STAFF REPORT

TO: Environment & Planning Committee

FROM: Neil Jackson, Policy Planner

REFERENCE: R434

SUBJECT: **CLIMATE CHANGE RISKS BRIEFING PAPER - EP07/05/03 -** Report Prepared for 9 May 2007 Meeting

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1. PURPOSE OF THE REPORT

This purpose of this report is to brief the committee on climate change risks, and assist it to address the question of whether Council needs to make any changes to its risk management policies or operations in relation to those risks that may be aggravated by climate change.

Underlying this purpose is a need to avoid creating liability for future communities and councils.

2. COMPONENTS OF THE REPORT

The report separates four components:

- What changes to climate are occurring?
- What are causes of climate change?
- What are appropriate Council responses to those changes?
- What are appropriate Council responses to those causes?

3. WHAT CHANGES TO CLIMATE ARE OCCURRING?

3.1 Primary Drivers

The 2007 Fourth Assessment Report from the Intergovernmental Panel on Climate Change (IPCC) states:

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."

(Climate Change 2007: The Physical Science Basis – Summary for Policymakers, page 5.)

Extrapolation from observations and measurements of what has already occurred, to projections of what is likely to occur in the future, is difficult. The IPCC works with a range of possible scenarios. For global average surface warming to 2100, the "best estimate" temperature given by these different scenarios ranges from 1.8^{o} C to 4.0^{o} C. Similarly, for sea level rise, these scenarios give a range from 18 cm to 59 cm by 2100.

These are global figures. There will be regional variations.

The third measured factor is atmospheric concentrations of greenhouse gases:

Carbon dioxide:	pre-industrial: 280 ppm*;	2005: 379 ppm
Methane:	pre-industrial: 715 ppb*;	2005: 1732 ppb
Nitrous oxide:	pre-industrial: 270 ppb;	2005: 319 ppb

* parts per million; parts per billion.

Pre-industrial is pre 1750.

3.2 Likely changes

IPCC investigations and reports are primarily at a global scale. IPCC published "Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability – Summary for Policymakers" on 6 April. The full report, which will include a chapter on Australia and New Zealand, is not yet (26 April) available on the IPCC website. The IPCC material will need further analysis to provide any guidance on regional variations within New Zealand. At present all that can be said is that the additional information since the IPCC Third Assessment in 2001 confirms the trends reported then.

NIWA have produced a leaflet and a media release summarising implications for New Zealand – copies are appended to this report.

Both the IPCC report and the NIWA material indicate the most significant impacts for New Zealand are likely to be on natural ecosystems, water security, and coastal communities.

For Tasman, there are obvious risks to the soft coastline and to development on flood plains or in areas vulnerable to inundation from the sea. These risks come from the projected rise in sea level, and probable increase in frequency of flood and storm surge events. The three could occur in combination at any time.

The District already experiences water shortages. The increased frequency or duration of water short periods will mean increased implementation of the water rationing programme, unless additional water storage or augmentation can be achieved.

Increased dryness and windiness may lead to increased fire risk. Plantation forests, forest parks, and national parks are at risk. This risk is likely to be greatest when water supplies are lowest.

Biosecurity risks to both indigenous ecosystems and to commercial plant and animal stock may increase.

The NIWA leaflet says:

"Risks to major infrastructure are likely to increase markedly. These risks include failure of flood protection and urban drainage/sewerage systems, and more storm damage to buildings. The present design criteria for extreme events are very likely to be exceeded more frequently by 2030. Risks to large structures such as dams and bridges will need reassessment in light of future climate threats."

3.3 Uncertainty

While increases in temperature, sea level, and greenhouse gasses have been measured and can be projected with varying degrees of probability, there is less certainty about consequential climate factors such as rainfall, drought, or wind. These are risks that are currently managed through Council's asset management plans, engineering standards, and building and planning consent processes. Climate change adds further uncertainty about the likely occurrence, frequency and severity of rainfall and drought events, leading to debate about what is prudent risk-taking and what is prudent expenditure to minimise risk.

4. WHAT ARE CAUSES OF CLIMATE CHANGE?

4.1 Natural Causes

There is a variety of natural causes of climate change. They are not identified or explained here, as they are beyond intervention.

4.2 Induced Causes

The Fourth Assessment Report states:

"Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years … The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture."

(Climate Change 2007: The Physical Science Basis – Summary for Policymakers, pages 2.)

New Zealand greenhouse gas emissions for 2004, in CO_2 equivalents, were:

- CO_2 48%, (transport 19.2%, electricity 8.1%, energy – other processes 15.1%, industrial processes 5.6%);
- CH_4 33.5% (agriculture 31%, waste 2.5%);
- N_2O 18% (urine 15%, fertiliser 3%);
- Solvents 0.1%.

(Get a Grasp of the Facts, Ministry for the Environment, 2006)

5. WHAT ARE APPROPRIATE COUNCIL RESPONSES TO CLIMATE CHANGE?

5.1 What is Council already doing in response?

5.1.1 Water Security

The Wai iti dam has been commissioned.

Council is investigating other sites for dams for irrigation purposes, including the Lee dam concept as a major water augmentation proposal with possible hydropower generation as well.

Council operates a staged water rationing scheme as and when required.

TRMP requires a reliable and potable domestic water supply, and 23,000 litres of water storage, for dwellings in rural zones.

5.1.2 Coastal Development

Engineering standards include minimum ground levels and floor levels that take in to account projected sea level rise. These are reviewed as sea level rise estimates are refined.

Climate-related risks of inundation and flood are being considered in development proposals for Eastern Golden Bay and Richmond West.

More detailed contour information in certain low-lying areas has been commissioned.

Ad hoc coastal protection works are undertaken as and when necessary by Council. Private coastal protection works have usually been granted consent, some retrospectively.

5.1.3 Infrastructure

TRMP Variation 54 promotes low impact design for stormwater management, including reducing the volume of water needing off-site disposal.

Progressive replacement of bores when salt water intrusion occurs.

5.1.4 Biosecurity

The periodic review of the biosecurity strategy should show whether additional pest management work is required.

5.2 What additional response is required?

5.2.1 Water security

Review allowed application rates of water for irrigation.

Review water storage requirement for rural dwellings.

Monitor effectiveness of trigger levels and application rates for water rationing, and review if droughts become more severe.

Continue to investigate water augmentation options.

5.2.2 Coastal \Ddevelopment

Periodic review of ground level and floor level requirements in the Engineering Standards, as further information on sea level rise becomes available.

Increase the coverage of detailed contour information in flood plains and low-lying coastal areas.

Address the hazard risks to all coastal and floodplain development in strategic settlement development planning where such risks are likely to be exacerbated by climate change. This includes defining and refining through time, the degree of climate change exacerbated risk on the ground, specifying the extent of development restrictions and a related time horizon for those risk-reducing measures.

