divall M, et al. (2020) Current Global Health Impact Assessment Practice. *Int J Environ Res Public Health.* 17: 2988. doi: 2910.3390/ijerph17092988.
123. Bolton A (2018) *Climate Change and Environmental Health*. Wellington: Institute of Environmental Science and Research Limited.
124. Ministry for the Environment (2016) *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment*. Wellington: Ministry for the Environment.
125. Spickett J, Katscherian D,Brown H (2015) *Climate Change, Vulnerability and Health: A Guide to Assessing and Addressing the Health Impacts*. Curtin University: World Health Organisation Collaborating Centre for Environmental Health Impact Assessment.
126. Statistics New Zealand (2022) Subnational population estimates (TA, SA2), by age and sex, at 30 June 1996-2022 (2022 boundaries). Statistics New Zealand.
127. Bodeker G, Cullen N, Katurji M, McDonald A, Morgenstern O, et al. (2022) *Aotearoa New Zealand climate change projections guidance: Interpreting the latest IPCC WG1 report findings. Prepared for the Ministry for the Environment, Report umber CR 501, 51p*.

128. Ministry for the Environment (2018) *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment, 2nd Edition*. Wellington: Ministry for the Environment.
129. Eyring V, Bony S, Meehl GA, Senior CA, Stevens B, et al. (2016) *Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, Geosci. Model Dev., 9, 1937–1958*.
130. NIWA (2023) Mā te haumaru ō nga puna wai ō Rākaihautū ka ora mo ake tonu: Increasing flood resilience across Aotearoa.
131. NIWA (2019) Annual climate summary 2018. New Zealand National Institute of Water and Air.
132. Bell RG,Hannah J (2019) Update to 2018 of the annual MSL series and trends around New Zealand, 20. National Institute of Water & Atmospheric Research Ltd.
133. Reisinger A, Kitching RL,Chiew F (2014) Australasia. In: Intergovernmental Panel on Climate, C, editor. *Climate Change 2014 – Impacts, Adaptation and Vulnerability: Part B: Regional Aspects: Working Group II Contribution to the IPCC Fifth Assessment Report: Volume 2: Regional Aspects*. Cambridge: Cambridge University Press. pp. 1371-1438.
134. Stocker T F et al. (2013) Technical Summary. In: TF Stocker, D Qin, G-K Plattner, M Tignor, SK Allen, et al., editors. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.
135. Louis S, Carlson AK, Suresh A, Rim J, Mays M, et al. (2023) Impacts of Climate Change and Air Pollution on Neurologic Health, Disease, and Practice. *Neurology* 100: 474.
136. Hajat C,Stein E (2018) The global burden of multiple chronic conditions: A narrative review. *Prev Med Rep.* 12:284-293.: 10.1016/j.pmedr.2018.1010.1008. eCollection 2018 Dec.
137. Balbus JM,Malina C (2009) Identifying Vulnerable Subpopulations for Climate Change Health Effects in the United States. *Journal of Occupational and Environmental Medicine* 51.
138. English PB,Richardson MJ (2016) Components of Population Vulnerability and Their Relationship With Climate-Sensitive Health Threats. *Current Environmental Health Reports* 3: 91-98.
139. McNamara KE,Buggy L (2017) Community-based climate change adaptation: a review of academic literature. *Local Environment* 22: 443-460.
140. Ebi KL,Semenza JCJAjopm (2008) Community-based adaptation to the health impacts of climate change. *American Journal of Preventive Medicine* 35: 501-507.
141. Te Whatu Ora – Health New Zealand (2020) *Canterbury Wellbeing Survey, 2020: Report prepared by Nielsen for te Whatu Ora – Health New Zealand and partnering agencies*. Ōtautahi Christchurch: Te Whatu Ora – Health New Zealand.
142. Harrison S, Macmillan A, Bond S,Stephenson J (2022) *Climate change adaptation decision-making for health and wellbeing in South Dunedin: Report on the use of causal mapping for stakeholders*. Otago, new Zealand: The Department of Preventive and Social Medicine, School of Geography, and Centre for Sustainability, University of Otago.
143. Fernandez A, Black J, Jones M, Wilson L, Salvador-Carulla L, et al. (2015) Flooding and mental health: a systematic mapping review. *PLoS One.* 10: e0119929. doi: 0119910.0111371/journal.pone.0119929. eCollection 0112015.
144. Liang K,Kosatsky T (2020) Health impacts of sea level rise on BC's coastal communities. *BC Med J,* 62: 71-73.
145. Companion Animals New Zealand (2020) *Companion Animals in New Zealand*. Auckland, New Zealand: Companion Animals New Zealand.
146. Glassey S (2020) Legal complexities of entry, rescue, seizure and disposal of disaster-affected companion animals in New Zealand. *Animals* 10.
147. Cann G (2017) Insurers warn climate change will hit policy prices and make some properties uninsurable. Stuff. Nov 12 2017 ed.
148. Stephen Forbes (17 February 2023) Kāinga Ora tenants sleep in flood-damaged homes as agency struggles to meet demand. Stuff.
149. McCaull A (2023) Flood, humidity and contaminated food leading to increase in pest control calls. RNZ. 7 February 2023 ed.

