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Changing Water Management Practice in Canterbury to Address Sustainability Limits

Abstract

Irrigation expansion in Canterbury has led to sustainability limits being reached for water availability and cumulative effects of land use intensification. Increasing water availability through storage was proposed, but there was strong community opposition to impacts of storage and further intensification. Effects-based institutional arrangements proved inadequate to address these issues.

The regional council introduced a strategic approach based on nested adaptive systems and collaborative governance. A regional water strategy was developed through a multi-stakeholder steering group under the Canterbury Mayoral Forum and with extensive community engagement. Zone committees were established to develop zone implementation programmes. Farmer collectives are being established for operational delivery of water management targets. Farmers develop farm management plans to meet property-level outcomes, which are independently audited.

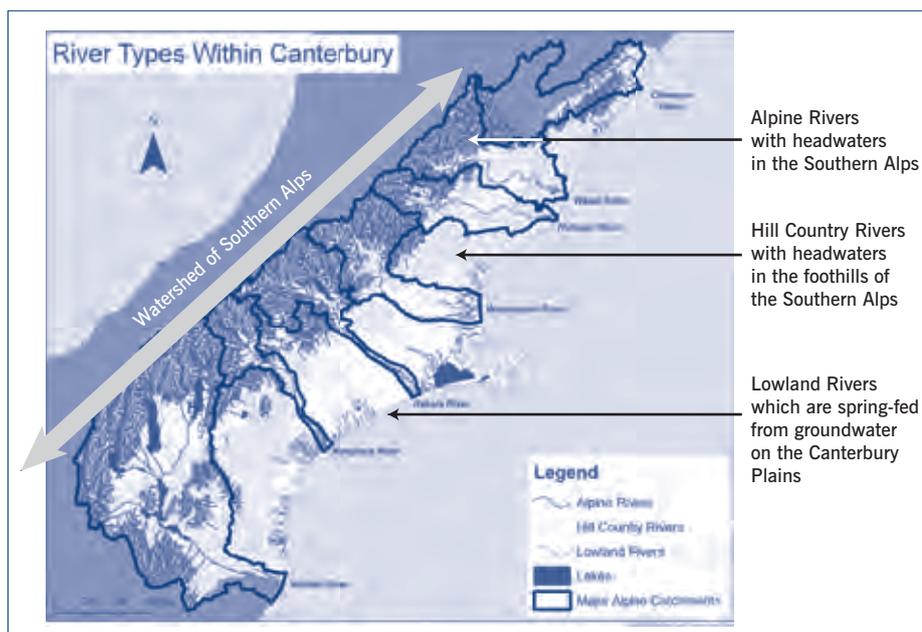
Strategy investigations demonstrated that focusing on new development would not

achieve sustainable development; rather, existing users also had to improve. Water use efficiency improvements were more cost-effective than new storage. Furthermore, different forms of storage, such as managed aquifer recharge, were identified to avoid adverse effects on main stems of alpine rivers. Proactive measures were needed to address water quality degradation, biodiversity loss, Māori involvement and ecological restoration.

A systems perspective and a governance change from regulatory to collaborative have improved water management. However, they also identified issues concerning affordability of proactive measures, equity in allocation, and need for a public infrastructure agency. Uneven implementation of measures has led to some groups withdrawing from the collaborative process.

Keywords nested adaptive systems, collaborative governance, sustainability strategies, water resource management, community outcomes

Figure 1: River types in Canterbury



Source: Environment Canterbury

Background to reaching sustainability limits

Water is a vital component of both the economy and the ecology of the Canterbury region. Although only 12% of New Zealand’s area, Canterbury allocates 58% of the country’s water, has 64% of its irrigated land, generates 24% of the country’s power through hydroelectricity, has 65% of the nation’s hydro storage, and provides a high-quality drinking water supply to its major city, Christchurch, without treatment. Moreover, water sustains braided rivers of international significance, high country and coastal lakes, groundwater basins of the Canterbury Plains, and groundwater-fed lowland streams and wetlands (Jenkins, 2007a).

