# Managing peri-urban floodplains and urban-rural connectivity: A case study in ecosystems governance following a disaster event

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**Abstract**

Peri-urban environments are critical to the connections between urban and rural ecosystems and their respective communities. Lowland floodplains are important examples that are attractive for urbanisation and often associated with the loss of rural lands and resources. In Christchurch, New Zealand, damage from major earthquakes led to the large-scale abandonment of urban residential properties in former floodplain areas creating a rare opportunity to re-imagine the future of these lands. This has posed a unique governance challenge involving the reassessment of land-use options and a renewed focus on disaster risk and climate change adaptation. Urban-rural tensions have emerged through decisions on relocating residential development, alternative proposals for land uses, and an unprecedented opportunity for redress of degraded traditional values for indigenous (Māori) people.

Immediately following the earthquakes, existing statutory arrangements applied to many recovery needs and identified institutional responsibilities. Bespoke legislation was also created to address the scale of impacts. Characteristics of the approach have included attention to information acquisition, iterative assessment of land - use options, and a wide variety of opportunities for community participation. Challenges have included a protracted decision-making process with accompanying transaction costs, and a high requirement for coordination. The case typifies the challenges of achieving ecosystem governance where both urban and rural stakeholders have strong desires and an opportunity to exert influence. It presents a unique context for applying the latest thinking on ecosystem management, adaptation, and resilience, and offers transferable learning for the governance of peri-urban floodplains worldwide.

# 1. Introduction

The Canterbury region of New Zealand experienced a sequence of strong earthquakes during 2010 - 2011 that included four earthquakes exceeding magnitude $M_W$ 6.0, and many thousands of aftershocks, all on previously unrecognised faults (Beavan et al. 2012). The city of Christchurch was severely affected with 185 lives lost and widespread damage to property, infrastructure, and the natural environment (Potter et al. 2015). As part of the recovery process several thousands of homes were acquired by the government in the Ōtākaro / Avon River catchment on land too badly damaged to be quickly remediated for residential redevelopment. This area is the Ōtākaro / Avon River Corridor (OARC) 'Red Zone' (Figure 1). Land use decisions for this 602 ha area are the subject of this case study.