150. Mason K, Lindberg K, Haenfling C, Schori A, Marsters H, et al. (2021) Social Vulnerability Indicators for Flooding in Aotearoa New Zealand. *Int J Environ Res Public Health.* 18: 3952. doi: 3910.3390/ijerph18083952.
151. Awatere S, King D, Reid J, Williams L, Masters-Awatere B, et al. (2021) *He huringa āhuarangi, he huringa ao: a changing climate, a changing world*.
152. King D, Penny,Severne (2010) The climate change matrix facing Māori society: Climate change adaptation in New Zealand: Future scenarios and some sectoral perspectives. pp. 100-111.
153. Alderman K, Turner LR,Tong S (2012) Floods and human health: a systematic review. *Environ Int.* 47:37-47.: 10.1016/j.envint.2012.1006.1003. Epub 2012 Jun 1027.
154. Global Cement and Concrete Association (2023) Porous Concrete.
155. Christchurch City Council (2009) *Surface Water Strategy 2009 – 2039, Ōtautahi/Christchurch and Te Pātaka o Rākaihautū/Banks Peninsula*. Christchurch: Christchurch City Council.
156. Welch T (2023) Auckland floods: even stormwater reform won't be enough – we need a 'sponge city' to avoid future disasters. The Conversation.
157. Winkless L (2023) Could 'sponge cities' help us prepare for our flooded future? 30 January 2023 ed.
158. Waka Kotahi NZ Transport Agency (2022) *Tiro Rangi: our climate adaptation plan 2022–24*. Wellington: Waka Kotahi NZ Transport Agency.
159. Bush T (2021) Potential adverse health consequences of climate change related to rheumatic diseases. *The Journal of Climate Change and Health* 3: 100029.
160. Crimp L Road repair costs leave councils feeling the pinch. RNZ.
161. Lassa J, Petal M,Surjan A (2022) Understanding the impacts of floods on learning quality, school facilities, and educational recovery in Indonesia. *Disasters* n/a.
162. Kubal CA, Haase D, Meyer V, Scheuer SJNH,Sciences ES (2009) Integrated urban flood risk assessment – adapting a multicriteria approach to a city. 9: 1881-1895.
163. Elms D (2015) Improving community resilience to natural events. *Civil Engineering and Environmental Systems* 32: 77-89.
164. Cropp A (2022) Motorists and businesses pay dearly as poorly maintained roads fall apart under the onslaught of climate change and wild weather.
165. Wang T, Qu Z, Yang Z, Nichol T, Clarke G, et al. (2020) Climate Change Research on Transportation Systems: Climate Risks, Adaptation and Planning. *Transportation Research Part D: Transport and Environment* 88.
166. Borowska-Stefańska M,Wiśniewski S (2022) The Role of Road Transportation in the Flood Evacuation Process. Oxford University Press.
167. Portier CJ, Thigpen TK, Carter SR DC, Grambsch AE, Gohlke J, Hess J, Howard SN, Luber G, Lutz JT, Maslak T, Prudent N, Radtke M, Rosenthal JP, Rowles T, Sandifer PA,,Scheraga J SP, Strickman D, Trtanj JM, Whung P-Y. (2010) *A Human Health Perspective On Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate*. Change. Research Triangle Park, NC:Environmental Health Perspectives/National Institute of Environmental Health Sciences.
168. Allen TR, Crawford T, Montz B, Whitehead J, Lovelace S, et al. (2018) Linking Water Infrastructure, Public Health, and Sea Level Rise: Integrated Assessment of Flood Resilience in Coastal Cities. *Public Works Management & Policy* 24: 110-139.
169. Department of Internal Affairs (2017) *Government Inquiry into Havelock North Drinking Water, 2017, Report of the havelock north drinking water inquiry: Stage 2*. Auckland, New Zealand: Department of Internal Affairs.
170. Moore D, Drew R, Davies P,Rippon R (2017) *The economic costs of the Havelock North August 2016 waterborne disease outbreak*: Sapere Research Group.
171. Seidman NL, Christopher James, Dara Torre, Donna Brutkoski, Janine Migden-Ostrander, et al. (2020) *Energy Infrastructure: Sources of Inequities and Policy Solutions for Improving Community Health and Wellbeing*. Synapse Energy Economics & Community Action Partnership.
172. Burton H, Rabito F, Danielson L,Takaro TK (2016) Health effects of flooding in Canada: A 2015 review and description of gaps in research. *Canadian Water Resources Journal / Revue canadienne des ressources hydriques* 41: 238-249.

