FACTORS THAT INFLUENCE THE HAZARDSCAPE

CLIMATE VARIABILITY AND CLIMATE CHANGE

New Zealand's climate varies from year to year but is strongly influenced by natural climate cycles operating on scales of years to decades.

Climate change is a phenomenon that is driven by the increasing concentration of greenhouse gases in the atmosphere and how the global climate system responds to these changing concentrations. The evidence for climate change comes from measured increases in the concentration of carbon dioxide and other greenhouse gases in the atmosphere, measured sea-level rise, and measured increases in global-average temperatures. This is driving changes in atmospheric circulation and rainfall patterns. Regional climate change impacts are now also evident in increasing stresses on water supply and agriculture, changed natural ecosystems, reduced seasonal snow cover and ongoing glacier shrinkage. Natural climate variations may offset or enhance some of the predicted impacts of climate change for New Zealand in the short-term.

Climate variability

Some of the shortest-term climate variability arises simply because of the natural variability in the weather and its random fluctuations. However, other changes are associated with large-scale climate patterns over the Southern Hemisphere or the Pacific Ocean. There are a number of natural processes that operate over time scales of seasons to decades, particularly the El Niño Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO).

The ENSO is a tropical, Pacific-wide oscillation that affects air pressure, wind, sea-surface temperature, and rainfall. In the El Niño phase, New Zealand usually experiences stronger than normal southwesterly airflows. This generally results in lower seasonal temperatures nationally with drier conditions in northern and eastern areas. Stronger than normal northeasterly flows are experienced during the opposite La Niña phase.

The IPO is a recently identified cause of natural variability in climate with cycles that last over several decades. Three phases of the IPO during the twentieth century have been identified. In a positive phase (for example, 1978–1998) sea-surface temperatures around New Zealand tend to be lower and westerly or southwesterly winds stronger. Temperatures throughout New Zealand are lower. In the negative phase (for example, 1947–1977), airflows from the east and north-east increase, as do temperatures in all regions. More rainfall occurs in the north of the North Island and it is drier in the south-east of the South Island. A new negative phase of the IPO started in 1998.

Climate change effects

Global average temperatures are projected to increase by between 1.1 and 6.4°C by 2100 if greenhouse gas emissions are not reduced. The increase is expected to be less in New Zealand than the global average because of the delayed warming of the oceans surrounding New Zealand.

Temperature projections for New Zealand are for an increase of 0.2-1.3°C by the 2030s, and 0.5-3.5°C by the 2080s. There are likely to be slightly greater increases in winter temperatures, meaning that the difference between winter and summer temperatures is likely to decrease. The difference in temperature between the north and south is expected to increase.

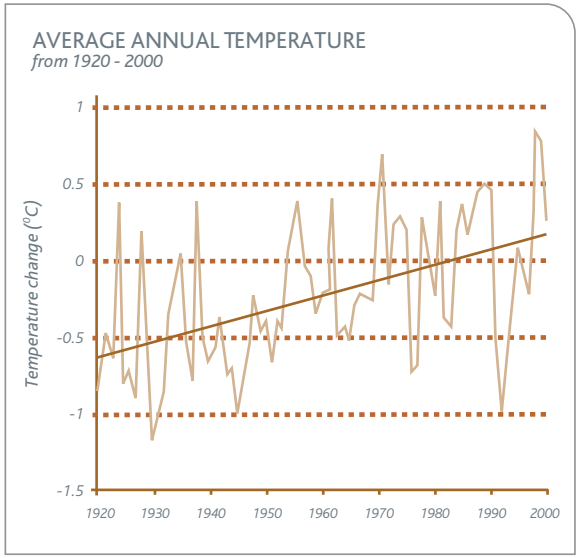
Rainfall projections for New Zealand for the same periods are from less than 19 per cent of what it is now to more than 15 per cent (-19 to +15 per cent) by the 2030s, and from less than 32 per cent of what it is now to more than 40 per cent (-32 to + 40 per cent) by the 2080s. Generally, a trend to drier conditions in northern and eastern regions and wetter conditions in the west and south is expected, meaning that the difference in rainfall between western and eastern regions is likely to increase.

These and other climate patterns (for example, the Interdecadal Pacific Oscillation (IPO) and the El Niño-Southern Oscillation (ENSO) cycles) are likely to lead to more floods and more droughts in some parts of New Zealand, with significant consequences for land-based industries.