Develop a policy about coastal protection works. This could include:

- Locations where Council will (or will not) undertake such works (i.e. how much coastline can the community afford to protect, and which sectors of the community should meet the cost?);
- Criteria under which Council will allow private coastal protection works;
- Appropriate forms of protection works.

Develop a policy about managing the margins of estuaries. There will be conflicting views about protecting adjoining private land, and allowing the habitat provided by estuarine margins to move inland as the sea advances.

Tag consent approvals where there is reasonable risk of inundation.

5.2.3 Infrastructure

Consider whether pumping for stormwater disposal will become inevitable in low-lying locations, or whether it can and should be avoided.

Review the risk of inundation or flooding of the oxidation ponds at the Motueka River mouth and Bells Island, and prepare (update?) contingency plans if that risk is likely to occur.

Identify options for roads that are vulnerable to sea level rise or flooding: for example, protection works, raising road level, re-routing; or accepting an increased occurrence of “outages” and unplanned maintenance or repair work.

Consider implications of a longer summer period on water supply and waste water management in popular holiday areas.

Review levels of service of risk and asset management measures, and return periods for risk events of given magnitude, as further information becomes available. This is a continuing obligation as risk events occur or projections are realised and become more refined.

Avoid development where, despite minimum ground level and floor level requirements on building sites, utility services may be inundated and consequently have a higher risk of malfunction or failure.

Consider whether secondary flood channels should be regarded as part of infrastructure, with TRMP, Engineering Standards, or bylaw requirements that they be kept free of obstruction.

The design parameters for new infrastructure, upgrades, and maintenance, should take account of the best available climate related data at the time of the work.

5.2.4 Reserves

Develop policy about reserve land which is to be protected, and which is not, from erosion by the sea or rivers; and what form any protection work should take. This will need consideration of over what time span protection is likely to be effective.

Develop policy about whether esplanade entitlement should be taken as a reserve or a strip, in locations vulnerable to erosion or inundation. (Does the esplanade reserve or strip need to endure indefinitely to meet its intended purpose, or is its gradual disappearance accepted?)

Consider contingency planning for increased fire risk in reserves with significant vegetation.

5.2.5 Council Forests

Any increasing risk of wind damage or fire should be taken into account in valuing Council-owned forest.

5.2.6 LIMs

The responsibility for providing good information in response to LIMs requests requires continued monitoring and reporting of climate-related risk factors.

5.2.7 Risk Management

TRMP includes a policy in both Chapters 13 and 23: “To prepare a hazard management strategy identifying hazards and hazardous areas, and management options for these”.

TRMP includes a method statement that investigations to implement the policy should be undertaken within three years of the policy becoming operative.

This should include a review of Council's current risk management measures, especially those likely to be aggravated by climate change. Council's response to climate change may be that its current risk management measures be re-evaluated to take account of increased risks indicated in climate change projections – to the extent that these can be quantified.

5.2.8 General

Develop a strategy to ensure that development does not outstrip the availability of water.

To what extent should Council take on an advocacy role that essentially repeats advice from other sources and agencies, such as:

- Vehicle maintenance and driving practices;
- Energy efficiency at home;
- Recycling, composting.

(Is this cost-effective use of Council resources?)

To what extent can Council achieve energy efficiencies in buildings through regulation or advice? Can Council impose preferred solutions to a higher standard than required by the Building Code?

Should provision for stock refuge on higher ground be a consideration when subdivision of low-lying rural land is proposed?

Ensure that development decisions are not dictated by existing TRMP or other Council policy, if these conflict with more up-to-date information on relevant climate factors.

6. WHAT ARE APPROPRIATE COUNCIL RESPONSES TO CAUSES OF CLIMATE CHANGE?

6.1 Agricultural Emissions

Greenhouse gasses from pastoral farming are largely products of animal metabolism, which is beyond Council's ability to alter.

There is the option of Council advocating a reduction in livestock farming, and a reduction in fertiliser use. Neither could be easily pursued through regulatory measures available to Council – TRMP or bylaws.

6.2 CO_2 emissions

6.2.1 Transport

Commercial transport in the regions is primarily by road. Rail is not an option. Shipping may bring goods to the region, but distribution within the region is by road.

Non-commercial transport is primarily by car. It offers greater flexibility than the resent privately operated bus services, and is likely to remain the preferred option until there are economic disincentives to using cars.

Greater use of "public transport" in the region may need to be seeded by subsidy for an indefinite period until private transport reach unacceptable levels. But even that incentive may not overcome the inflexibility inherent in public transport routes and timetables. At present people can choose where they want to live, work, and play, knowing that cars give flexibility to link all of those activities. The region provides options for people to live near their places of work and to minimise their transport needs, but transport options, particularly the availability of public transport, are not a dominant factor in many peoples' location and activity choices.

6.2.2 Energy Emissions

The region has no electricity generation from burning fossil fuels, and no source of bulk fuel supply for that. There is no piped supply of natural gas. The Cobb power scheme provides up to 32 MW of electricity.

Energy is imported into the region in the form of electricity, petrol and diesel. Home heating is commonly from burning locally-sourced wood.

A reduction in greenhouse gas emissions (or in their rate of increase) from energy use in the region is likely to be limited to:

- Improved efficiencies in operations, equipment and appliances (including phasing out of inefficient equipment and appliances);
- Reduced discretionary use of energy.

6.3 Emissions Management

6.3.1 Communities for Climate Protection

This is a programme to assist councils to reduce greenhouse gas emissions from their own operations and from their communities. The programme assists councils through five "milestones":

- Conducting a greenhouse gas emissions inventory, analysis and forecast;
- Setting emission reduction goals;
- Developing a local action plan to achieve these goals;
- Implementing and quantifying the benefits of policies and measures in the action plan;
- Monitoring progress towards the reduction goal.

Examples for reducing emissions include:

- Saving energy and promoting sustainable energy;
- Increasing sustainable transport;
- Enhancing urban design;
- Reducing emissions form landfills;
- Supporting adoption of low-carbon technology.

There is a fee of $800 to join the CCP programme. Grant money up to $4,000 is available to facilitate Council employing an intern to assist the Council in completing the first milestone, and commencing the second, within six months. The remainder of the programme would be a cost to Council.

Sections 6.1 and 6.2 indicate that achievable emissions reduction in the region may not be great, but part of the greenhouse gas issue is that 'every little bit counts' – whether that little bit is an increase or a decrease in emissions.