Canterbury is in the rain shadow of the Southern Alps on the relatively dry east coast of New Zealand’s South Island. It is the region with the greatest evapotranspiration deficit (322 mm/a) and is dependent on irrigation for increasing agricultural productivity. Aquatic ecology is sensitive to flow variability, low flows and water quality, making it vulnerable to water extraction for irrigation and water quality impairment from land use intensification (Jenkins, 2018).

Canterbury has seen a 60-fold increase in dairy production, from 6 million kilograms of milk solids in 1984–85 to 385 million kilograms in 2015–16 (LIC and DairyNZ, 2016). This is from converting dryland farms to irrigated dairy farms,

adding significantly to the irrigated area in the region. Census data estimated irrigated area in Canterbury at 287,168ha in 2002, while detailed mapping indicated 507,468ha in 2015 (Brown, 2016).

Expansion of irrigation resulted in cumulative effects on river flows from abstraction (primarily associated with lower flows and reduced variability), groundwater drawdown and reduced flow in groundwater-fed streams, and water quality effects from land use intensification (primarily nutrients, bacterial contamination and sediments). Flow reductions and longer duration of low flows led to decreased freshwater habitat and reduced connectivity to other habitats. Reduced flow variability lowered streams’ ability to flush fine particles and algae, thereby diminishing the quality of freshwater habitat. Reduced flood flows decreased riverbed mobility required to maintain the braided character of Canterbury’s alpine rivers (Biggs, Ibbitt and Jowett, 2008).

Surface water availability is at sustainability limits as out-of-stream withdrawals are restricted at low flows (Environment Canterbury, 2016a). Groundwater availability is at sustainability limits as effective allocation exceeds the allocation limit for nearly all groundwater zones (Jenkins, 2018). In addition, nitrate and bacterial contamination of groundwater from land use intensification

is increasing and exceeds drinking water standards in some locations (Hansen and Abraham, 2009). This has resulted in nutrient enrichment, algal blooms, faecal contamination, siltation and nitrate toxicity approaching, and in many cases exceeding, water quality standards in groundwater-fed lowland streams and the lower reaches of foothill and alpine rivers (Stevenson, Wilks and Hayward, 2010; Robinson and Bolton-Ritchie, 2014).

Water availability concerns associated with the droughts in the late 1990s led to an initial strategic response to increase storage on Canterbury’s alpine rivers. A regional supply/demand analysis (Morgan et al., 2002) indicated that allocable flow from surface and groundwater was unable to meet existing demand (as at 2001), let alone future demand, with current means of abstraction (i.e. direct withdrawal). However, based on annual average flow, there was potential for 594m³/s to be allocated from surface water if storage infrastructure was provided. When added to the then (2001) groundwater allocation of 16m³/s, this could provide 610m³/s. This was greater than the 2001 annual average demand (81m³/s) and forecast future (2021) annual average demand (229m³/s).

The second stage of strategic investigations was undertaken to identify major storages (Aqualinc Research, 2008). The focus was on storages on alpine rivers of Canterbury, which carry 88% of the annual average flow (Figure 1), as the hill country and lowland rivers have lower flows and were already under greater pressure from extraction. The third stage of strategic investigation was a multi-stakeholder evaluation of possible storage options; however, the multi-stakeholder group also recommended that before storage decisions were made, rigorous scientific and public consideration was needed of: (1) impacts of land use intensification and its effects on water quality; (2) mitigation and management systems of water quality; and (3) methods for maintaining or improving flow variability and low flows in major rivers (Whitehouse, Pearce and McFadden, 2008).

While storage on the main stems of alpine rivers may provide a means of addressing water availability, there are

significant sustainability issues with this approach. They include: (1) impacts on the naturalness of high country areas in relation to landscape, ecosystem habitat and amenity values; (2) reduction in flood flows, which decreases the number of braids in braided rivers; (3) sediment entrapment, which reduces the bedload downstream of dams and the sediment supply to the coast, leading to increased coastal erosion; (4) reduction in flushing flows, resulting in greater frequency and persistence of algal blooms; (5) temperature stratification in reservoirs, which inhibits oxygen diffusion to the hypolimnion, resulting in deoxygenation of bottom waters; (6) nutrient retention in reservoirs from land use intensification, leading to occurrence of aquatic weeds; and (7) reduced in-stream recreational opportunities for white-water sports and fishing (Jenkins, 2007b).