Climate change projections for New Zealand also include fewer frosts, increased frequency of heavy rain, and an increase in average sea level.

Climate change is not expected to create new hazards, but it may change the frequency and intensity of existing hazards, as well as introducing long-term shifts in climate patterns.

In any year the annual New Zealand-wide temperature can deviate from the long-term average by up to +/-1°C. Despite these fluctuations, there has been a long-term increase of about 0.6 °C between 1920 and 2000. Annual rainfall, too, can deviate from its long-term average, by about +/-20 per cent. Sea levels have risen by an average of 16cm between 1900 and 2000, with similar +/-20 per cent year-to-year variations.



Average annual temperatures are shown by the light brown line and the long-term trend by the dark brown line (represented as the change in °C from the 1961 to 1990 average). *National Institute of Water and Atmospheric Research.*

Climate change and hazards

Temperature, rainfall and wind are the key influences on climate related hazards. The general indications are that New Zealand could experience more climatic extremes in the future. This could include:

- more intense rainfall, and associated flooding, in most parts of New Zealand
- more frequent and more intense droughts in eastern areas
- more damaging windstorms
- more heat waves
- increased wildfire risk in drier eastern areas.

Rainfall is the key climatic influence on river flow. River flows are likely to increase, on average, in western areas and decrease in eastern areas of New Zealand. More intense rainfall could increase flooding. It is estimated that by the 2080s there could be up to four times as many heavy-rainfall events. Less water for irrigation in northern and eastern areas, and increasing demand, is likely to lead to extended periods of drought. Increased rainfall in western areas and more intense rainfall throughout New Zealand, could lead to higher rates of soil erosion and slope instability.

Sea-level rise, storm frequency and intensity, wave patterns, and sediment supply are key climate influences for coastal areas. Effects of sea-level rise and other changes will vary regionally. Coastal erosion is likely to accelerate where it is already occurring, and erosion may become a problem over time in coastal areas that are presently either stable or advancing.

Temperature and rainfall are key climate influences for biosecurity. Even small increases in temperature could significantly increase the incidence of pest outbreaks in New Zealand, particularly in the North Island and the north of the South Island. Existing and new plant and animal pests could become established more widely.

The main features of New Zealand climate projections are qualitatively summarised in the following table using the best current scientific estimate of the direction and magnitude of change – the level of confidence in the projections is indicated in brackets (VH = very high, H = high, M = medium, L = low).

NEW ZEALAND CLIMATE CHANGE PROJECTIONS FOR 2030s AND 2080s - IPCC 3rd Assessment Report

CLIMATE VARIABLE	DIRECTION OF CHANGE	SIZE OF CHANGE
Average temperature	Increase (VH)	0.5–0.7°C by 2030s, 1.5–2.0°C by 2080s (M) (mid-range projection)
Daily temperature extremes (frosts, hot days)	Fewer cold temperatures and frosts (VH), more high temperature episodes (VH)	
Average rainfall	Varies around New Zealand. By 2080s Taranaki, Manawatu–Wanganui, West Coast, Otago and Southland show increases, and Hawke's Bay, Gisborne, eastern Canterbury, and eastern Marlborough show decreases (M)	Substantial variation around New Zealand
Extreme rainfall	Heavier or more frequent extreme rainfalls, especially where average rainfall increase predicted (M)	Ranges from no change through to halving of heavy rainfall return period by 2030s, and no change through to fourfold reduction in return period by 2080s (L)
Snow	Snow cover decrease, snowline rise, shortened duration of seasonal snow lying (all M)	
Wind (average)	Increase in the average westerly wind flow across New Zealand (M)	Ranges from slight increase up to doubling of average annual westerly flow by 2080s (L)
Strong winds	Increase in severe wind risk possible (L)	Ranges from little change up to double the frequency of winds above 30m/s by 2080s (L)
Storms	More storminess possible, but little information available for New Zealand (L)	
Sea level	Increase (VH) It is important to note that many parts of the New Zealand coast will experience tectonic uplift at a rate equivalent to, or even faster than, sea level rise	30–50cm rise (New Zealand average) between 1990 and 2100 (H), accelerating the historic trend (mid-range projection) Strong regional variability can be expected because of variable rates of tectonic uplift
Waves	Increased frequency of heavy swells in regions exposed to prevailing westerlies (M)	

Adapting to climate change

There is a general acceptance in New Zealand and internationally that climate change is happening, that the changes are due to human activity, and that many areas of life will be affected. New Zealand's response to climate change is in its early stages, but is gaining momentum particularly at central government level. The two main approaches to the management of climate change impacts are mitigation of climate change impacts by reducing greenhouse gas emissions (for example, through afforestation and decreasing transport emissions), and adaptation by preparing for the effects of climate change.