173. McLellan B, Zhang Q, Farzaneh H, Utama NA,Ishihara KN (2012) Resilience, Sustainability and Risk Management: A Focus on Energy. Challenges. pp. 153-182.
174. Powell T, Hanfling D,Gostin LO (2012) Emergency Preparedness and Public Health: The Lessons of Hurricane Sandy. *JAMA* 308: 2569-2570.
175. Miller RI. Hurricane Katrina: Communications & Infrastructure Impacts; 2006.
176. Dine J (2023) Warkworth residents say communication, preparation inadequate during flood alert. RNZ 3 February 2023. 3 February 2023 ed.
177. Food and Agriculture Organization's Interdepartmental Working Group on Climate Change (2008) *Climate change and food security: A framework document*: Food and Agriculture Organization of the United Nations, Rome.
178. Howlett BG, Butler RC, Nelson W,Donovan BJ (2013) *Impact of climate change on crop pollinator in New Zealand*. Wellington: Ministry for Primary Industries.
179. Radio New Zealand (20 March 2023) Cyclone takes out thousands of beehives, fears for bee health.
180. Cleghorn C, Nghiem N,Ni Mhurchu C (2022) Assessing the Health and Environmental Benefits of a New Zealand Diet Optimised for Health and Climate Protection. Sustainability.
181. Romanello M, Di Napoli C, Drummond P, Green C, Kennard H, et al. (2022) The 2022 report of the Lancet Countdown on health and climate change: health at the mercy of fossil fuels. *Lancet.* 400: 1619-1654. doi: 1610.1016/S0140-6736(1622)01540-01549. Epub 02022 Oct 01525.
182. MacManus J Sea walls protecting New Zealand cities are losing their battle with the ocean, UN report warns. Stuff.
183. Galuszka J (2022) Flood protection short by $150m per year as councils grapple with climate change impact. Stuff.
184. Ponter D (2022) Rising cost of flood protection can't be left to councils alone. Stuff.
185. Macdonald N (2021) More than 300 old dumps at risk of coastal erosion and flooding. Stuff.
186. Mills L (27 July 2021) Town faces thousands of tonnes of waste after flooding. Otago Daily Times.
187. Price D, Hughes KM, Thien F,Suphioglu C (2021) Epidemic Thunderstorm Asthma: Lessons Learned from the Storm Down-Under. *J Allergy Clin Immunol Pract.* 9: 1510-1515. doi: 1510.1016/j.jaip.2020.1510.1022. Epub 2020 Oct 1522.
188. Hayes K, Blashki G, Wiseman J, Burke S,Reifels L (2018) Climate change and mental health: risks, impacts and priority actions. *International Journal of Mental Health Systems* 12: 28.
189. RNZ (2022) Timaru flood warning system has proven its worth - scientist. RNZ.
190. Baker MG, Goodyear R, Telfar BL,Howden-Chapman P (2012) *The distribution of household crowding in New Zealand: An analysis based on 1991 to 2006 Census data*. Wellington: He Kainga Oranga/ Housing and Health Research Programme, University of Otago.
191. Graham S, Barnett J, Fincher R-ME, Hurlimann AC, Mortreux C, et al. (2013) The social values at risk from sea-level rise. 41: 45-52.
192. Wade T,ClimAtlantic (2022) Health risks associated with sea level rise.: National Collaborating Centre for Environmental Health (NCCEH). Vancouver, BC: NCCEH.
193. Boston J (2023) *Funding Managed Retreat: Designing a Public Compensation Scheme for Private Property Losses: Public Issues and Options*. Auckland: Environmental Defence Society Incorporated.
194. Talukder B, Salim R, Islam ST, Mondal KP, Hipel KW, et al. (2023) Collective intelligence for addressing community planetary health resulting from salinity prompted by sea level rise. *The Journal of Climate Change and Health* 10: 100203.
195. Institute of Health Economics (2022) *Adaptation strategies for reducing extreme heat health impacts: a rapid review*. Edmonton (AB): Institute of Health Economics.
196. Grabowski ZJ, McPhearson T,Pickett STA (2023) Transforming US urban green infrastructure planning to address equity. *Landscape and Urban Planning* 229: 104591.
197. Christchurch City Council (2023) *Our Urban Forest Plan for Ōtautahi Christchurch*. Christchurch, New Zealand: Christchurch City Council.
198. Pickles K (January 2022) Up on a roof: why New Zealand's move towards greater urban density should see a rooftop revolution. University of Canterbury
199. Bakshi N,Perdersen Zari M (2020) Climate explained: how white roofs help to reflect the sun's heat.: The Conversation.