6.4 Alternative Sources of Energy

6.4.1

The report: "Renewable Energy Assessment: Tasman District", Sinclair Knight Merz, July 2006, identifies renewable energy potential in the District as:

- Hydro: about 45 MW in mini, small and medium scale projects outside Department of Conservation or Native Forest areas;

- Ethanol: about 27 million litres per year for transport fuel using around 25% of available arable land; about 60 million litres or 250 GWh per year of electrical energy from low0grade forestry;

- Wave energy: several hundred megawatts (ignoring environmental constraints and conflicts with other maritime users);

- Wind power: potential for small scale wind power generation;

- Solar: significant potential for solar thermal systems (hot water); considerably less for photovoltaics (electricity).

These are estimates of resource quantities. They do not take into account any environmental or cultural constraints on the availability of those resources. Council could explore which of those constraints are insurmountable, and which may be overcome through trade-offs with other values such as the matters of national importance listed in the RMAct.

Council does not need to investigate the technical and economic constraints to using these resources, but should keep aware of changes.

7. RECOMMENDATIONS

7.1 That Council commit resources to fund detailed contour information on low-lying coastal land, to be completed by 30 June 2010.

7.2 That in the next LTCCP review, Council promote a strategy to ensure that development does not outstrip the availability of water.

7.3 That Council apply the best available climate information at the time of:

- infrastructure installation, upgrade, or maintenance;
- asset management reviews;
- risk management reviews;
- reviews of policy documents including: Regional Policy Statement, Tasman Resource Management Plan, Engineering Standards and Policies, Civil Defence Emergency Management Plan, and reserve management plans.

7.4 That Council notes the staff responsibility to report on climate-related risks when evaluating resource consent and building consent applications.

7.5 That Council upgrade the priority for the all-hazards management strategy stated in TRMP and link it with the NelTas lifelines project work still required.

7.6 That Council directs consideration of the benefits and costs of its joining the Communities for Climate Change Programme (CCCP) managed by the Ministry for the Environment.

8. WEB LINKS RELATED TO CLIMATE CHANGE:

www.ipcc.ch
www.climatechange.govt.nz
www.niwascience.co.nz

Gisborne District Council produced a 66 page report "An Overview of Climate Change and Possible Consequences for Gisborne District" in July 2006. It is a comprehensive report on practical implications of climate change in Gisborne District. Much of what the report says is relevant Tasman. It can be found at:

www.gdc.govt.nz Plans/Reports, Civil Defence and Emergency Management, Climate Change Report.

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Climate Change

NIWA
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IPCC Fourth Assessment Report

Impacts: New Zealand & the South Pacific

The Intergovernmental Panel on Climate Change (IPCC) has released an authoritative report on climate change impacts, adaptation, and vulnerability. This leaflet highlights some of its key findings for New Zealand, Australia, and the South Pacific.

The report of Working Group II of the IPCC was released (subject to final edits) in April 2007. It contains chapters on regional climate change including for the New Zealand/Australia region and small islands.

The Fourth Assessment

The IPCC was formed in 1988 to provide reliable scientific advice on climate change. Approximately every six years, it has produced a full assessment of the current state of scientific knowledge on climate change and what it means for us. These reports synthesise evidence and analyses published either in peer-reviewed journals or other credible sources.

The IPCC Fourth Assessment Report comprises four volumes:

- Working Group I: The Physical Science Basis
- Working Group II: Impacts, Vulnerabilities, and Adaptation
- Working Group III: Mitigation of Climate Change
- Synthesis Report

The process involved over 1200 scientific authors and over 2500 expert reviewers from more than 130 countries.

More data, more certainty

The IPCC's previous (third) assessment was published in 2001.
Since then, there has been:

- more extensive documentation of observed changes to natural systems as a result of warming. (Over 29,000 data series of observations were used in the report as a whole.)
- major advances in understanding potential future climate changes and impacts
- more attention to the role of planned adaptation in reducing vulnerability
- new assessment of key risks and benefits
- advancement in research on assessing vulnerability to future climate change

Regional climate change has already occurred

Since 1950, there has been 0.3–0.7 °C warming across the Australia/NZ region as a whole, with more heat waves, fewer frosts, more rain in southwest New Zealand, less rain in northeastern New Zealand, and a rise in sea level of about 70 mm.

We are already experiencing the impacts of climate change

The report states with "high confidence" that impacts of regional climate change are now evident in increasing stresses on water supply and agriculture, changed natural ecosystems, reduced seasonal snow cover, and ongoing glacier shrinkage.

Adaptation is already occurring to combat observed climate change: examples come from sectors such as water, natural ecosystems, agriculture, horticulture, and coasts. However, ongoing vulnerability to extreme events is demonstrated by substantial economic losses caused by droughts, floods, fire, tropical cyclones, and hail.

Adaptation can have immediate benefits

A portfolio of adaptation and mitigation measures can diminish the risks of climate change. Even if we shut off greenhouse gas emissions today, the world is committed to a 0.6 °C rise in global average surface temperature by 2100. In addition, because of lags in the climate system, the report says there is unlikely to be any noticeable climate effect from reducing greenhouse gas emissions (mitigation) until at least 2040. The benefits of adaptation, by contrast, can be immediate, especially when they also address climate variability. Adaptive measures can be implemented at all levels now with local benefit, without the need for global agreements. However, over the long run, adaptation alone cannot deal with all the projected effects of climate change if temperatures continue to rise. Eventually adaptation measures will be insufficient. Vulnerability to climate change will increase as impacts worsen.

New Zealand: future climate projections

During the 21st century, New Zealand's climate is "virtually certain" [more than 99% probability] to be warmer, with noticeable changes in extreme events:

- Heat waves and fire risk are virtually certain to increase in intensity and frequency.
- Floods, landslides, droughts, and storm surges are very likely to become more frequent and intense, and snow and frost are likely to become less frequent.
- Large areas of eastern New Zealand are likely to have less soil moisture, although western New Zealand is likely to receive more rain.

New Zealand: the impacts

Some beneficial effects initially

- Up to about 2050, enhanced growing conditions from higher carbon dioxide concentrations, longer growing seasons and less frost risk are likely to benefit agriculture, horticulture, and forestry over much of New Zealand provided adequate water is available. But by 2050, agriculture and forestry production is likely to be reduced over parts of eastern New Zealand due to increased drought and fire.
- Reduced energy demand is very likely in winter.
- Flows in New Zealand's largest rivers are likely to increase, benefiting hydroelectricity generation and irrigation supply.

These benefits are limited to specific sub-sectors and sub-regions, and are for a global average temperature increase of about 1–2 °C.

The potential impacts of climate change are likely to be substantial without further adaptation. The most vulnerable sectors for New Zealand are natural ecosystems, water security, and coastal communities.

Natural ecosystems

The structure, function, and species composition of many natural ecosystems are very likely to alter. Some of these are within World Heritage sites.

The impacts of climate change are likely to be significant by 2020, and are virtually certain to:

- exacerbate existing stresses such as invasive species and habitat loss;
- increase the probability of species extinctions;
- degrade many natural systems;
- reduce ecosystem services for tourism, fishing, forestry, and water supply.

