Water Resource Impacts and Adaptation under Climate Change

Water is a critical resource for New Zealand's primary industries. Our capacity to achieve export earnings from the land hinges on the relative abundance of water we have and on our ability to anticipate and control its availability. With climate change expected to manifest itself within the coming decades, the water resources on which primary industries depend are likely to change making it prudent to begin the adaptation process now.

New Zealand's water resources

New Zealand has several sources of good quality water including snowfields, glaciers, groundwater aquifers, rivers and lakes. These water resources are a product of the prevailing climate and topography but are also influenced by human activity.

Climatic drivers

Rainfall patterns in New Zealand are strongly influenced by the interaction between its mountainous terrain and the predominant westerly circulation. A west-east gradient dominates the regional rainfall regime with the greatest amount of precipitation falling along the west coast of the South Island (Figure 1). Variations in precipitation from year to year are largely due to the El Niño Southern Oscillation (ENSO).

River flow and flooding

As with rainfall, the greatest source of variability in river flow from year to year derives from ENSO. Snowmelt contributes to substantial springtime flow in rivers with alpine headwaters, and up to 24% of the annual inflows to the major South Island lakes.

Floods occur frequently in New Zealand and can have substantial impacts on communities, infrastructure and erosion. Flooding is typically associated with mid-latitude storms, thunderstorms or, in the northern parts of the country, ex-tropical cyclones.

Anthropogenic change

In addition to natural fluctuations in river flow, human-induced changes have also occurred. The substantial clearance of forest following the two waves of settlement and damming of some rivers has changed the nature of downstream flow regimes.

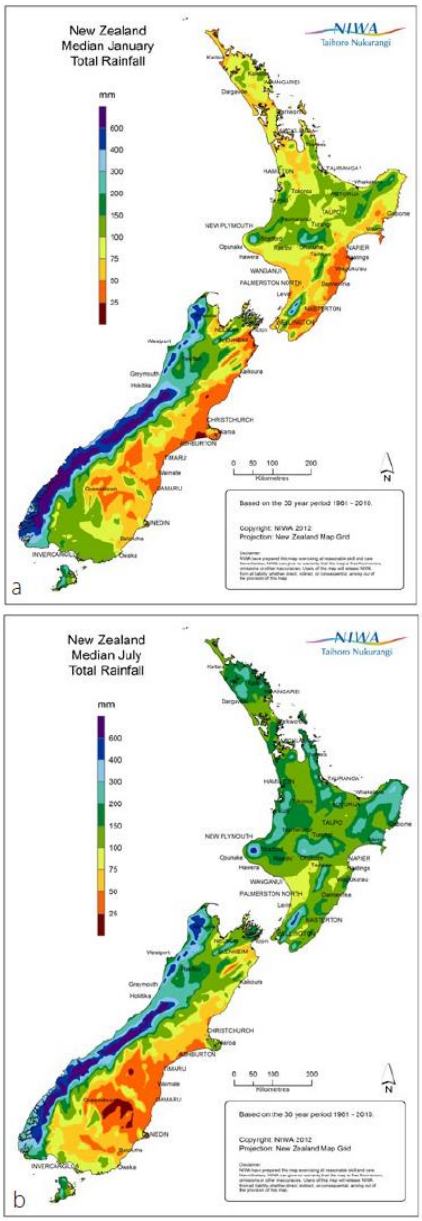

Figure 1. Median rainfall for New Zealand in (a) January and (b) July

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Manatū Ahu Matua

A resource developed through the Climate Change Technology Transfer Programme

Groundwater abstraction has also been suggested as a possible cause of reduced river flows, particularly in the Selwyn River of the South Island. At a local scale the drainage of much of the country's wetlands for farm land has likewise altered hydrological flows.