200. Keith L,Meerow S (2022) *Planning for urban heat resilience PAS r e p o r t 6 0 0*: American Planning Association.
201. (7 Feb, 2006) Canterbury rail crash blamed on heat.
202. Tso M (Nov 23 2018) Melted roads caused by hot weather pose a potential safety hazard this summer. Stuff: Stuff.
203. Community and Public Health | Te Mana Ora (2020) Toxic Algal Blooms: What you need to know. In: National Public Health Service Te Whatu Ora, editor. Christchurch.
204. McKergow LA, Matheson FE,Quinn JM (2016) Riparian management: A restoration tool for New Zealand streams. *Ecological Management & Restoration* 17: 218-227.
205. Ministry for the Environment & Stats NZ (2020) *New Zealand's Environmental Reporting Series: Our atmosphere and climate 2020*.
206. Joshi A (2022) Motivating sustainable behaviors by framing biodiversity loss as a public health risk. *Journal of Risk Research* 25: 156-175.
207. Aerts R, Honnay O,Van Nieuwenhuyse A (2018) Biodiversity and human health: mechanisms and evidence of the positive health effects of diversity in nature and green spaces. *British Medical Bulletin* 127: 5-22.
208. Cotrone V (2022) Selecting Community Trees in a Changing Climate. Pennsylvania State University.
209. Spickett J, Brown H,Katscherian D (2008) *Health impacts of climate change: adaptation strategies for Western Australia*: Environmental Health Directorate Department of Health 2008.
210. Torres C,Dixon J (2023) Pathways to Climate Health: Active learning and effective communication to optimize climate change action an evaluation of the climate change and renal health awareness and education toolkit for healthcare providers: Reducing climate-health risks in primary care. *The Journal of Climate Change and Health* 9: 100198.
211. Kanner J, Stevens DR, Nobles CJ, Rohn MCH, Ha S, et al. (2021) Risk of cardiovascular events during labor and delivery associated with acute ambient temperature changes. *The Journal of Climate Change and Health* 3: 100060.
212. Cai W, Zhang C, Zhang S, Bai Y, Callaghan M, et al. (2022) The 2022 China report of the Lancet Countdown on health and climate change: leveraging climate actions for healthy ageing. *Lancet Public Health.* 7: e1073-e1090. doi: 1010.1016/S2468-2667(1022)00224-00229. Epub 02022 Oct 00229.
213. Moda HM, Filho WL,Minhas A (2019) Impacts of Climate Change on Outdoor Workers and their Safety: Some Research Priorities. *Int J Environ Res Public Health.* 16: 3458. doi: 3410.3390/ijerph16183458.
214. Misiou O,Koutsoumanis K (2022) Climate change and its implications for food safety and spoilage. *Trends in Food Science & Technology* 126: 142-152.
215. NZ Cancer Society Sunsmart events: Planning a SunSmart event means the people attending your event will be better protected from harmful UV rays. NZ Cancer Society.
216. Outlines Landscape Architecture Shade Design for Public Places: Selecting appropriate, innovative and cost effective shade measures. Victorian State Governmen.
217. Bambrick HJ, Capon AG, Barnett GB, Beaty RM,Burton AJ (2011) Climate change and health in the urban environment: adaptation opportunities in Australian cities. *Asia Pac J Public Health.* 23: 67S-79. doi: 10.1177/1010539510391774. Epub 1010539510392011 Jan 1010539510391717.
218. Johnson DE, Fisher K,Parsons M (2022) Diversifying Indigenous Vulnerability and Adaptation: An Intersectional Reading of Māori Women’s Experiences of Health, Wellbeing, and Climate Change. Sustainability.
219. Drought causes house problems Auckland's drought has seen serious land stability problems double, say experts. NZ Herald.
220. Yusa A, Berry P, J JC, Ogden N, Bonsal B, et al. (2015) Climate Change, Drought and Human Health in Canada. *Int J Environ Res Public Health.* 12: 8359-8412. doi: 8310.3390/ijerph120708359.
221. Environment Canterbury (25 Aug 2022) New groundwater quality reports released.
222. Ministry of Health (2022) Potential effects of high nitrate levels in drinking-water. New Zealand Ministry of Health.
223. CDC National Center for Environmental Health (2022) Health Implications of Drought.
224. Ngāi Tahu Farming Whenua to whānau.

225. Bryan K, Ward S, Roberts L, White MP, Landeg O, et al. (2020) The health and well-being effects of drought: assessing multi-stakeholder perspectives through narratives from the UK. *Climatic Change* 163: 2073-2095.
226. Wilhite DA, Sivakumar MVK,Pulwarty R (2014) Managing drought risk in a changing climate: The role of national drought policy. *Weather and Climate Extremes* 3: 4-13.
227. Muyambo F, Jordaan AJ,Bahta YT (2017) Assessing social vulnerability to drought in South Africa: Policy implication for drought risk reduction. *Jamba.* 9: 326. doi: 310.4102/jamba.v4109i4101.4326. eCollection 2017.
228. Fire and Emergency New Zealand (2023) New Zealand Wildfire Summary. Fire and Emergency New Zealand.
229. Langer ER,Wegner S (2018) Wildfire risk awareness, perception and preparedness in the urban fringe in Aotearoa/New Zealand: public responses to the 2017 Port Hills wildfire. *Australasian Journal of Disaster and Trauma Studies*: 75-84.
230. Finlay SE, Moffat A, Gazzard R, Baker D,Murray V (2012) Health impacts of wildfires. *PLoS Curr.* 4:e4f959951cce2c.: 10.1371/1374f959951cce959952c.
231. Cohen O, Shapira S,Furman E (2022) Long-Term Health Impacts of Wildfire Exposure: A Retrospective Study Exploring Hospitalization Dynamics Following the 2016 Wave of Fires in Israel. *Int J Environ Res Public Health.* 19: 5012. doi: 5010.3390/ijerph19095012.
232. Jakes PJ,Langer ER (2012) The adaptive capacity of New Zealand communities to wildfire. *International Journal of Wildland Fire* 21: 764-772.
233. Fire and Emergency New Zealand Port Hills Operational Review and Action Plan: Research and reports.
234. Fraser AM, Chester MV,Underwood BS (2022) Wildfire risk, post-fire debris flows, and transportation infrastructure vulnerability. *Sustainable and Resilient Infrastructure* 7: 188-200.
235. Civil Defence Emergency Management (2009) Mass evacuation.
236. Dennis FC (1999) Fire-resistant landscaping. Colorado State University Cooperative Extension.
237. Aderemi AO,Otitoloju AA (2012) An assessment of landfill fires and their potential health effects-a case study of a municipal solid waste landfill in Lagos, Nigeria. *International Journal of Environmental Protection* 2: 22-26.
238. Zimlich R (2015) Prevention is Key in Managing Landfill Fires. Waste 360. Sep 15, 2015 ed.
239. Reisen F, Duran SM, Flannigan M, Elliott C,Rideout K (2015) Wildfire smoke and public health risk. *International Journal of Wildland Fire* 24: 1029-1044.
240. Ranse J, Luther M, Hertelendy A,Skinner R (2022) Impact of fine particulate matter (PM2.5) smoke during the 2019 / 2020 Australian bushfire disaster on emergency department patient presentations. *The Journal of Climate Change and Health* 6: 100113.
241. Grant E,Runkle JD (2022) Long-term health effects of wildfire exposure: A scoping review. *The Journal of Climate Change and Health* 6: 100110.
242. Ministry of Health (2023) *Commissioning for Pae Ora Healthy Futures*. Wellington: Ministry of Health.