The projected rates of climate change are very likely to exceed rates of evolutionary adaptation in many species, and habitat loss and fragmentation are very likely to limit species migration in response to shifting climatic zones.

By 2080, 200–300 New Zealand indigenous alpine plant species may be extinct due to climate change. Little research exists on climate change impacts for New Zealand species or ecosystems outside the alpine zone and some forested areas.

The report says that actions to reduce non-climatic stresses such as water pollution, habitat fragmentation, and invasive species can enhance the resilience of many ecosystems.

Water security

Projections show that drought events are likely to increase in both frequency and severity in the eastern lowlands of New Zealand. Ongoing water security problems are very likely to increase by 2030 in those parts of eastern New Zealand that are distant from major rivers.

The report says increasing demand for water has already exceeded supply in some catchments but "ongoing and proposed adaptation strategies are likely to buy some time."

Coastal development

Ongoing coastal development is very likely to exacerbate the future risk to lives and property from sea-level rise and storms:

- Sea level is virtually certain to rise.
- By 2050, there is very likely to be increasing loss of high-value land, faster road deterioration, degraded beaches, and loss of landmarks of cultural significance.

The report says tighter planning and regulation are likely to be required if continued rates of coastal development are to remain sustainable.

Hotspots

By 2050, vulnerability is likely to be high in a few identified hotspots.

In New Zealand, the hotspots are:

- **Northland to Bay of Plenty:** ongoing coastal development is very likely to exacerbate the future risk to lives and property from sea-level rise and storms.
- **Eastern lowland regions:** water security problems from increased drought and rising demand where irrigation is unavailable.
- **Alpine zones (Southern Alps):** loss of plant and animal species, increase in shrubs at expense of herb fields. Glacier shrinkage and reduction in snow cover. Threats to built environment from increased flooding, erosion, and landslides.

These hotspots were chosen based on the following criteria: large impacts, low adaptive capacity, substantial population, economically important, substantial exposed infrastructure, and subject to other major stresses (e.g., continued rapid population growth, ongoing development, ongoing land degradation, ongoing habitat loss, threats from rising sea level).

Infrastructure

Risks to major infrastructure are likely to increase markedly. These risks include failure of flood protection and urban drainage/sewerage systems, and more storm damage to buildings. The present design criteria for extreme events are very likely to be exceeded more frequently by 2030. Risks to large structures such as dams and bridges will need reassessment in light of future climate threats.

Tourism

Changes in seasonal snow cover are likely to have a significant impact on the ski industry. The snow line is likely to rise by 120–270 m based on scenarios for the 2080s, but tourist flows from Australia to New Zealand might grow as a result of the relatively poorer snow conditions there. Noticeable glacier shrinkage and retreat are very likely for even small temperature rises, and likely to reduce visitor flows through tourism-dependent towns such as Fox and Franz Josef.

Pastoral farming

In cool areas of New Zealand, annual pasture production is very likely to increase by 10–20% by 2030, although gains may decline thereafter. Subtropical pasture species with lower feed-quality are likely to spread southwards, reducing productivity, particularly near Waikato.

The range and incidence of many pests and diseases are likely to increase. Water security problems are likely to make irrigated agriculture vulnerable. Less cold-stress is likely to reduce lamb mortality.

Horticulture

Areas suitable for particular crops are projected to change. For example, production of current kiwifruit varieties is likely to become uneconomic in Northland by 2050 because of lack of winter chilling, but more areas in the South Island are likely to become suitable. New Zealand is likely to be more susceptible to the establishment of new horticultural pests.

Forestry

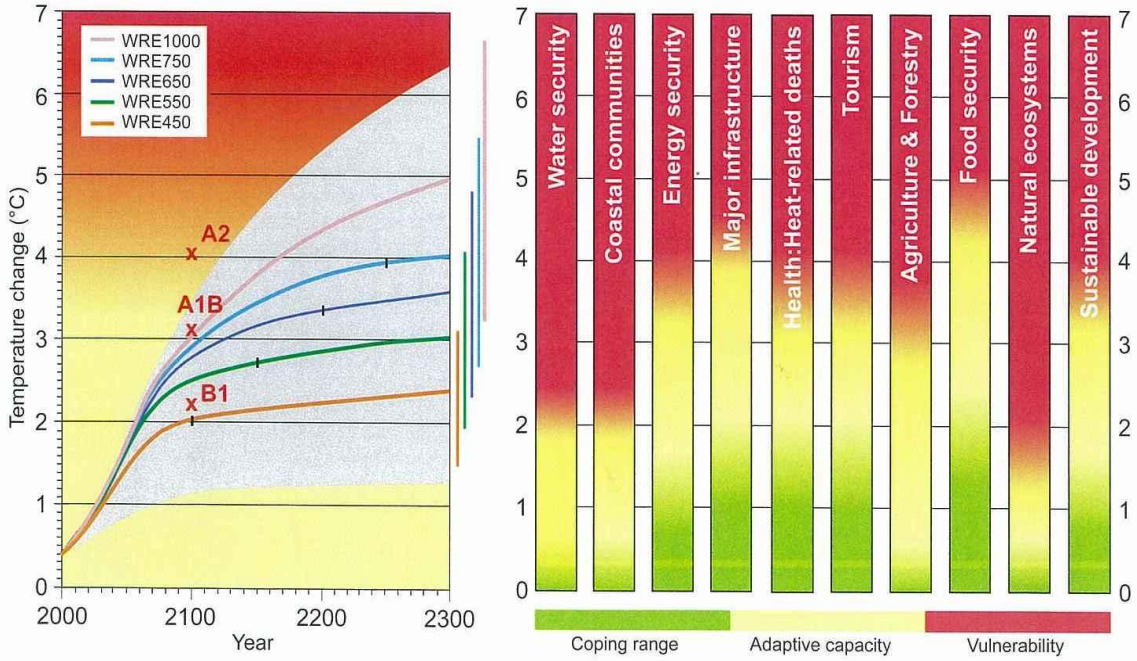
In the south and west, growth rates of economically-important plantation forests (mainly *Pinus radiata*) are likely to increase, but tree growth reductions are likely for the east of the North Island.

Fisheries

Few climate change impact studies have been undertaken, but impacts are likely to be greater for temperate endemic species than for tropical species, and on coastal and demersal fisheries relative to pelagic and deepsea fisheries.

New Zealand: vulnerability

Ecosystems, water security, and coastal communities of the region have a narrow coping range. They become vulnerable if the global temperature rises by 1.5–2 °C even with adaptive measures.
Energy security, health, agriculture, and tourism have considerable coping ranges and adaptive capacity, but they become vulnerable if global warming exceeds 3.0 °C.