Avoiding or minimising risks from climate hazards in New Zealand is the responsibility of local government under the RMA. Planning to reduce the adverse effects of natural hazards is particularly important at local government level because the hazards usually have localised effects and may require locally distinct management and adaptation methods.

Ongoing research will lead to a greater understanding of the possible impact of climate change but there are still large uncertainties. These uncertainties have made it difficult to react to climate change at a national level. However, policy makers at both national and local level, and decision makers within industry groups, now recognise the importance of adaptation. This recognition is becoming increasingly reflected in policy and strategic planning documents where issues such as dune restoration, including climate change effects in storm water system design, developing crops for biofuels, and the role of irrigation are being addressed.

The United Nations Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report says that without further adaptation, the impacts of climate change for New Zealand are likely to be substantial. Based on the vulnerabilities for New Zealand identified by the IPCC, the Ministry for the Environment has identified four critical decision areas on which stakeholder efforts should focus. The four areas have considerable adaptive capacity and a significant emergency management context. They are:

- water and coastal emergency and hazard management, for example, Civil Defence Emergency Management Group plans and Regional Council plans, flood and storm surge preparedness, and coastal management
- infrastructure investment and maintenance, for example, asset management, design and resilience
- primary industry, for example, sustainable agriculture, drought, flood and snow preparedness, and land use changes
- biodiversity and biosecurity.

A sound risk-assessment process is fundamental to ensuring that climate change is appropriately planned for. The purpose of risk assessment for climate change is to identify where climate change may have a material effect and to evaluate the significance of the impact. This also allows climate change risks and responses to be compared equally with other risks and their associated costs and required resources.

FURTHER INFORMATION

GENERAL CLIMATE CHANGE INFORMATION

MINISTRY FOR THE ENVIRONMENT
www.climatechange.govt.nz
www.climatechange.govt.nz/resources/local-govt/guidance.html
www.ipcc.ch/

CLIMATE CHANGE AND DROUGHT

NIWA, 2005, CHANGES IN DROUGHT RISK WITH CLIMATE CHANGE.

CLIMATE CHANGE AND AGRICULTURE

NIWA, 2005, CLIMATE CHANGE – LIKELY IMPACTS ON NEW ZEALAND AGRICULTURE.

HUMAN MODIFICATION OF THE NATURAL ENVIRONMENT

Human modification of the natural environment can both worsen and mitigate natural processes that create hazards. Much of the natural landscape has been modified since people first settled in New Zealand several hundred years ago. This has generally led to an increase in hazards, particularly floods, landslides, and coastal hazards. Restoration of catchments, wetlands, dunes, and other natural systems is now recognised as an integral part of hazard management.

Vegetation

Native forest covered around 85 per cent of New Zealand's land area before people arrived. Much of this forest was cleared by Māori for hunting, and later by Europeans for farming. Today native forest covers around 23 per cent of New Zealand, with exotic forest making up another 6.5 per cent. Pasture is now the dominant land cover, making up 52 per cent of the North Island and 29 per cent of the South Island.

Vegetation helps to stabilise slopes by intercepting rainfall and binding the soil. Removal of much of New Zealand's native vegetation has left many areas, particularly in the North Island hill country, exposed to landslides and soil erosion. Soil erosion decreases the productivity of land. Pasture takes about 20 years to recover to within 70–80 per cent of its pre-erosion level, and growth is generally less productive because the soil is thinner and holds fewer nutrients. Soil erosion also contributes large amounts of sediment to rivers and floodplains, which reduces the flood-carrying capacity of rivers.

The contrasting effects of different land uses on erosion-prone hill country in the Mangawhero Valley, Manawatu. Many shallow landslides occurred on grass-covered slopes during the February 2004 storm, but there were few landslides in areas of mature pine forest. *Graham Hancox*.