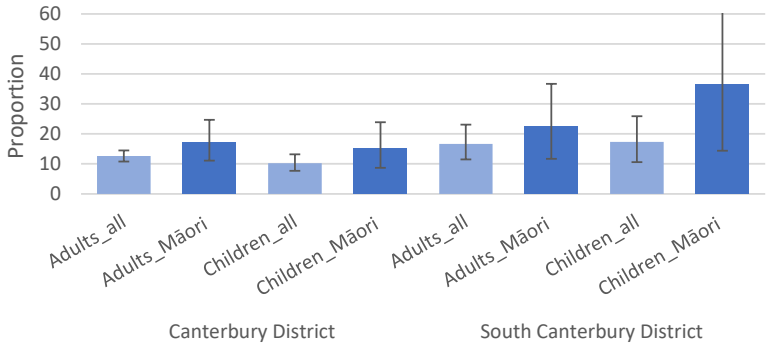
Appendix A

Prevalence of selected climate-sensitive health conditions in the Waitaha Canterbury

Asthma

Figure 16 presents the proportion of respondents to the New Zealand Health Survey who indicated (or for those aged 2-14 years, whose parents or caregivers indicated) that they had been told by a doctor that they have asthma and were taking treatments for asthma (inhalers, medicine, tablets or pills, or any other treatments).

Figure 16: Medicated asthma prevalence in Canterbury and South Canterbury districts, for Māori and all respondents, 2017–20*



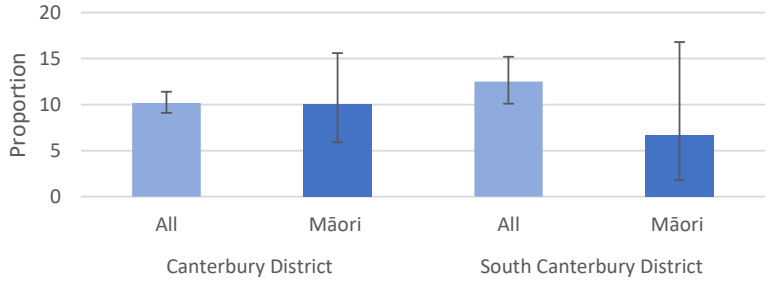
*Note: the New Zealand Health Survey provides estimates from a sample of households from each geographical area, in this case, by CDHB/SCDHB boundaries, not Waitaha Canterbury overall. This question relies on self-report and will be affected by various response biases.

The figure shows a pattern of a higher prevalence of medicated asthma (proportion of adult and child respondents reporting medicated asthma) for South Canterbury district respondents compared with Canterbury district respondents, although noting wider confidence intervals in South Canterbury due to smaller absolute numbers. The prevalence of medicated asthma for Māori respondents aged 2–14 years (36.5%) in the South Canterbury district (SCDHB) was statistically significantly higher than for all respondents aged 2–14 years in Canterbury district (CDHB, 10.2%).

Hypertension

Figure 17 presents the proportion of respondents to the adult New Zealand Health Survey who indicated that they had been told by a doctor that they have high blood pressure and were currently taking blood pressure medication.