Water quality impairment from land use intensification was a major concern. Monitoring indicated that 11% of sampled wells in the central Canterbury Plains exceeded the maximum acceptable value for drinking water of 11.3mg/L (Hanson and Abraham, 2009). Regional modelling of nitrate leaching to groundwater predicted increases above drinking water quality in many locations if all potentially irrigable land was irrigated using existing land use practices (Bidwell et al., 2009). Further intensification with current land

use practices would also exacerbate water quality contamination of surface water.

There was recognition by 2008 that a paradigm shift in water management in Canterbury was needed. The focus on storage as a means of addressing water availability issues did not have widespread community support. Effects-based legislation and legal processes focused on individual projects were inadequate to deal with cumulative effects of multiple projects and exacerbated community conflict. There was need for an approach which (1) addressed sustainability limits of water availability, (2) managed cumulative effects of water extraction and land use intensification, and (3) facilitated consideration of multiple issues at multiple scales.

A major factor in seeking a new paradigm was the failure of the Resource Management Act 1991 (RMA) to address resource use and cumulative impacts at sustainability limits. The RMA is effects-based legislation and focuses on the environmental effects of activities rather than the activities themselves. The act established an Environment Court with powers to review the technical merit of decisions. This makes resource management a highly legalistic process and led to an adversarial style of decision-making. A major process under the act is environmental impact assessment of new development proposals. This provides a capacity to address project-specific effects,

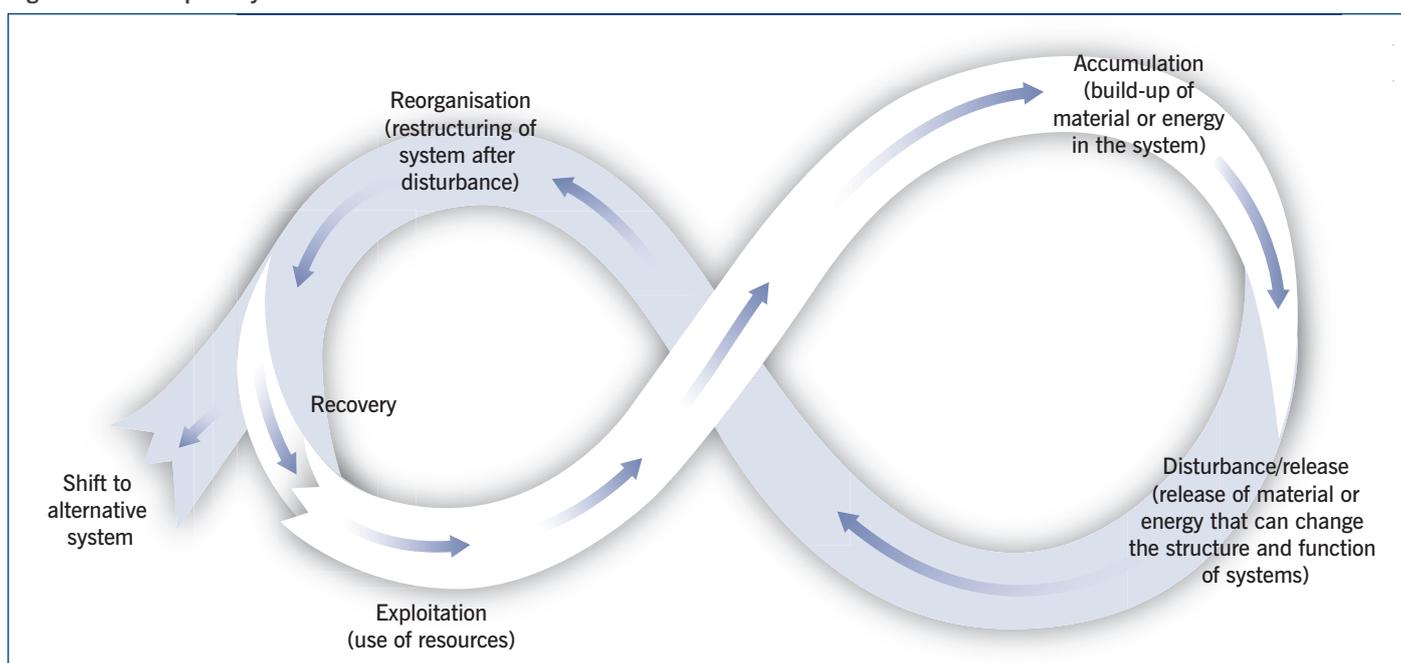
but the act was not designed to manage cumulative effects of multiple activities.