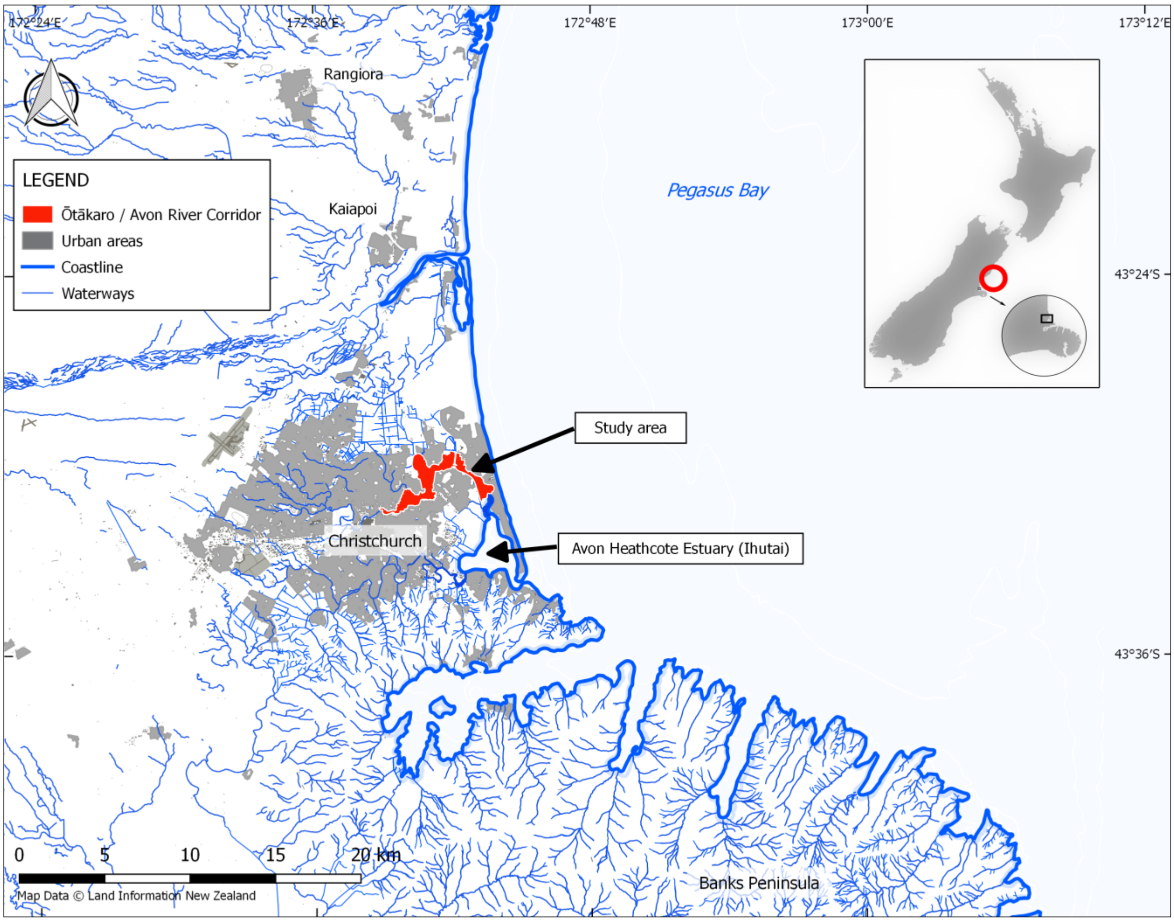


**Figure 1**. Location of the Ōtākaro / Avon River Corridor (OARC) in the City of Christchurch on the east coast of the South Island of New Zealand.

# 2. Study site

## 2.1 Overview

The study area is located at 43.5$^{o}$S, 172.7$^{o}$E in the city of Christchurch on the east coast of New Zealand (Figure 2). It is situated within the catchment of the Avon Heathcote Estuary (Ihutai), a low-lying tidal lagoon system (Figure 3) at the southern end of a large embayment known as Pegasus Bay (Kirk 1979). The Avon River is known by Māori as Ōtākaro. It is one of two spring-fed river systems entering the estuary, the other being the Heathcote or Ōpāwaho. Both are meandering lowland rivers with average base flows of approximately 2 and 1 cumecs respectively (White et al. 2007).

Impacts of the earthquakes in the study area included land subsidence, lateral spreading, liquefaction, and hydrological changes associated with new water levels on the landscape (Hughes et al. 2015; Quigley et al. 2016). Long term changes in ground levels were in the order of ± 0.5 m (Beavan et al. 2012) with a trend towards subsidence in the OARC (Figure 4).

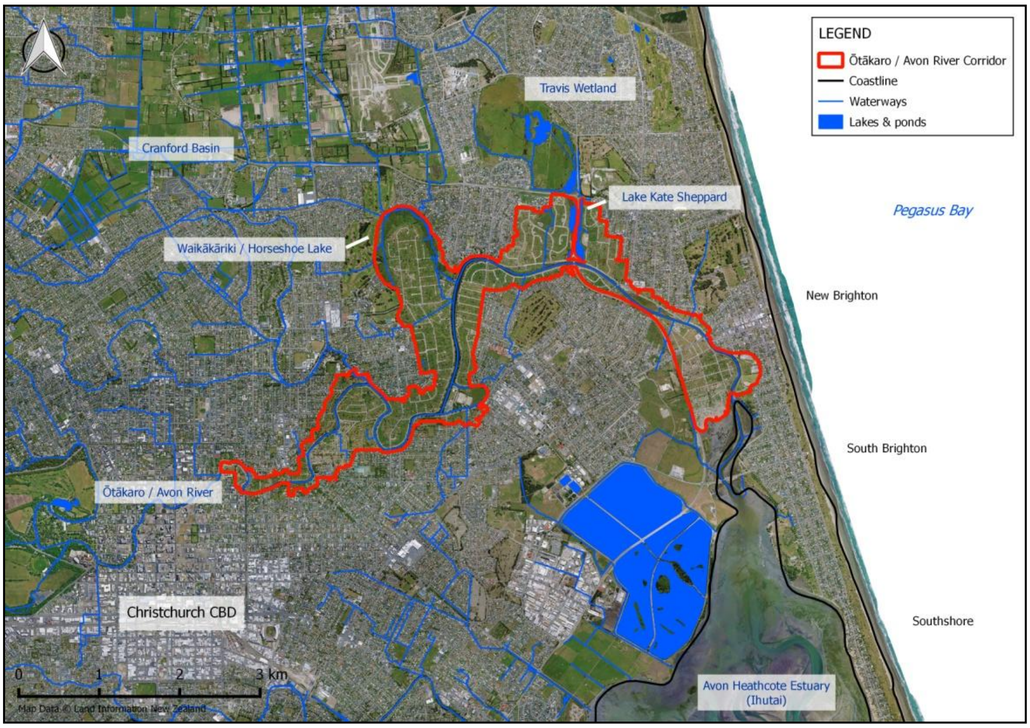


**Figure 2**. Aerial view of the study area taken in 2016 shortly after the demolition and removal of thousands of homes on earthquake-damaged lands in the Ōtākaro / Avon River Corridor.