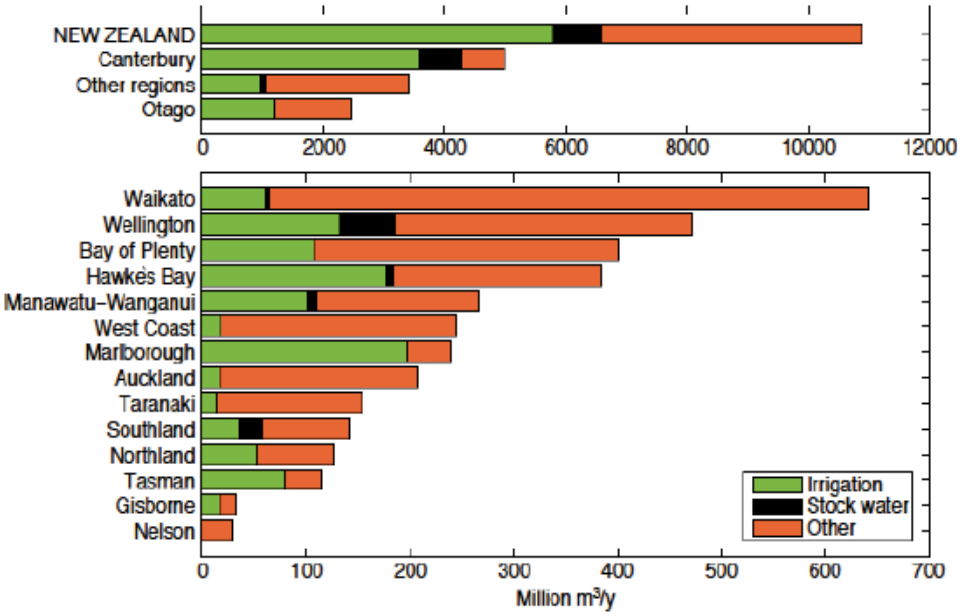

Figure 2. Consumptive annual regional water allocation by primary use, excluding the Manapouri hydropower scheme (note the different horizontal scales). The 'other' uses include industry and drinking water. Data from the Ministry for the Environment.

Primary sector water use

Water requirements for primary production depend on the needs of particular crops, the hydro-climatic conditions of the growing region, and on soil characteristics. Particularly important, are the summer soil moisture deficits in many areas of New Zealand.

About two-thirds of the consumptive water allocation in New Zealand (excluding Lake Manapouri) is from surface waters (rivers and lakes). The remaining one-third is sourced largely from groundwater with 5% from reservoirs. Across New Zealand, the relative importance of each water source varies depending on the abundance and reliability of supply. In Otago, surface waters are of high importance and provide 84% of the allocated water supply to the region. Conversely, water reservoirs are predominantly utilised in the Auckland region, with only 4% of allocated water supply sourced from surface waters.

Irrigation accounted for the consumption of over half of the allocation of water countrywide in 2010 (5800 million m^3/year) with the remaining uses being industry and drinking water. Both Canterbury and Otago allocated more water to irrigation than all other regions combined which highlights the importance of water availability in these regions for primary industries (Figure 2).

Patterns of water use by the primary sector are not expected to remain the same in the future and some significant changes have already occurred within the last 10 years. These changes include the irrigation of land previously thought to be unproductive (e.g. McKenzie Basin), and the expansion of dairying in Canterbury and Southland. There have also been changes among uses, most notably a shift from irrigation of arable land to pasture in Canterbury due to economic incentives, and a change towards more efficient spray irrigation systems. Demand for water continues to grow, and given that some catchments and aquifers are already over-allocated, alternative sources of water and/or storage will become necessary.

Water resources management

Managing water resource use and water-related hazards requires a range of legal and regulatory instruments operating at both national and regional levels. In New Zealand, the overarching framework for managing the environment is the Resource Management Act 1991 (RMA). The RMA requires regional authorities to carry out certain functions such as setting policies to control water use and rules for water allocation. Since the amendment of Section 7 of the Act in 2004, climate change must be taken into account when producing policy statements and plans. During the planning process, the potential use of resources needs to be balanced in a way that maintains their natural value. For example, when considering

the amount of water that can be taken from a river to be used for irrigation, the amount of water required to protect ecological and recreational values should also be considered.

New Zealand's water resources in a changing climate

Several studies have assessed potential impacts of climate change on New Zealand's water resources. Some of the more significant projections are presented here:

Hydrology

- Projections of annual precipitation indicate decreases in the North and East of the country and increases in the South and West are likely, with most of the change occurring during winter and spring.
- Increased precipitation is anticipated in the alpine regions, however, it is more likely to fall as rain rather than snow.
- The capacity of alpine regions to serve as temporary stores of water will decline. More water will run off and replenish rivers in the winter and less in the spring (e.g., the Clutha River).
- Alpine-fed rivers are expected to have higher flows by 2040, particularly during winter, though it is possible that summer flows will decrease.
- Floods are generally expected to become more frequent and more extreme in coming decades consistent with the expected increases in extreme rainfall events. Coastal areas would be affected the most due to the additional impact of sea-level rise.
- Regions that are already drought-prone are likely to experience more frequent and more severe droughts in the coming decades (e.g. Eastern Canterbury and Gisborne).