Figure 17: Adults medicated high blood pressure prevalence in Canterbury and South Canterbury districts, for Māori and all respondents, 2017–20*



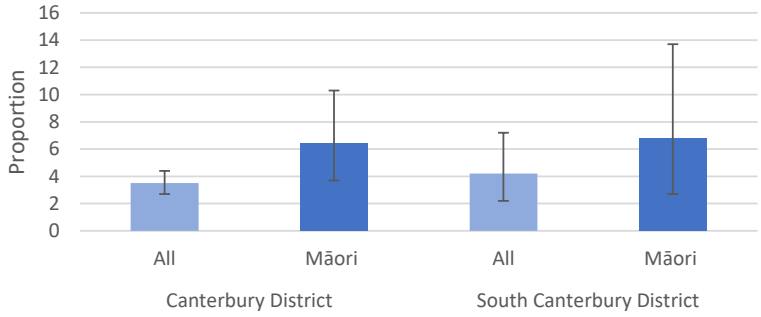
*Note: the New Zealand Health Survey provides estimates from a sample of households from each geographical area, in this case, by CDHB/SCDHB boundaries, not Waitaha Canterbury overall. This question relies on self-report and will be affected by various response biases.

The figure shows that approximately 10 percent of Waitaha Canterbury district (CDHB) respondents and 12.5 percent of South Canterbury district (SCDHB) respondents aged 15 years and over indicated that they had experienced medicated hypertension in the past 12 months. There are no statistically significant differences between the groups presented.

Diabetes

Figure 18 presents the proportion of respondents to the adult New Zealand Health Survey who indicated that they had been told by a doctor that they have diabetes. This does not include diabetes during pregnancy (gestational diabetes).

Figure 18: Adults diabetes prevalence in Canterbury and South Canterbury districts, for Māori and all respondents, 2017–20



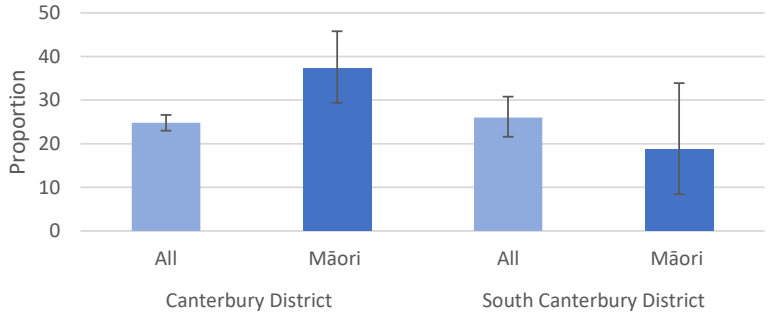
*Note: the New Zealand Health Survey provides estimates from a sample of households from each geographical area, in this case, by CDHB/SCDHB boundaries, not Waitaha Canterbury overall. This question relies on self-report and will be affected by various response biases.

The figure shows that the proportion of Māori respondents (aged 15+ years) in the Waitaha Canterbury district (CDHB) who indicated that they have diabetes was notably higher than the total population in the Waitaha Canterbury district(Māori adults, 6.4%; All, 3.5%) for 2017-2020; although this difference was not statistically significant. The results are similar for South Canterbury district (SCDHB) respondents. Note that this definition is likely to underestimate the true number of people with diabetes, as some people may not be aware that they have diabetes.

Psychiatric illness/mood and/or anxiety disorder

Figure 19 presents the proportion of respondents to the adult New Zealand Health Survey who indicated that they had been told by a doctor that they have depression, bipolar and/or anxiety disorder.

Figure 19: Proportion of adults with depression, bipolar and/or anxiety disorder in Canterbury and South Canterbury districts, for Māori and all respondents, 2017–20*



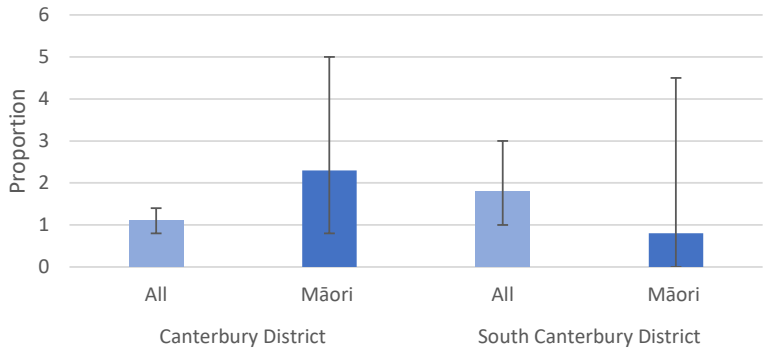
*Note: the New Zealand Health Survey provides estimates from a sample of households from each geographical area, in this case, by CDHB/SCDHB boundaries, not Waitaha Canterbury overall. This question relies on self-report and will be affected by various response biases.

The figure shows that the proportion of Māori respondents (aged 15+ years) in the Waitaha Canterbury district who indicated that they have a mood and/or anxiety disorder was notably higher than for the total population in the Waitaha Canterbury district (Māori adults, 37.3%; All, 24.8%) for 2017-2020. This difference is statistically significant. There is no significant difference in the proportion for Māori respondents compared to all respondents in the South Canterbury district. Note that this definition is likely to underestimate the true number of people with mood or anxiety disorders, as some people may not be aware that they have a mood or anxiety disorder. Also note that not all respondents who have ever had depression, bipolar and/or anxiety disorder would meet the criteria for depression, bipolar and/or anxiety disorder at the time they were surveyed.