Vulnerability to climate change aggregated for key sectors in the Australia and New Zealand region. Right-hand panel is a schematic diagram assessing relative coping range, adaptive capacity, and vulnerability. Left-hand panel shows global temperature change taken from the Third Assessment Report. The coloured curves in the left-hand panel represent temperature changes associated with stabilisation of CO_2 concentrations at 450 ppm, 550 ppm, 650 ppm, 750 ppm, and 1000 ppm. Year of stabilisation is shown as black dots. It is assumed that emissions of non-CO_2 greenhouse gases follow the SRES A1B scenario until 2100 and are constant thereafter. The shaded area indicates the range of climate sensitivity across the five stabilisation cases. The narrow bars show uncertainty at the year 2300. Crosses indicate warming by 2100 for the SRES B1, A1B, and A2 scenarios.
[Source: IPCC WGII Fourth Assessment Report, chapter 11, figure 11.4]

Australia: the drying continent

This section contains just a few examples of Australian impacts of interest to New Zealanders. For more detail, refer to chapter 11 of the full report.

Water security

By 2030, water security problems are very likely to be exacerbated over large areas of southern and eastern Australia. Their largest river system, the Murray-Darling Basin, currently accounts for about 70% of irrigated crops and pastures, and water allocations already exceed supply. Annual streamflow in the basin is likely to fall 10–25% by 2050 and 16–48% by 2100.

In southern Australia, agricultural production is likely to be reduced due to increased droughts and fires, and cropping is likely to become unviable at the dry margins.

Natural ecosystems: Great Barrier Reef

By 2050, 97% of the Great Barrier Reef could be bleached every year. By 2080, the picture is one of "catastrophic mortality" of coral species each year, with a 95% decrease in the distribution of Great Barrier Reef species.

Human health: dengue fever

Dengue fever represents a "substantial threat" to Australia. Projected climate changes, combined with population growth, are likely to increase the number of people living in areas capable of supporting *Aedes aegypti*, the major mosquito vector of the dengue virus.

The South Pacific: small islands, big impact

Working Group II identifies small islands, including those in the South Pacific, as one of four regions of the world likely to be especially affected by climate change. (The other three regions are: the Arctic, Africa, and Asian megadeltas.)

Sea-level rise

Sea-level rise is likely to exacerbate inundation, storm surge, erosion, and other coastal hazards, thus threatening vital infrastructure, settlements, and facilities. Some studies suggest sea level rise could lead to possible reduction in island size, particularly in the Pacific, whilst others show a few islands are morphologically resilient and expected to persist.

Port facilities at Suva (Fiji) and Apia (Samoa) are likely to experience overtopping, damage to wharves, and flooding of the hinterland following a 0.5 m rise in sea level combined with waves associated with a 1-in-50 year cyclone.

Coral reefs, fisheries, and other marine-based resources

The impact of climate change is likely to be heavy here. The following factors are very likely to affect the health of coral reefs and other marine ecosystems which sustain small island fisheries:

- increasing sea surface temperature and sea level;
- increased turbidity, nutrient loading, and chemical pollution;
- damage from tropical cyclones;
- possible decreases in growth rates due to ocean acidification.

Such impacts will exacerbate non-climate change stresses on coastal systems. It is likely that these changes would in turn negatively affect the attraction of small islands as premier tourism destinations.

Pressure on water resources

There is strong evidence that under most climate change scenarios, water resources in small islands are likely to be seriously compromised. A 10% reduction in average rainfall by 2050 would lead to a 20% reduction in the size of the freshwater lens on Tarawa Atoll, Kiribati. Reduced rainfall coupled with sea-level rise would compound this threat.

Human health effects

There is growing concern that climate change is likely to adversely affect human health. Many small islands are located in regions whose weather and climate are already conducive to the transmission of diseases such as malaria, dengue, filariasis, and food- and water-borne diseases. Increasing temperatures and decreasing water availability are likely to increase diarrhoeal and other infectious diseases on some islands.

Economic impact

Without adaptation, by 2050, agricultural economic costs from climate change are likely to reach between 2–3% of 2002 GDP on high terrain islands (e.g., Fiji) and 17–18% of 2002 GDP on low terrain islands (e.g., Kiribati). These figures are for mid-range climate change scenarios.

Costs & benefits of adaptation

Studies so far suggest that adaptation options for small islands are likely to be limited and the costs high relative to GDP. Despite this, "exploratory research" indicates prudent adaptation strategies can generate other benefits as well. For example, the use of waste-to-energy and other renewable energy systems can promote sustainable development, while strengthening resilience to climate change.

This leaflet was produced by the NIWA National Climate Centre, in collaboration with the Royal Society of New Zealand and the NZ Ministry for the Environment. It was reviewed by B.Fitzharris (Otago University), H.Larsen (MfE), P.Lefale (MetService), J.Salinger (NIWA), D.Wratt (NIWA).

Further copies are available from:
NIWA National Climate Centre
Tel: 0800 RING NIWA (0800 746 464)
Email: climate-enquiries@niwa.co.nz
Also available online at: www.niwascience.co.nz/ncc

NIWA Taihoro Nukurangi

Ministry for the Environment Manatū Mō Te Taiao

the Royal Society of New Zealand

April 2006

Media Release

IPCC identifies climate change impacts & vulnerability for New Zealand

10 April 2007

Water security, natural ecosystems, and coastal communities are the three sectors most vulnerable to climate change in New Zealand, according to an Intergovernmental Panel on Climate Change (IPCC) report finalised in Brussels last Friday.

Changes already observed since 1950 include:

- A warming in mean temperature for New Zealand of 0.4 °C;
- A decrease in cold nights and frosts by 10–20 days per year;
- Sea level rise of about 70 mm;
- Loss of at least a quarter of alpine ice mass;
- Increased seed production in beech forest.

Referring to New Zealand, the report's findings include:

- As a result of reduced precipitation and increased evaporation, water security problems are projected to intensify by 2030 in Northland and some eastern regions.
- Sites at risk of loss of biodiversity include the alpine areas and sub Antarctic Islands.
- Ongoing coastal development and population growth in areas such as Northland to Bay of Plenty are projected to exacerbate risks from sea-level rise and increases in the severity and frequency of storms and coastal flooding by 2050.
- Production from agriculture and forestry is projected to decline by 2030 over parts of eastern New Zealand due to increased drought and fire. However, initial benefits to agriculture and forestry are projected in western and southern areas and close to major rivers due to a longer growing season, less frost, and increased rainfall. A southward shift in agricultural pests and diseases is likely with New Zealand becoming more susceptible to the establishment of new horticultural pests.

Dr Jim Salinger of NIWA, who was a lead author of the chapter in the report referring to Australia and New Zealand, says: "This chapter is the product of a comprehensive survey of the science since 2001. 's based on over 550 research studies of what's happening in Australia and New Zealand. In addition, over 50 independent experts reviewed the chapter."