Water Quality and Use

- Water quality is expected to decline and receiving water bodies will become more vulnerable due to changes in both river flow and water temperature.
- Increasing water temperatures would lead to greater stress on aquatic life through effects on dissolved oxygen and nitrate concentrations Salmon and trout, in particular, are very sensitive to water temperature, and their distribution is very likely to contract with increasing water temperatures.
- An increase in evaporative demand is expected, in line with rising temperatures. This has the effect of decreasing freshwater available for abstraction and increasing the need for irrigation.
- With higher evaporation rates, water demand will increase if production is to be maintained. If the hydrological changes lead to a reduction in reliability of supply, then there will also be a greater demand for water storage, both large scale and on-farm to maintain irrigation reliability.
- The efficiency of irrigation schemes is likely to decline as rates of evaporation increase. Compared with cool and calm conditions, warmer and windier conditions accelerate evaporation before water is able to reach plants' roots. More water would need to be abstracted to compensate for the losses during the storage and delivery of water to crops.

Water Resource Infrastructure

- Higher temperatures may foster greater growth of aquatic weeds, with implications for water flow.
- Screened intakes may become more clogged by sediment or organic matter therefore requiring changes in capacity or cleaning regimes.
- Mechanical devices, such as pumps and gates, may be affected by changes in sediment-induced damage or changes in the frequency of use, leading to altered lifespans and operation or maintenance costs.
- Pipe infrastructure is anticipated to be less vulnerable, while canal-based schemes may be prone to increased operation costs with sediment and weed accumulation.

Adapting to changing water resources

The possible impacts of climate change on New Zealand's water resources may operate in isolation or in combination with one another. Additionally, they will differ in severity depending on the region or particular land use activity. It is highly likely that some form of adaptation will be required, regardless of the variability in projected impacts. Three levels of adaptation are described in Table 1. These adaptation options address the water resource impacts described in this review and provide some examples. They apply to stakeholders ranging from the land owner and industry groups to regional and national government.

Table 1: Adaptation options for water resource impacts due to climate change

Tactical Adaptation	Involves modifying existing water resource systems using current practices. Tactical adaptations require lower investment, are well understood, and are already being implemented. This allows them to be actioned at shorter notice. However, they may be insufficient to adapt to anything more than minor climate change	**Examples:** * Changing crop varieties * Improving soil nutrient management * On-farm water storage * Changing stock numbers and policy
Strategic Adaptation	Involves changing to another known water resource system, or making substantive changes to the current system, where practices and technologies are well known. The cost of strategic adaptation is higher than for tactical, but it has a greater ability to respond to higher level of climate change	**Examples:** * Changing crop species * Water use monitoring and forecasting programmes * Offset groundwater abstraction with managed recharge
Transformational Adaptation	Involves innovation to develop completely new water resource systems. Such adaptation is the least well understood, the most expensive, the slowest to implement and carries the highest risk. It may become necessary only under severe climate change.	**Examples:** * Improving crop water uptake * Re-evaluate the societal values behind water allocation *Inter-regional water transfers

Identifying the most suitable adaptation pathway for any one stakeholder or group will not be an easy task. There is no 'one-size-fits-all' approach, rather the focus should be risk management; incorporating a range of benefits and costs – economic, environmental, social and cultural. It is important to note that decisions made today will leave a legacy in the future when climate change is expected to have tangible effects.

Further Information

The full technical report, Water resource impacts and adaptation under climate change: Chapter 8. Water Resources can be downloaded from www.climatecloud.co.nz/CloudLibrary/2012-33-CC-Impacts-Adaptation_SLMACC-Chapter8.pdf

A sector-by sector guide to adaptation can be found at: http://www.mpi.govt.nz/environment-natural-resources/climate-change/resources-and-tools/climate-change-resources-bysector

Additionally, a practical online adaptation toolbox to help guide you through key decisions is available at: http://www.mpi.govt.nz/environment-natural-resources/climate-change/resources-andtools/adaptation-toolbox.aspx