The purpose of the act is 'sustainable management' – allowing use of resources subject to environmental bottom lines. However, there is no elaboration in the act on how decision-makers can apply this purpose. Interpretations by courts have defined an 'overall broad judgement' of balancing resource use and environmental effects (Skelton and Memon, 2002). This concept of overall broad judgement has led the Environment Court and hearing commissioners to approve further intensification in Canterbury despite limitations on water availability or degraded water quality (Environment Court, 2005; Milne et al., 2010).

Theoretical framework underpinning the new paradigm

The regional council introduced a strategic approach based on nested adaptive systems and collaborative governance. A regional water strategy was developed through a multi-stakeholder steering group under the Canterbury Mayoral Forum and with extensive community engagement. The alternative paradigm developed was based on the concept of nested adaptive systems developed by Gunderson and Holling (2002) to define failure pathways, and sustainability strategies derived from Chapin and his colleagues (Chapin, Kofinas and Folke, 2009). The

Figure 2: The adaptive cycle



Source: adapted from Gunderson and Holling, 2002

collaborative governance approach for developing the regional strategy was based on Elinor Ostrom's institutional design for governing the commons (Ostrom, 1990).

Gunderson and Holling define an 'adaptive cycle' to describe how an ecological or human system can be sustained in obtaining resources for its ongoing survival, and in accommodating disturbance to the system and restructuring. This provides the basis for defining sustainability with respect to the maintenance of the relationships in adaptive cycles across different time and spatial scales. There are four phases in the adaptive cycle: (1) exploitation – use or harvesting of resources; (2) accumulation – storage of

flow requirements in river reaches, and ecosystem management of streams and their riparian margins; and (4) property level, to address land use practices that influence water quantity and water quality (Jenkins, 2007a).

The governance approach designed for Canterbury was based on Ostrom's collaborative governance arrangements for managing common pool resources, such as water extracted for irrigation. She found that long-term survival of common pool resources was associated with self-governing communities with the following characteristics: (1) clearly defined boundaries; (2) congruence between appropriation and provision rules with

options in relation to economic, social, cultural and environmental criteria; and (6) agreement on a strategic approach to water management, environmental restoration, infrastructure requirements and governance arrangements (Jenkins and Henley, 2014).

Development of the strategy was under the auspices of the Canterbury Mayoral Forum (comprising the mayors of city and district councils in the Canterbury region, the chair of the regional council, and their chief executives) to achieve political collaboration. Oversight of the process was by a multi-stakeholder steering group (a 16-person group with backgrounds in irrigation, industry, conservation, fishing, recreation, the Māori community, and local, regional and central government).

Community engagement included the following processes: (1) open meetings across the region on uses and benefits of water, leading to the definition of a 'vision and fundamental principles' for a strategy and ten community outcomes for water; (2) facilitated workshops for developing strategic options by the multi-stakeholder steering group and public consultation on those options; (3) facilitated workshops for the sustainability appraisal of strategic options to define components of a draft strategy; and (4) public hearings and stakeholder review of the draft strategy, leading to the preparation of the final strategic framework document (Canterbury Water, 2009).