"The potential impacts of climate change for New Zealand are likely to be substantial without further adaptation. The most vulnerable sectors are natural systems, water security and coastal communities."

"Apart from natural systems, New Zealand has substantial adaptive capacity to cope with small amounts of climate change. This is due to our well-developed economy and strong scientific and technical capabilities. But there are considerable constraints to implementation and there will be major challenges from changes in extreme events and larger amounts of changes in climate," Dr Salinger says.

Key findings – what the report says about New Zealand

NZ & Australia: Adaptation

Planned adaptation can greatly reduce vulnerability.

For Australia and New Zealand, the magnitude of investment in adaptation is far outweighed by that in

mitigation [measures to reduce greenhouse gas emissions]. The latter is intended to slow global warming. However, there is unlikely to be any noticeable climate effect from reducing greenhouse gases until at least 2040.

In contrast, the benefits of adaptation can be immediate, especially when they also address climate variability. Adaptation options can be implemented now for Australia and New Zealand at personal, local and regional scales. Enhancing society's response capacity through the pursuit of sustainable development pathways is one way of promoting both adaptation and mitigation.

Changes since the Third Assessment (2001)

Since the Third Assessment Report, Australia and New Zealand have taken notable steps in building adaptive capacity by increasing support for research and knowledge, expanding assessments of the risks of climate change for decision makers, infusing climate change into policies and plans, promoting awareness and better dealing with climate issues. However, there remain formidable environmental, economic, informational, social, attitudinal and political barriers to implementation of adaptation.

Natural ecosystems

For many natural ecosystems, impacts have limited reversibility. Planned adaptation opportunities for offsetting potentially deleterious impacts are often limited due to fixed habitat regions (e.g. the Wet Tropics and upland rainforests in Australia and the alpine zone in both Australia and New Zealand). One adaptive strategy is to provide corridors to facilitate migration of species under future warming. This will require changes in land tenure in many regions with significant economic costs; although schemes to promote such connectivity are already underway in some Australian states. Another strategy is translocation of species. This is a measure of "last resort" due to cost, but may be considered desirable for some iconic or charismatic species.

Water

For water, planned adaptation opportunities lie in the inclusion of risks due to climate change on both the demand and supply side. In urban catchments, better use of stormwater and recycled water augment supply, although existing institutional arrangements and technical systems for water distribution constrain implementation. Moreover, there is community resistance to the use of recycled water for human consumption (*e.g.* in such cities as Toowoomba in Queensland, and Goulburn in NSW). Installation of rainwater tanks is another adaptation response and is now actively pursued through incentive policies and rebates. For rural activities, more flexible arrangements for allocation are required, via expansion of water markets, where trading can increase water use efficiency. Existing attitudes toward water pricing and a lack of political will to adjust the structure of the existing system are significant barriers.

Agriculture

For agriculture, there are opportunities for planned adaptation via improvements in crop varieties, rotations, farm technology, farm practices and land use mix. Cropping can be extended to historically wetter regions. Implementation will require new investment and significant managerial changes. Farmers in the eastern New Zealand are engaging in local discussion of risks posed by future climate change and how to enhance adaptation options. They stress the need for support and education for 'bottom-up' adaptation. Farming of marginal land at the drier fringe is likely to be increasingly challenging, especially in those regions of both countries with prospective declines in rainfall.

Coasts

In coastal areas, there is solid progress in risk assessments and in fashioning policies and plans at the local and regional level in New Zealand. However, there remain significant challenges to achieving concrete actions that reduce risks. Consistent implementation of adaptation measures (e.g. setback lines, planned retreat, dune management, building designs, prohibition of new structures and siting requirements that account for sea-level rise) has been difficult. Differences in political commitment, lack of strong and clear

guidelines from government, and legal challenges by property owners are major constraints.

Barriers to adaptation

Considering all sectors, four broad barriers to adaptation are evident:

1. Lack of methods for integrated assessment of impacts and adaptation that can be applied on an area-wide basis. Sector-specific knowledge and tools have steadily progressed. However, vulnerability of water resources, coasts agriculture and ecosystems of local areas and regions are inter-connected and need to be assessed accordingly.
2. Lack of well-developed evaluation tools for assessing planned adaptation options, like benefit-cost analysis, incorporating climate change and adapted for local and regional application.
3. Ongoing scepticism about climate change science, uncertainty in regional climate change projections, and a lack of knowledge about how to promote adaptation. This despite 87% of Australians being more concerned about climate change impacts than terrorism. Application of risk-based approaches to adaptation (*e.g.* upgrading urban storm-water infrastructure design demonstrate how developments can be "climate proofed". While a risk-based method for planned adaptation has been published for Australia, there are few examples of where it has been applied.
4. Weak linkages between the various strata of government, from national to local, regarding adaptation policy, plans and requirements. Stronger guidance and support are required from state (in Australia) and central government (in New Zealand) to underpin efforts to promote adaptation locally. For example, the New Zealand Coastal Policy Statement states that regional councils should take account of future sea-level rise. But there is lack of guidance as to how this should be accomplished and little support for building capacity to undertake the necessary actions. As a consequence, regional and local responses have been limited, variable and inconsistent.

Vulnerability varies between sectors, depending on adaptive capacity

Ecosystems, water security, and coastal communities of the region have a narrow coping range. Even if adaptive capacity is realised, vulnerability occurs for 1.5–2.0 °C of global warming.

Energy security, health (heat-related deaths), agriculture and tourism, have considerable coping ranges and adaptive capacity, but they become vulnerable if global warming exceeds 3.0 °C.

NZ Impacts: Agriculture

Cropping

In New Zealand, for C3 crops such as wheat, the CO_2 response is likely to more than compensate for a moderate increase in temperatures. The net impact in irrigation areas depends on availability of water.

For maize (a C4 crop), reduction in growth duration reduces crop water requirements, providing closer synchronisation of development with seasonal climatic conditions.

Horticulture

Kiwifruit: Warmer summer temperatures for Hayward kiwifruit are likely to increase vegetative growth at the expense of fruit growth and quality. Kiwifruit budbreak is likely to occur later, reducing flower numbers and yield in northern zones. Production of current kiwifruit varieties is likely to become uneconomic in Northland by 2050 because of lack of winter chilling, and be dependent on dormancy-breaking agents and varieties bred for warmer winter temperatures in the Bay of Plenty. In contrast, more areas in the South Island are likely to be suitable.

Apples: are very likely to flower and reach maturity earlier, with increased fruit size, especially after 2050.

Grapes: Earlier ripening and possible reductions in grape quality are likely by 2030. In cooler Australian climates, warming is likely to allow alternative varieties to be grown. With warming in New Zealand, red wine production is increasingly likely to be practised in the south, with higher yields. Higher CO_2 levels increase vine vegetative growth and subsequent shading is likely to reduce fruitfulness. Distribution of vines is likely to change depending upon suitability compared with high yield pasture and silviculture, and with irrigation water availability and cost.