Awareness of soil erosion on New Zealand's hill country increased after storms in the 1930s and 1940s caused widespread soil erosion on recently developed pastoral hill country. Concerns over the increased flood risk led to the Soil Conservation and Rivers Control Act 1941. The Act brought together soil conservation, river control, and land drainage matters under unified control at both national and local levels. Soil conservation initiatives included planting trees, erosion control and retiring land from pasture.

The removal of farm subsidies has led to land reverting back to scrub and native bush in some areas. In other areas, such as the hill country around Gisborne, exotic forest has been planted to reduce soil erosion and runoff into rivers. Progress has been made, but the February 2004 storm again illustrated how vulnerable pastoral hill country is to heavy rain.

Wetlands

Wetlands are areas that are permanently or temporarily wet and include streams, lakes, lagoons, estuaries, swamps, bogs, and tarns. Wetlands contain unique plants and animals that have adapted to wet conditions.

Wetlands store large amounts of water during heavy rain and release it gradually, reducing downstream flooding. Coastal wetlands help stabilise shorelines and protect against coastal hazards. Wetlands also retain sediment and nutrients, improve water quality, mitigate climate change by storing greenhouse gasses, and have important biodiversity and cultural values.

Scientists estimate that the area of wetlands in New Zealand was reduced from 672 000 hectares in the early 1800s to around 100 000 hectares in the mid-1970s, an 85 per cent decrease. Farmers were encouraged, through government subsidies, to drain wetlands up until the mid-1980s. The draining or filling of mostly lowland wetlands has reduced the water-storage capacity within river catchments, creating quicker and higher flood peaks after heavy rain.

Many wetlands in New Zealand are under Department of Conservation or Fish and Game New Zealand control. Many others, however, are privately owned and are threatened by excess runoff and sedimentation, stock grazing, and draining or infilling for pasture or urban development. Wetland restoration often requires a collaborative effort between local authorities and landowners and involves removing drains, fencing to prevent grazing, reducing nutrient inputs, controlling weeds, and planting.

Dunes

Coastal dunes occur along approximately 1100km of New Zealand's coastline and provide natural protection from coastal hazards. Dunes act as buffers that absorb the impacts of coastal erosion and storm surge, protecting areas further inland, and contain sand reserves that help maintain beaches. Dunes may also reduce the impact of tsunamis, as they did in some places during the tsunami of 26 December 2004. The role they play will become increasingly important with climate change and sea-level rise.

Most of New Zealand's coastal dune systems have been removed or modified by people. This has led to major changes in dune shape and vegetation, and has affected other natural coastal processes, leaving coastal buildings and assets more vulnerable to coastal hazards.

The benefits that dunes contribute to hazard risk reduction, as well as to biodiversity and amenity values, are now recognised. Many dune systems are being restored around New Zealand through community-based dune management groups (often called coast care or beach care groups) that involve local authorities working in partnership with community groups. Natural dune repair and restoration is dependent on plants that trap sand on the seaward face of the dune. Native sand-binding plants, such as pingao (or pikao) and spinifex are more effective at this than the exotic marram grass, ice plant and kikuyu grass. Planting pingao and spinifex allows dunes to recover between storms, reducing further erosion, and these plants also reduce wind erosion.

Dune restoration also involves restricting people and vehicles to specific accessways across dunes, to protect the sensitive dune vegetation.

The Coastal Dune Vegetation Network, established in 1997, provides both technical support for coast care programmes in New Zealand and a forum for information exchange.

Papamoa Domain in 1995 (left), 2000 (bottom left) and 2004 (bottom right). Lack of native dune plants meant sand was regularly blown into the car park which blocked beach access. Coast Care Bay of Plenty members fenced off parts of the dunes and planted spinifex and pingao which have now trapped sand, restoring the dunes. *Environment Bay of Plenty.*

Urbanisation

Urban areas make up less than one per cent of New Zealand's land cover. However, almost 86 per cent of New Zealanders live in these urban areas, so the impacts of urbanisation on the natural environment affect many New Zealanders and their assets.

Urban areas have a high proportion of impermeable surfaces, such as roofs, roads, driveways, and car parks. Rainfall is unable to soak into the ground in such areas, and runoff is rapidly fed into waterways and stormwater drains, which may overflow. Subdivision design now often incorporates designated water retention areas or swales where water can pond and infiltrate the ground, decreasing the rate of stormwater runoff.