Stroke

Figure 20 shows the proportion of Waitaha Canterbury district and South Canterbury district respondents to the adult New Zealand Health Survey who indicated that they had been told by a doctor that they have had a stroke. This does not include 'mini-strokes' or transient ischaemic attacks (TIAs).

Figure 20: Proportion of adults who have had a stroke in Canterbury and South Canterbury districts, for Māori and all respondents, 2017–20*



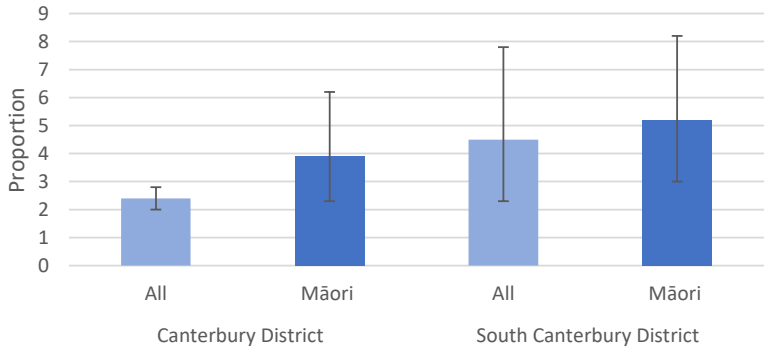
*Note: the New Zealand Health Survey provides estimates from a sample of households from each geographical area, in this case, by CDHB/SCDHB boundaries, not Waitaha Canterbury overall. This question relies on self-report and will be affected by various response biases.

The figure shows that the proportion of Māori respondents (aged 15+ years) in the Waitaha Canterbury district who indicated that they have had a stroke was notably higher than the total population in the Waitaha Canterbury district (Māori adults, 2.3%; All, 1.1%) for 2017-2020. However, this difference was not statistically significant, noting the wide confidence intervals for the estimate for Māori (due to a combination of small absolute numbers and relatively low prevalence). The prevalence estimate for the South Canterbury district is not reliable due to small absolute numbers.

Heart disease

Figure 21 presents the proportion of respondents (aged 15+ years) to the New Zealand Health Survey who indicated that they have ischaemic heart disease, defined as having ever been admitted to hospital with a heart attack or having ever been diagnosed with angina by a doctor.

Figure 21: Proportion of adults with ischaemic heart disease in Canterbury and South Canterbury districts, for Māori and all respondents, 2017–20*



*Note: the New Zealand Health Survey provides estimates from a sample of households from each geographical area, in this case, by CDHB/SCDHB boundaries, not Waitaha Canterbury overall. This question relies on self-report and will be affected by various response biases.

The figure shows that the proportion of Māori respondents (aged 15+ years) in the South Canterbury district who indicated that they have ischaemic heart disease was notably higher than the total population in the Waitaha Canterbury district (Māori adults in South Canterbury, 5.2%; All adults in, Waitaha Canterbury 2.4%) for 2017-2020. This difference is statistically significant. Note that this definition is likely to underestimate the true number of people with ischaemic heart disease, as some people may not be aware that they have ischaemic heart disease.

Appendix B

Key environmental protection policy, agreements, and strategies

The Paris agreement

The Paris agreement is generally considered to be the most significant global agreement, under the United Nations Framework Convention on Climate Change (UNFCCC). At the 2015 Paris Climate Conference, 195 nations agreed to curb greenhouse gas emissions sufficiently to limit global warming to "well below" 2 degrees Celsius above pre-industrial levels (conveyed as 'pursuing efforts to limit' global temperature rise to 1.5°C). New Zealand ratified the Paris Agreement on 4 October 2016 (New York time). The Paris Agreement entered into force on 4 November 2016 and took effect in 2020. This means New Zealand's commitments to reduce greenhouse gas emissions apply from 2021. New Zealand's Nationally Determined Contribution (contribution to reducing emissions) sets a headline target of a 50 per cent reduction of net emissions below our gross 2005 level by 2030. The Climate Change Response Act 2002 put in place a legal framework to enable New Zealand to meet its international obligations under the United Nations Framework Convention on Climate Change, the Kyoto Protocol, and the Paris Agreement.

The Climate Change Response (Zero Carbon) Amendment Act

Subsequently, the Climate Change Response (Zero Carbon) Amendment Act 2019 amended the 2002 Act to provide a framework by which New Zealand can develop and implement clear and stable climate change policies that—

(i) contribute to the global effort under the Paris Agreement to limit the global average temperature increase to 1.5° Celsius above pre-industrial levels; and

(ii) allow New Zealand to prepare for, and adapt to, the effects of climate change.

The changes encompass four specific areas:

1. set a new domestic greenhouse gas emissions reduction target for New Zealand to:
   - reduce net emissions of all greenhouse gases (except biogenic methane) to zero by 2050
   - reduce emissions of biogenic methane to 24–47 per cent below 2017 levels by 2050, including to 10 per cent below 2017 levels by 2030
2. establish a system of emissions budgets to act as stepping-stones towards the long-term target
3. require the Government to develop and implement policies for climate change adaptation and mitigation
4. establish a new, independent Climate Change Commission to provide expert advice and monitoring to help keep successive governments on track to meeting long-term goals.