New Zealand is likely to be more susceptible to the establishment of new horticultural pests. For example, under the current climate, only small areas in the north are suitable for oriental fruit fly, but by the 2080s it is likely to expand to much of the North Island.

Pastoral farming

In cool areas of New Zealand, higher temperatures, higher CO_2 concentrations and less frost are very likely to increase annual pasture production by 10 to 20% by 2030, although gains may decline thereafter.

Subtropical pastoral species with lower feed-quality such as *Paspalum* are likely to spread southwards, reducing productivity, particularly near Waikato.

The range and incidence of many pests and diseases are likely to increase.

Water security problems are likely to make irrigated agriculture vulnerable, *e.g.* intensive dairying in Canterbury.

NZ Impacts: Coasts

Sea-level rise is virtually certain to cause greater coastal inundation, erosion, loss of wetlands, and salt-water intrusion into freshwater sources, with impacts on infrastructure, coastal resources and existing coastal management programs.

The likely rise in sea-level, together with changes to weather patterns, ocean currents, ocean temperature and storm surges are very likely to create differences in regional exposure. In New Zealand, there is likely to be more vigorous and regular swells on the west coast.

Future effects on coastal erosion include climate-induced changes in coastal sediment supply and storminess. In Pegasus Bay, for example, shoreline erosion of up to 50 m is likely between 1980 and 2030 near the Waipara River if southerly waves are reduced by 50%, and up to 80 m near the Waimakariri River if river sand is reduced by 50%.

Coasts are also likely to be affected by changes in pollution and sediment loads from changes in the intensity and seasonality of river flows, and future impacts of river regulation.

NZ Impacts: Natural Ecosystems

The flora and fauna of Australia and New Zealand have a high degree of endemism (80–100% in many taxa). Many species are at risk from rapid climate change because they are restricted in geographic and climatic range. Most species are well-adapted to short-term climate variability, but not to longer-term shifts in mean climate and increased frequency or intensity of extreme events.

Many reserved areas are small and isolated, particularly in the New Zealand lowlands and in the agricultural areas of Australia. Bioclimatic modelling studies generally project reductions and/or fragmentation of existing climatic ranges. Climate change will also interact with other stresses such as invasive species and habitat fragmentation.

The most vulnerable for New Zealand include alpine areas, isolated lowland habitats, and coastal and freshwater wetlands. Little research exists on climate change for New Zealand species or natural ecosystems, with the exception of the alpine zone and some forested areas.

Major changes are expected in all vegetation communities.

Alpine zones: Reductions in duration and depth of snow cover are likely to alter distributions of communities, for example favouring an expansion of woody vegetation into herbfields. Alpine vertebrates dependent on snow cover for hibernation are likely to be at risk of extinction.

Freshwater: Saltwater intrusion as a result of sea level rise, decreases in river flows and increased drought frequency, are very likely to alter species composition of freshwater habitats, with consequent impacts on estuarine and coastal fisheries.

NZ native forest: fragmented native forests of drier lowland areas (Northland, Waikato, Manawatu) and in the east (from East Cape to Southland) are likely to be most vulnerable to drying and changes in fire regimes.

On the sub-Antarctic Islands, likely impacts include increased mortality of burrowing petrels, increased invasions by disturbance-tolerant alien plants such as *Poa annua*, increased abundance of existing rats, mice and rabbits on islands, and reduced distribution of *Sphagnum* moss.

NZ Impacts: Energy

Energy consumption is projected to grow due to demographic and socio-economic factors. However, average and peak energy demands are also linked to climatic conditions.

Increases in peak energy demand due to increased air conditioner use are likely to exceed those for base load, so more peak generating capacity is likely to be needed beyond that for underlying economic growth, and the risk of black-outs is likely to increase. However, *annual total* demand may be less sensitive to warming as there is likely to be a reduction in winter heating demand counteracting the increasing summer demand, *e.g.* New Zealand electricity demand decreases by 3% per 1 °C increase in mean winter temperature.

Climate change is likely to affect energy infrastructure in New Zealand through impacts of severe weather events on wind power stations, electricity transmission and distribution networks, oil and gas product storage and transport facilities, and off-shore oil and gas production. There are also likely to be costs and damages that can be avoided by adaptation and mitigation.

Increased westerly wind speed is very likely to enhance wind generation and spill-over precipitation into major South Island hydro catchments, and to increase winter rain in the Waikato catchment. Warming is virtually certain to increase melting of snow, the ratio of rainfall to snowfall, and river flows in winter and early spring. This is very likely to assist hydro-electric generation at the time of peak energy demand for heating.

NZ Impacts: Forestry

The growth rates for plantation forestry (mainly *P. radiata*) are likely to increase in response to elevated CO_2 and wetter conditions in the south and west of New Zealand. Studies of pine seedlings confirm growth and wood density of *P. radiata* are enhanced during the first two years of artificial CO_2 fertilization.

Tree growth reductions are likely for the east of the North Island due to projected rainfall decreases.

Uncertainties remain regarding increased water use efficiency with elevated CO_2 , and whether warmer and drier conditions could increase the frequency of upper mid-crown yellowing and winter fungal diseases.

NZ Impacts: Human Health

One of the most significant health impacts of climate change is likely to be an increase in heat-related deaths. In Auckland and Christchurch, a total of 14 heat-related deaths occur per year in people aged over 65, but this is likely to rise to 28, 51 and 88 deaths for warmings of 1, 2 and 3 °C, respectively, assuming no planned adaptation. Demographic change is likely to amplify these figures.

The winter peak in deaths is likely to decline.

There are likely to be alterations in the geographic range and seasonality of some mosquito-borne infectious diseases. Parts of the North Island are likely to become suitable for breeding of the major dengue vector, while much of the country becomes receptive to other less efficient vector species. The risk of dengue in New Zealand is likely to remain below the threshold for local transmission beyond 2050.

Warmer temperatures and increased rainfall variability are likely to increase the intensity and frequency of summer-time (salmonella) food-borne and water-borne diseases.

Impacts on aeroallergens and photochemical smog in cities remain uncertain.

NZ Impacts: Māori

Changes in New Zealand's climate over the next 50–100 years are likely to challenge the Māori economy and influence the social and cultural landscapes of Māori people.

Some Māori have significant investment in fishing, agriculture and forestry and down-stream activities of processing and marketing, as well as being important stakeholders in New Zealand's growing tourist industry. Economic performance and opportunities in these primary industries are likely to be influenced by climate-induced changes to production rates, product quality, pest and disease prevalence, drought, fire-risk and biodiversity, which, in turn, will affect the ability to raise development capital in these industries.