Some key conclusions from the strategy comparison were that: (1) the status quo of reliance on the Resource Management Act was not sustainable; (2) a strategy based on main stem storage on alpine rivers could meet economic but not environmental criteria; (3) a strategy based on environmental enhancement could meet environmental but not economic criteria; and (4) to achieve sustainability it was not sufficient to assess new developments; there was also a need to improve water use efficiency and land use practices (in relation to their effects on water quality) of existing users.

The Canterbury Water Management Strategy led to a transformation in water management in Canterbury from a polarisation of community views concerning water storage and land use

The focus of water management shifted from water availability and storage to identification of community values and the wide range of uses and benefits associated with water.

material or energy in the system; (3) release – disturbance of the system; and (4) reorganisation – restructuring of the system after disturbance.

The four phases of the adaptive cycle can be depicted as a Lissajous figure (Figure 2). The cycle is sustainable if the resources needed to maintain the system continue to be available and if the system can recover after disturbance. There is a critical point in the reorganisation phase as to whether the system continues (recovery) or whether the system fails and shifts to an alternative system.

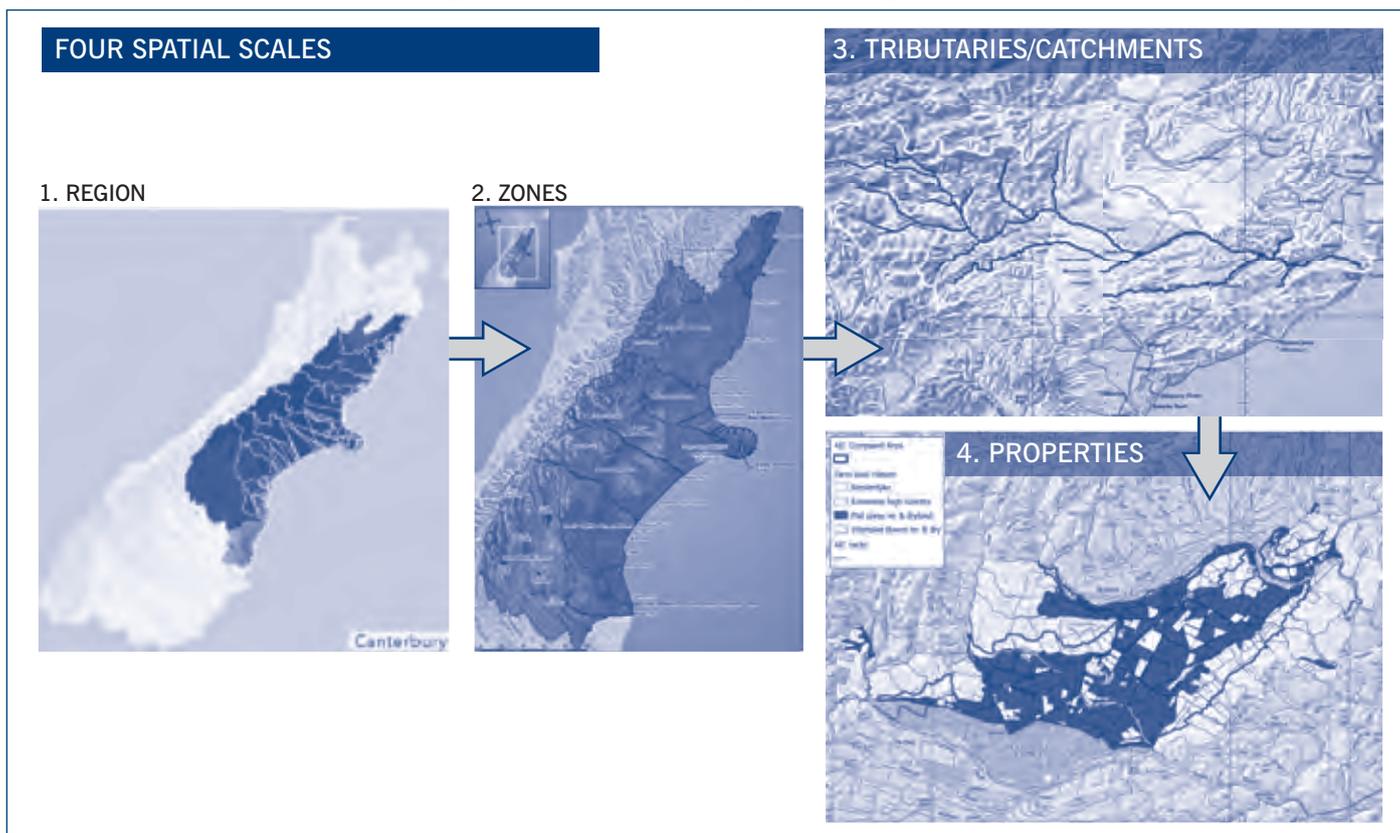
The adaptive cycles associated with different levels can be linked – what is referred to as 'nested adaptive systems'. For sustainable water management in Canterbury, at least four spatial scales need to be considered: (1) regional level, to address water availability and land use intensification; (2) catchment level, to address sustainable levels of water use, cumulative impacts of intensification, and reliability of supply for irrigation; (3) sub-catchment level, to address environmental