Urbanisation on slopes also often involves modifying the natural slope for building platforms and roads. Poorly constructed or retained cuts in slopes have created or worsened landslide hazards in many hillside suburbs in New Zealand. Developing high-density residential subdivisions on hills often involves extensive earthworks. The earthworks now commonly completely recontour the natural slopes, removing the need for oversteepened and unsupported cut slopes, and reducing the likelihood of shallow landslides.

Modification of slopes is not only an urban issue. Many slopes around New Zealand have been modified for road and railway line construction. Landslides triggered by high intensity or long duration rainfall often close roads in New Zealand.

FURTHER INFORMATION

URBAN DESIGN PROTOCOL

MINISTRY FOR THE ENVIRONMENT
www.mfe.govt.nz/issues/urban/design-protocol/index.html

WETLANDS

NATIONAL WETLAND TRUST OF NEW ZEALAND
www.wetlandtrust.org.nz/index.html
DEPARTMENT OF CONSERVATION
www.doc.govt.nz/Conservation/Wetlands/index.asp

DUNES

COMMUNITY-BASED DUNE MANAGEMENT FOR THE MITIGATION OF COASTAL HAZARDS AND CLIMATE CHANGE EFFECTS
www.lgnz.co.nz/projects/ClimateChange/index.html
COASTAL DUNE VEGETATION NETWORK
www.ensisjv.com/WorkingwithEnsis/Collaborations
/CoastalDuneVegetationNetworkCDVN/tabid/286/Default.aspx

VEGETATION AND SOIL CONSERVATION

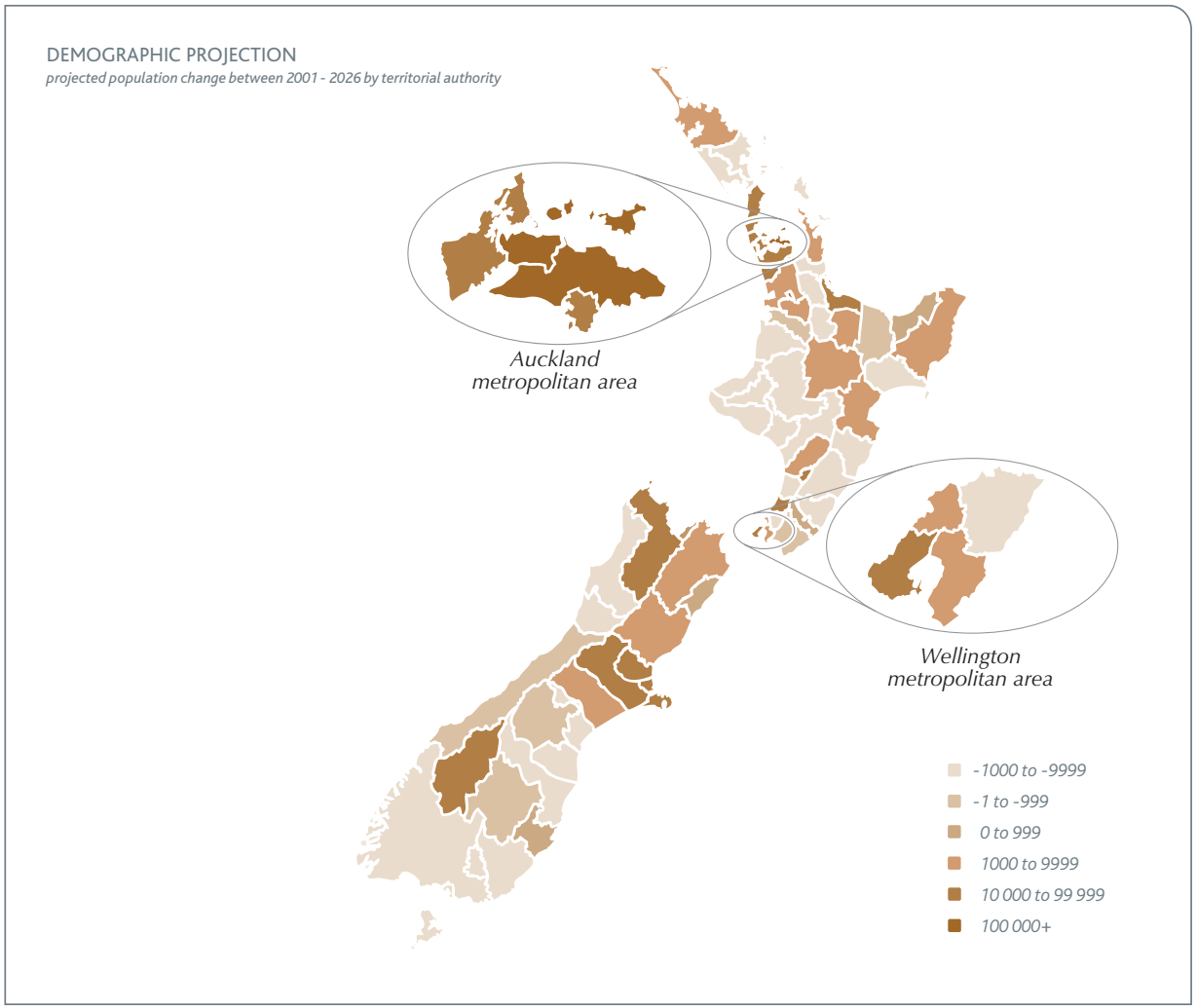
MONITORING PROGRESS TOWARDS A SUSTAINABLE NEW ZEALAND
www.stats.govt.nz/analytical-reports/monitoring-progress/default.htm
MINISTRY OF AGRICULTURE AND FORESTRY
www.maf.govt.nz/forestry/forestmanagement/ecfp/index.htm
MINISTRY FOR THE ENVIRONMENT
www.mfe.govt.nz/issues/land/soil/