**Figure 3**. Coastal wetland and floodplain environment at Lake Kate Sheppard, as is typical of the area.

**Figure 4**. Ground deformation and subsidence caused by the Canterbury earthquakes.

### 2.2 Urban-rural linkages and land use development

Historically, most of the OARC was an extensive floodplain environment supporting a rich mosaic of indigenous ecosystems that are relatively well documented in the 'Black Maps' of 1856 (Figure 5). These maps, digitised from original surveys, highlight the extensive network of waterways and floodplain landforms that characterise the area, and provide a baseline for considering impacts of land-use change through time. In the historical pattern of European settlement this was originally a rural area characterised by swampland and dune remnants situated east of the city centre towards Pegasus Bay (White et al. 2007). Over time it was progressively developed through floodplain drainage, channelisation of waterways, and steady urban encroachment (Watts 2011).

Significantly, the Avon-Heathcote Estuary/Ihutai and its catchment is of high cultural value for Māori (Tau et al. 1990), and is the subject of a specific chapter in the Mahaanui Iwi Management Plan (IMP) that sets out contemporary values and objectives (Jolly & Ngā Papatipu Rūnanga Working Group 2013). Ihutai was traditionally a sparsely-populated natural resource and food-gathering area for the main Māori population centre located further north at Kaiapoi (Figure 1). The rivers, floodplain and wetland areas were a rich source of resources that were managed according to traditional values of mahinga kai, kaitiakitanga, and rangatiratanga by *manawhenua* - the Māori locus of authority for natural resource governance and use (Roberts et al. 1995; Tau et al. 1990).

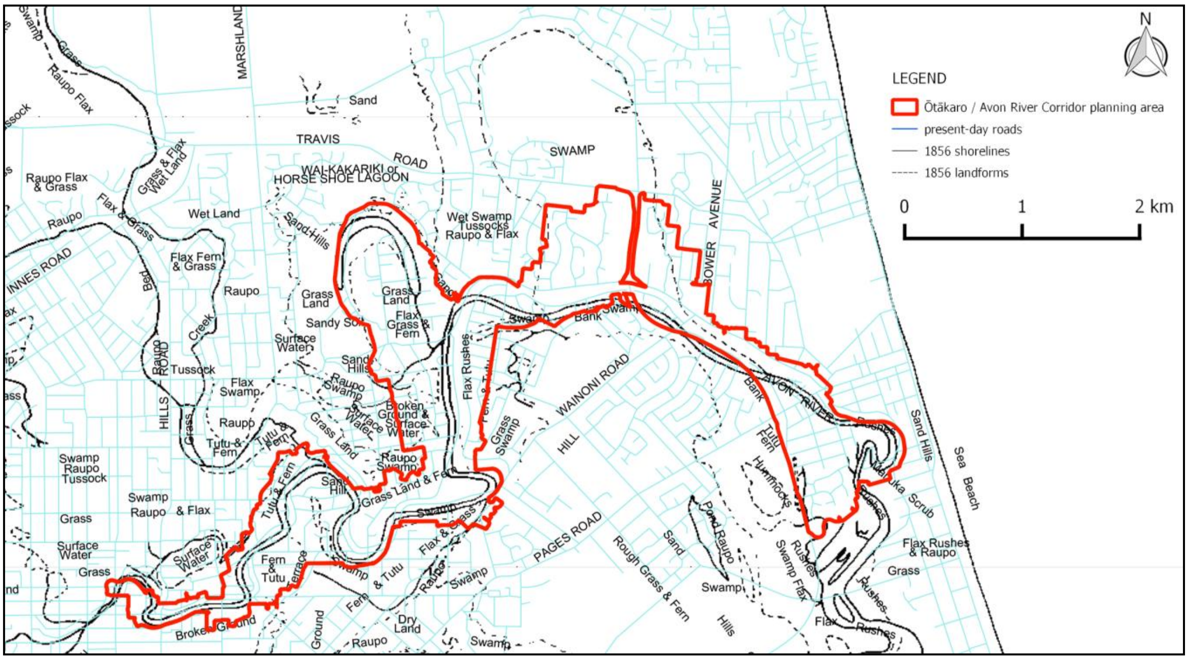


**Figure 5**. Excerpt from the Black Maps of 1856 with the position of the Ōtākaro / Avon River Corridor 'red zoned' area shown as an overlay. Note changes in the position of shorelines and landforms in relation to the position of modern day roads. [Black Map courtesy of Christchurch City Council].

## 2.3 Current societal context

There is a high level of community interest in future uses of the OARC. Among the range of stakeholders are the 5,442 former residential property owners, many of whom have remained engaged with the future of the area. There are also 30 properties remaining in private ownership as a result of those households resisting government acquisition offers. Since the 'red-zoning' and acquisition decision, many community groups have formed to champion and address different aspects of the recovery process. At least 25 community-led proposals for future land uses have been formulated and advanced through community activities (Figure 6). The stakeholders involved include charitable trusts and societies, Māori interests, businesses, sporting organisations, social enterprises, and many volunteers. Tensions are also apparent between many of the community-led proposals, especially where different land uses have been proposed for particular locations.