local conditions; (3) collective choice arrangements; (4) active monitoring of resource condition and member behaviour; (5) graduated sanctions for violating operational rules; (6) conflict resolution mechanisms; (7) rights of resource users to devise their own institutions; and (8) nested enterprises for larger systems (Ostrom, 1990).

The Canterbury approach

The fourth stage of the strategic investigations was developing the Canterbury Water Management Strategy (Canterbury Water, 2009). A key element of the strategy was the collective choice arrangements, including: (1) stakeholder and community engagement in developing strategic options and fundamental principles of the strategy; (2) definition of strategic options by a multi-stakeholder group; (3) region-wide consultation with communities on option preferences; (4) strategic investigations of likely outcomes to inform the engagement process; (5) sustainability appraisal of

Figure 3: Four spatial scales for implementing the Canterbury Water Management Strategy



Source: Jenkins, 2017

intensification, to widespread support for integrated water management that addressed ten community priority issues for water: ecosystem health, natural character, kaitiakitanga (Māori stewardship), drinking water, recreation, water use efficiency, irrigated land area, energy, economy and environmental limits.

The focus of water management shifted from water availability and storage to identification of community values and the wide range of uses and benefits associated with water. The acceptance of the strategy appeared to be related to the ability to be involved and to influence strategy development and the outcome of the process.

Collaborative processes increased the level of constructive dialogue between different stakeholder interests compared with the legalistic, adversarial style of statutory processes. New concepts for water availability were brought into the process, such as diversions to tributary storage and managed aquifer recharge, rather than main stem storage and water use efficiency (Jenkins, 2018). They also led to addressing land use practices to reduce water quality impairment (MGM Governance Group,

2015) and to proactive approaches to biodiversity enhancement (Environment Canterbury, 2016b).

The implementation of the Canterbury Water Management Strategy strategic framework document (Canterbury Water, 2009) contained three key elements: (1) proposed immediate actions – for example, establishment of nutrient limits; (2) investigations to deal with important areas of uncertainty – for example, setting of catchment load limits; and (3) definition of the way that deferred choices would be made – that is, continuation of the collaborative approach at the local level through 10 zone water management committees, and at the regional level through a regional water management committee, with the development of zone and regional implementation programmes.

Zone committees brought together the authorities for water (regional council) and land use (city and district councils), rūnanga (Māori tribal groupings), and six to seven appointed members of the community. The purpose of zone committees was to facilitate community engagement in developing zone implementation programmes (ZIPs) to

give effect to strategy targets at the zone level. The ten zones are shown in Figure 3. The regional committee has regional council, city/district council, Māori and community representation and a representative from each zone committee. It is a nested rather than hierarchical arrangement: zone committees deal with catchment issues and the regional committee with regional issues.