DEMOGRAPHIC TRENDS

Demographic projections

New Zealand's population is increasing, but the rate of increase is slowing. New Zealand's population is projected to reach 5 million by 2051, an increase of 20 per cent from the current population of around 4.15 million. The age structure of the population will undergo significant changes in the future. There will be fewer children and more older people. Half of New Zealand's population will be aged 46 or older by 2051, compared to age 35 in 2004. By 2051, 25 per cent of the population will be aged 65 and over, compared with 12 per cent of the population in 2004. The most significant projected future changes in ethnic diversity will be the growth of the Asian population, from seven per cent of the total population in 2001 to 15 per cent in 2021.

The average size of households is likely to continue declining, from 2.6 people in 2001 to 2.4 people in 2021. There are likely to be more couples without children, overtaking two-parent families, and a continuing increase of one-person households.



Projected population changes between 2001 and 2026 by territorial authority. Most growth is expected to occur in urban areas. Almost half of New Zealand's 74 territorial authorities, mostly rural, will have fewer residents in 2026 than they did in 2001. *Statistics New Zealand.*

New Zealand's labour force numbered 1.97 million in 2001. This is projected to peak at 2.39 million in the mid-2020s before declining to 2.38 million in 2051. The average age of people in the workforce will also increase.

Population growth is fastest in New Zealand's cities and on the urban fringe because of the increase in 'lifestyle' properties. This growth is expanding urbanisation and creating higher urban property values, particularly in at-risk areas such as coastlines and steep slopes.

In contrast, the population of New Zealand's rural areas, which make up most of the country's land area, is decreasing. Intensification of farming has led to fewer but bigger properties, more commercial enterprises with fewer family-owned properties, the dissolution of rural schools, and generally lower rural populations.

Two-thirds of New Zealand's population growth between 2001 and 2026 is projected to be in the Auckland region with an increase of 560 000 people (46 per cent) from 1.22 million to 1.77 million. After Auckland, the highest growth regions will be Canterbury, Bay of Plenty, Waikato, and Wellington.

Implications for emergency management

Knowing where people live and work or study is important for response planning, especially for providing information and warnings. Health, mobility, wealth, and cultural values, which influence a community's vulnerability and ability to recover from emergencies, vary across the community. There is an increasing range of ethnic groups. Knowing a community's perspectives, expectations and needs, and how these are likely to change over time, is crucial to hazard management across reduction, readiness, response and recovery.

Changing demographics have a large bearing on risk. As the population grows, along with assets and infrastructure, so too do the potential consequences of hazards. As population density increases in urban areas, more people are potentially vulnerable to a hazard event in those areas. People also tend to be more reliant on infrastructure, the built environment, and commercial food supply chains, leaving them vulnerable if those resources fail. Of particular current interest is the demand for coastal property for residential development, and the rising value of coastal property, which is a worldwide trend. However, many of these properties, and others behind them, are in areas subject to coastal hazards.