While the majority of Māori live in urban environments, they also occupy remote and rural areas where the economy and social and cultural systems are strongly tied to natural environmental systems (*e.g.* traditional resource use, tourism), and where vital infrastructure and services are vulnerable to extreme weather events (*e.g.* flooding, landslides).

The capacity of Māori to plan and respond to threats of climate change to their assets (i.e. buildings, farms, forests, native forest, coastal resources, businesses) varies greatly, and is likely to be limited by access to funds, information and human capital, especially in Northland and on the East Coast where there are large populations of Māori and increased risks of extreme weather are likely. Other pressures include:

- the unclear role of local authorities with regard to rules, regulations and strategies for adaptation;
- multiple land-ownership and decision-making processes can be complex often making it difficult to reach consensus and implement costly or non-traditional adaptation measures; and
- the high spiritual and cultural value placed on traditional lands/resources that can restrict or rule out some adaptation options such as relocation.

Many rural Māori also rely on the use of public and private land and coastal areas for hunting and fishing to supplement household food supplies, for recreation and the collection of firewood and cultural resources.

The distribution and abundance of culturally important flora and fauna is likely to be adversely influenced by climate change, so the nature of such activities and the values associated with these resources are likely to be adversely affected, including spiritual well being and cultural affirmation. These challenges compound the sensitivity of Māori to climate change.

NZ Impacts: Settlements, industry, society

Settlements, industry, and society are sensitive to extreme weather events, drought and sea-level rise. Many planning decisions involving settlements and infrastructure need to account for new climatic conditions and higher sea-levels, but little research has been done on climate change impacts. The planning horizon for refurbishing major infrastructure is 10–30 years, while major upgrades or replacement have an expected lifetime of 50 to 100 years. In New Zealand, there are 1.4 million homes valued at about US$0.2 million each, which is equivalent to about triple the national GDP. The average life of a house is 80 years and some last for 150 years or more.

Infrastructure

For infrastructure, design criteria for extreme events are very likely to be exceeded more frequently. Increased damage is likely for buildings (*e.g.* concrete joints, steel, asphalt, protective cladding, sealants), transport structures (*e.g.* roads, railways, ports, airports, bridges, tunnels), energy services, telecommunications (*e.g.* cables, towers, manholes) and water services.

Property values & investment

Climate change is very likely to affect property values and investment through disclosure of increased hazards, as well as affecting the price and availability of insurance. Insurance costs are very likely to rise in areas with increased risk.

Communities

There are major implications for amenities, cultural heritage, accessibility and health of communities. These include costs, injury and trauma due to increased storm intensity and higher extreme temperatures, damage to items and landscapes of cultural significance, degraded beaches due to sea-level rise and larger storm surges, and higher insurance premiums. Increased demand for emergency services is likely.

Climate change may contribute to destabilising unregulated population movements in the Asia-Pacific region, providing an additional challenge to national security. Population growth and a 1 m rise in sea-level are likely to affect 200–450 million people in the Asia-Pacific region. An increase in migrations from the Asia-Pacific region to surrounding nations such as New Zealand and Australia is possible.

NZ Impacts: Tourism

Tourism contributes about 5% of New Zealand GDP and 16% of exports. Most tourism and recreation in New Zealand rely on resources of the natural environment. Few regional studies have assessed potential impacts, but elsewhere there is evidence that climate change directly impacts on tourism.

Some tourist destinations may benefit from drier and warmer conditions, *e.g.* for beach activities, viewing wildlife and geothermal activity, trekking, camping, climbing, wine tasting and fishing. However, greater risks to tourism are likely from increases in hazards like flooding, storm surges, heatwaves, cyclones, fires and droughts. These adversely affect transport, personal safety, communication, water availability and natural attractions like coral reefs, beaches, freshwater wetlands, snow, glaciers and forests. Changes in species distribution and ecosystems in National Parks are likely to alter their tourism appeal.

Changes in seasonal snow cover are likely to have a significant impact on the ski industry. The snow line is likely to rise by 120–270 m based on seven scenarios for the 2080s. Tourist flows from Australia to New Zealand might grow as a result of the relatively poorer snow conditions in Australia.

Numerical modeling of Franz Josef glacier reveals that temperature is the dominant control on glacier length for New Zealand's maritime glaciers. Noticeable shrinkage and retreat is very likely for even small temperature increases, and likely to reduce visitor flows through tourism dependent towns such as Fox and Franz Josef.

NZ Impacts: Water

Water supply

Proportionately more runoff is very likely from South Island rivers in winter, and less in summer. This is very likely to provide more water for hydro-electric generation during the winter peak demand period, and reduce dependence on hydro storage lakes to transfer generation into the next winter. However, industries dependent on irrigation are likely to experience negative effects due to lower water availability in spring and summer, their time of peak demand.

Increased drought frequency is very likely in eastern areas, with potential losses in agricultural production.

The effects of climate change on flood and drought frequency are virtually certain to be modulated by phases of the ENSO [El Niño Southern Oscillation] and IPO [Interdecadal Pacific Oscillation].

The groundwater aquifer for Auckland City has spare capacity to accommodate recharge under all scenarios examined.

Base flows in principal streams and springs are very unlikely to be compromised unless many dry years occur in succession.

Flooding

Rain events are likely to become more intense, leading to greater storm-runoff, but with lower river levels between events. This is likely to cause greater erosion of land surfaces, more landslides, redistribution of river sediments, and a decrease in the protection afforded by levees. Increased demands for enhancement of flood protection works are likely, as evidenced by the response to large floods in 2004.

Flood risk to Westport has been assessed using a regional atmospheric model, a rainfall runoff model and a detailed inundation model, assuming the current levee configuration. The proportion of the town inundated by a 1-in-50 year event is currently 4.3%, but rises to 13-30% by 2030, and 30-80% by 2080. Peak flow of the Buller River increases 4% by 2030 and 40% by 2080. In contrast, a flood risk study for Auckland using 2050 climate scenarios with 1-2°C global warming indicated only minor increases in flood levels. Higher flows and flood risk are likely in the Wairau catchment in North Shore City.

Water quality

In New Zealand, lowland waterways in agricultural catchments are in a relatively poor state and these streams are under pressure from land use intensification and increasing water abstraction demands. There is no literature on impacts on water quality in New Zealand.

The above material is excerpted from the final draft of the IPCC WGII Fourth Assessment Report, Chapter 11: Australia and New Zealand. This draft is subject to final editing changes, and is expected be published in full at www.ipcc.ch on 20 April 2007.

Note on Terminology:

Scientific authors of IPCC reports choose their words with care. The following words have a precise meaning:

Virtually certain >99% probability of occurrence, *Extremely likely* >95%, *Very likely* >90%, *Likely* >66%, *More likely than not* >50%, *Very unlikely* <10%, *Extremely unlikely* <5%.

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