There has been progressive establishment of zone committees throughout the region. ZIPs were prepared within 12–18 months of committees being established (e.g. Canterbury Water, 2011). More recently, several zone committees have prepared addenda to their ZIPs focused on ‘solution packages’ for more difficult issues (primarily water quality issues for lakes) that had not been addressed in detail in the original ZIPs. The regional committee has produced a regional implementation programme (Canterbury Water, 2012).

Like the Canterbury Water Management Strategy, the recommended programmes of the committees in the ZIPs were non-statutory. Statutory backing of the Canterbury Water Management Strategy

was provided by a new regional policy statement (Environment Canterbury, 2013). Statutory backing for the implementation programmes was provided by the *Canterbury Land and Water Regional Plan* (Environment Canterbury, 2015), which is a nested document with a regional component for region-wide rules and ten zone components for rules within each zone.

Canterbury Water Management

Strategy outcomes

In relation to water availability, there has been a shift in emphasis from storage on alpine rivers to water use efficiency in

With respect to effects of land use intensification on water quality, there has been the introduction of changes in land management practices to reduce nutrients in surface run-off and seepage to groundwater. Water quality criteria for receiving waters have been defined and catchment nutrient load limits to achieve these criteria have been estimated (e.g. Norton, 2013).

Collaborative processes have led to agreements to raise minimum flows and reduce allocations at low flows – e.g. for the Pareora River (Environment Canterbury, 2010). These agreed changes do not always achieve the full extent of

Progress is also being made in kaitiakitanga. There is Māori representation at the governance level on zone committees and the regional committee. A relationship agreement – Tuia – has been signed between the regional council and rūnanga for ongoing collaboration in water management (Ngā Papatipu Rūnanga and Environment Canterbury, 2012). The Mahaanui Iwi Management Plan has been prepared, which includes ngā paetae (objectives), ngā take (issues of significance) and policies to guide freshwater management in a manner consistent with Ngāi Tahu cultural values and significance. Work on a restoration programme – Whakaora Te Waihora – for Te Waihora/Lake Ellesmere, a lake of cultural significance to Ngāi Tahu, is progressing (Ngāi Tahu and Environment Canterbury, 2016)

Operational management has introduced a new alternative to the RMA approach of the regulator setting consent conditions that are inspected for compliance by the regulator, adopting instead an approach reflecting Ostrom's principles. The primary governance element is the establishment of farmer collectives based on irrigation districts, tributary catchments (or stream allocation zones) or farm enterprises, with a secondary governance element as the farm property (Figure 3). It is a nested system based on the achievement of water quality targets in rivers and lakes which lead to catchment contaminant load limits defined as a collective responsibility; and with each farmer developing a farm environment plan to specify on-farm actions to meet farm management objectives and targets within the environmental management system for the collective. Each farmer is responsible for monitoring the actions undertaken and achievement of the targets, which are audited by a certified farm plan auditor.

Further changes needed

While there have been significant positive shifts towards sustainable water management, a sustainability analysis identified shortcomings in the level of intervention in the implementation programmes and issues needing to be adequately addressed (Jenkins, 2018).

Improved water use efficiency of existing users increases water availability without requiring further abstraction, and reduces surface run-off and groundwater leakage contaminated by land use intensification.

order to reduce water requirements for further irrigation. This has mainly been achieved through conversion of border dyke (flood) irrigation to spray irrigation (Brown, 2016), and of water distribution systems in irrigation schemes from open channels to piped distribution (e.g. the Ashburton Lyndhurst irrigation scheme).

New approaches to storage that avoided the effects of dams on main stems of alpine rivers were identified in order to improve water availability and enhance reliability of supply. Off-river storage of high river flows (e.g. at Arundel) and diversions to storage on tributaries (e.g. from the Hurunui River) were alternative approaches to accessing alpine river water. Another option is groundwater recharge, that is, managed aquifer recharge for storage and recovery, which is being trialled in the Hinds catchment. Improved reliability was achieved by on-farm storage and storage within irrigation schemes (e.g. the Carew storage in the Mayfield Hinds irrigation scheme).

desirable environmental flows because changes come at a cost to existing users. Collaborative outcomes have recognised the need for allocations at higher flows that involve on-farm storage for their effective use. There has also been the recognition that existing users need time to adjust.