One of the implications of the intensification of farming is that it creates greater geographical distance between rural neighbours and more isolated rural communities. This highlights the need for appropriate emergency management planning in rural areas.

The increase in the percentage of the population who have English as a second language presents challenges for communicating hazard and readiness information. The growth of the elderly population, which may be less mobile, has implications for evacuation and welfare planning. Neighbourhood support networks are becoming more important as the number of people living alone grows.

FURTHER INFORMATION

GENERAL DEMOGRAPHIC INFORMATION

STATISTICS NEW ZEALAND
www.stats.govt.nz/analytical-reports/dem-trends-05/default.htm
POPULATION AND SUSTAINABLE DEVELOPMENT
www.population.govt.nz/tools-resources/new-trends-in-topical-population-issues.htm

RELIANCE ON TECHNOLOGY

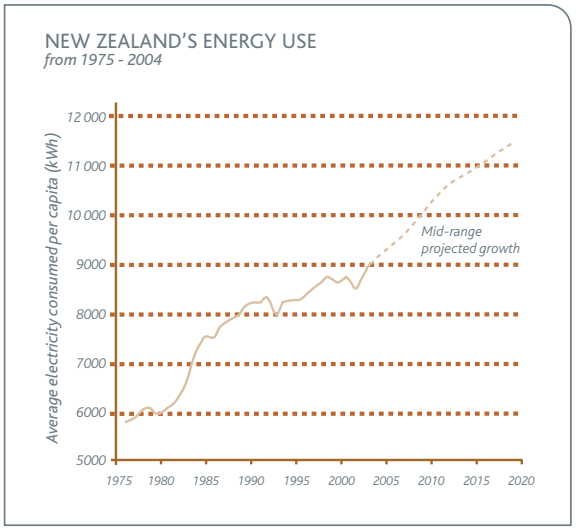
New Zealand society relies heavily on technology and interconnected infrastructure. This reliance continues to grow, and with it New Zealand's vulnerability to failure of these systems due to external or internal causes.

Trade, education, and entertainment are international. New Zealanders can travel to most places in the world within 2 or 3 days, buy products from many countries, and talk to people any time, anywhere.

New Zealand's commercial environment and social conditions are based on these opportunities. Tourism is a significant economic sector in New Zealand (4.8 per cent of GDP), and relies on well-functioning transport and information and communication systems. Imports total 27 per cent of GDP, and New Zealand has a diverse range of trading partners. Computer-based payments systems (EFTPOS and inter-bank settlements) work efficiently to support internal and overseas trade. It is possible to send and receive large amounts of data over the internet at low cost.

Competition within New Zealand has led to increased business efficiency, with small inventories and increased out-sourcing. Most of New Zealand's businesses are small to medium enterprises, and many contribute small parts to long production chains. Stock-turnover in supermarkets is rapid and highly organised. Industrial monitoring and control systems enable lifeline utilities to manage daily infrastructure operation from remote locations. Courier systems enable rapid deliveries, and New Zealand's economy is based on a 'just-in-time' model.

New Zealanders today are much more reliant on technology than past generations, with high expectations of immediate access to goods and services. For example, many households buy their food daily from supermarkets, restaurants, or fast-food outlets. Restaurants and takeaways now account for 25 per cent of New Zealanders' food consumption.



New Zealand's average annual energy use per capita has grown from around 6000 kilowatt hours a person in 1976 to around 9000 in 2004. This trend is likely to continue. *Electricity Commission*.

An effective supply chain enables New Zealanders to enjoy high living standards, but also leaves communities vulnerable when something goes wrong. The June 2006 Canterbury snowstorm led to electricity and communication outages that created difficulties for rural communities, and the failure of a single wire shackle at the Otahuhu substation in the same month resulted in a disruptive electricity blackout in Auckland.

Lifeline utilities are highly dependent on each other. For example, banks rely on the internet, computers need electricity, water supply depends on electricity-driven pumps, and monitoring and control systems within many infrastructure sectors rely on electricity and communications. A breakdown in even one part of this matrix can easily cause breakdowns in other parts.

The keys to infrastructure resilience are awareness and adaptability. These are functions not of the infrastructure itself but of the organisations that own, fund and regulate it. Organisations working together, through initiatives such as engineering lifelines groups, help minimise the risk of failure. Good business continuity and household planning helps minimise direct economic and social impacts. Business continuity planning can also reduce the loss of business confidence and promote recovery.

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