National Adaption Plan 2022

Aotearoa New Zealand's first national adaptation plan [111] sets out coordinated and comprehensive actions to support all sectors and communities adapt to the locked-in impacts of climate change, like rising sea levels and more frequent and severe weather events. The national adaptation plan sets the direction for how Aotearoa New Zealand will adapt to the unavoidable impacts of climate change, and address key climate risks up to 2028. The plan sets out the Government's objectives to address climate change risks, and the strategies, policies, and proposals Aotearoa New Zealand will take to adapt to prioritised risks. Actions outlined in the First National Adaptation Plan are centred around:

Focus area one: Reform institutions to be fit for a changing climate. Aotearoa New Zealand already has systems and institutions in place to plan for and respond to natural hazard risks or manage natural resources and infrastructure.

Focus area two: Provide data, information, and guidance to enable everyone to assess and reduce their own climate risks. Actions in the plan will make it easier to access up-to-date information and guidance on climate risk that can be used to assess what future climate changes are most important.

Focus area three: Embed climate resilience across government strategies and policies. Actions in the plan aim to embed the consideration of existing and future climate risk in all government strategies and proposals, so that adaptation becomes a mainstream part of government policy.

Pae Ora (Healthy Futures) Act 2022

The Pae Ora (Healthy Futures) Act 2022 provides a clear mandate to work in collaboration on the determinants of health, including work in climate change [242]. The purpose of this Act is to provide for the public funding and provision of services in order to—

1. protect, promote, and improve the health of all New Zealanders; and
2. achieve equity in health outcomes among New Zealand's population groups, including by striving to eliminate health disparities, in particular for Māori; and
3. build towards pae ora (healthy futures) for all New Zealanders.

Section 7 (e), health sector principles, states that the health sector should protect and promote people's health and wellbeing, including by— (v) undertaking promotional and preventative measures to address the wider determinants of health, *including climate change*, that adversely affect people's health [emphasis added]. The stated functions of Health New Zealand include collaborating with other agencies, organisations, and individuals to improve health and wellbeing outcomes and to address the wider determinants of health.

Te Kounga Paparangi, Ngāi Tahu Climate Change Action Plan

Te Kounga Paparangi sets out Ngāi Tahu's 88-point action plan to mitigate climate change, build resilience, and promote sustainable business practices. The action plan takes an inter-generational approach: "Mō tātou, ā, mō kā uri ā muri ake nei – for us and our children after us"[84]. The plan follows on from Ngāi Tahu's 2018 climate change strategy, and sets out how it will contribute to a low emissions economy in Aotearoa New Zealand. The plan covers greenhouse gas emissions, marae and whānau resilience, water and ecosystem protection, renewable energy and education. The aim is to make all of its tourism operations carbon-neutral by 2050 and reduce the environmental impacts of Ngāi Tahu Farming sites. The eight areas of the plan are: operations emit no greenhouse gases; marae and whānau resilience; water use is environmentally responsible; operational emissions do not harm people or the environment; operations do not encroach on ecosystems or communities; optimising resources; renewable energy; and education, communication and delivery.

Ōtautahi Christchurch Climate Resilience Strategy

In 2019, Christchurch City Council declared a Climate and Ecological Emergency and set the greenhouse gas emissions targets of net zero greenhouse emissions by 2045 (excluding methane), and to halve emissions by 2030 compared with 2016-17 levels [1]. In doing so, the Christchurch City Council joined a growing number of councils across New Zealand and cities worldwide committed to taking urgent action to reduce their carbon emissions. "Our Climate Resilience Strategy" is a blueprint for collective action and part of a wider conversation about how we work together to reduce our greenhouse gas emissions to minimise future harm, and plan for the ongoing effects of climate change. It reinforces Christchurch City Council's commitment to climate change leadership.

ECAN Long Term Plan

Long-term planning is a continuous process and ECAN refreshes the Long-Term Plan every three years. The plan sets out ECAN's service priorities, work programmes and resource requirements such as expenditure and funding for a 10-year period. ECAN adopted the current Long-Term Plan 2021-31 on 17 June 2021. ECAN's "Long Term Plan", vision and purpose is stated as: 'Taking action together to shape a thriving and resilient Canterbury, now and for future generations' |'Toitū te marae o Tāne, toitū te marae o Tangaroa, toitū te iwi'. Central government is responsible for policies to mitigate climate change, and Environment Canterbury recognises central government's role in leading greenhouse gas mitigation policy, and as a Regional Council, ECAN's focus is mandated to be on adaptation. While ECAN does not have a regulatory role in mitigating greenhouse gas emissions across the region, many of ECAN's policies and plans have the potential to reduce emissions, for example: farming within limits, reducing transport congestion, managing industrial emissions to air, and clean burning.

10 Extraordinary/urgent business I Panui autia hei totoia pakihi

No notifications of Extraordinary or Urgent Business were received for the meeting.

11 Public excluded business I He hui pakihi e hara mo te iwi

At the time of the agenda closing, no publicly excluded items had been received for the meeting.