For the target area of biodiversity, implementation programmes have identified priority areas for rehabilitation. Projects are being funded through the Immediate Steps Biodiversity and Enhancement Programme (Environment Canterbury, 2016) based on community recommendations and their contribution to the goals of the Canterbury Biodiversity Strategy (Environment Canterbury, 2008). Over 800 projects have been funded (as at June 2018). An example is the management of black-fronted tern breeding habitat in the upper Clarence River: through a combination of safe breeding islands and predator control, a five-fold increase in breeding success has been achieved compared to non-managed areas (Environment Canterbury, 2019).

The solution packages for water quality management devised by zone committees will improve water quality compared to current management. However, they will not achieve desired community water quality outcomes. This is recognised by zone committees, with their proposals being seen as a significant first step and awareness that there is a need for further improvement over time.

Improved water use efficiency was a critical element of the Canterbury Water Management Strategy. Improved water use efficiency of existing users increases water availability without requiring further abstraction, and reduces surface run-off and groundwater leakage contaminated by land use intensification. It was recognised that defining efficiency is not straightforward, so development of benchmarks and reporting on them was a target of the strategy implementation scheduled for 2015. This has not been achieved.

New Zealand's response to climate change has been minimal, with emissions continuing to increase. The agricultural sector is the largest contributing sector, responsible for 47% of total emissions and projected to provide 77% of the growth in emissions (Sustainability Council of New Zealand, 2015). However, there are actions that could be taken through mitigation measures and offsets. Furthermore, better use could be made of economic instruments and environmental impact assessment procedures to manage emissions. While the consequences of climate change have been identified, there is not an adaptation or emission reduction strategy in place.

A key element of the acceptance of the Canterbury Water Management Strategy

was the commitment to targets that reflected the range of uses and benefits that the community sought from water management in Canterbury. However, there has been differential progress in the implementation of these targets. In particular, the 2015 targets for recreational and amenity opportunities, ecosystem health and biodiversity, and economic externalities have not been met, leading to the withdrawal of some stakeholders from the collaborative process.

Affordability of management measures has been a constraint on the ability to implement elements of the strategy. Affordability has been an issue in finding viable storage schemes to improve water availability, for improvements in land management practices to reduce water quality contamination, and for communities in water treatment for addressing the risks of waterborne diseases. Related to this is the need for funding mechanisms for water infrastructure. While the private sector can address commercial water resources development, it is not well placed to address lake or river restoration, climate change strategies, managed aquifer recharge, biodiversity projects and catchment-wide public good infrastructure. There is no central government agency for water management, and regional councils have been established with a regulatory function.

The paradigm in current legislation as determined by the Resource Management Act is based on managing effects of development within environmental limits. However, with pollutant load uncertainties, inaccuracies in load estimation, natural variability, multiple variables affecting outcomes, contributions from legacy issues

as well as current activities, lag times in effects, unresolved cause–effect relationships and difficulties in enforcing limits that lack certainty, managing to limits for project effects to achieve sustainable outcomes is not enough. Furthermore, for cumulative effects there are multiple geographical scales, many potential points of intervention and multiple actors. A statutory framework involving a systems-based approach, like nested adaptive cycles, is needed to achieve sustainable outcomes.

While the RMA provides a framework for regulation of activities and mitigation of adverse effects, it does not provide a framework for proactive measures to achieve sustainable outcomes. The act is not well suited to managing water scarcity and cumulative effects of diffuse sources from land use intensification. This could be achieved by putting in place water framework legislation, like the European Union approach of the Water Framework Directive (European Commission, 2000), and a requirement for regional sustainability strategies like the Canterbury Water Management Strategy. The concepts of sustainable development have evolved since the framing of the RMA in 1991. The role of government has also changed. It is appropriate to change the legislative and institutional framework to reflect these evolving concepts of sustainability, and the changing role of government from environmental regulator to facilitator of sustainable development.

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