A unique situation exists in consideration of the impacts of previous land-use patterns that adversely affected Māori values and associations with the Ōtākaro. These impacts have impaired access to traditional resources

(Tau et al. 1990), the cultural health of waterways (Lang et al. 2012; Pauling et al. 2007), and opportunities to influence decisions (Jolly & Ngā Papatipu Rūnanga Working Group 2013). Part of the unique governance challenge that has emerged in the earthquake recovery context relates to unprecedented opportunities to restore both ecological and cultural values (Orchard 2017a).


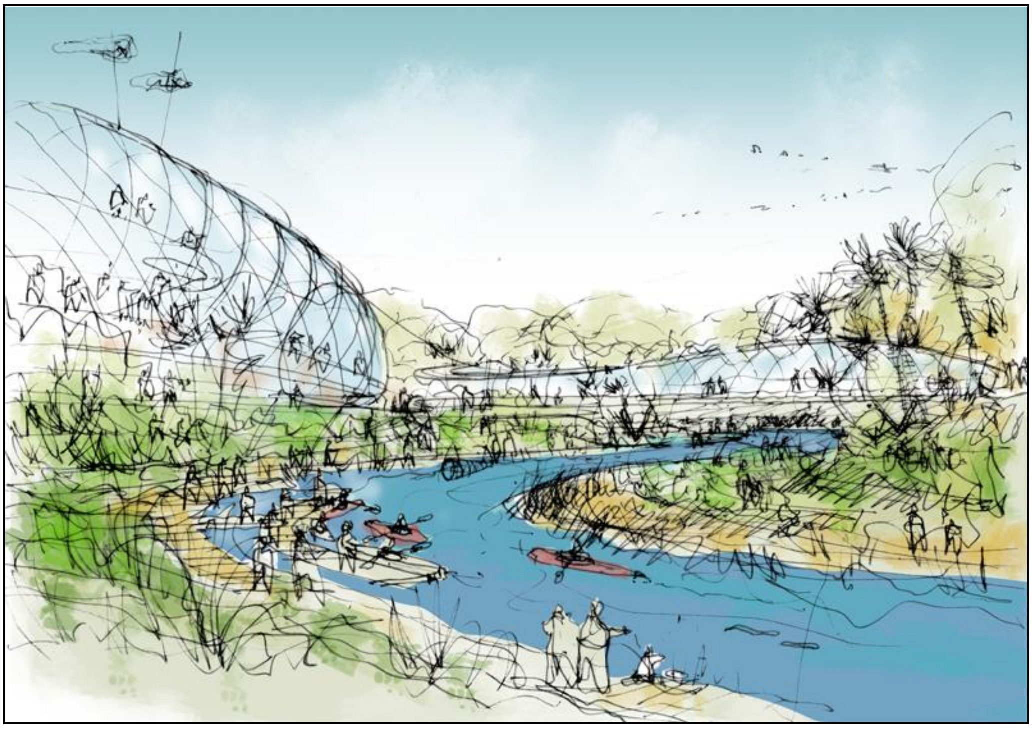

**Figure 6**. Examples of community-led proposals for future land uses in the Ōtākaro / Avon River Corridor. a) Avon-Ōtākaro Forest Park, and b) Eden Project New Zealand.

## 3. Evolving governance context

Following the earthquakes, urgent decisions were required to address threats to property and life (Potter et al. 2015). As the recovery phase progressed, the reinstatement of essential infrastructure was an initial priority. Other land-use decisions have had the benefit of more time. They present opportunities for innovative governance and strategic thinking to secure potential adaptation benefits and address longer term socio-ecological resilience in planning and design. The current OARC governance context is unique in several respects, with both pre-existing and new statutory arrangements currently in effect.

At the national level environmental management is guided by the Treaty of Waitangi, a founding document signed in 1840 by representatives of the British Crown and Māori chiefs. Treaty principles are incorporated within key legislation such as the Resource Management Act 1991 and Conservation Act 1987. However, the bulk of decision making occurs under subsidiary policies and plans prepared by regional and local authorities (Memon & Perkins 2000). These are developed in accordance with statutory responsibilities set out in the higher legislation and national policy statements, and require consultation with Māori, and other stakeholders, to varying degrees (Harmsworth 1995; Tipa et al. 2016).

In the wake of the Canterbury earthquakes, additional bespoke legislation was created to address the magnitude of effects. The Canterbury Earthquake Response and Recovery Act 2010 (amended 2011) was designed to assist reconstruction, and permitted government ministers to suspend or make exemptions to almost any New Zealand law (New Zealand Government 2011). This prompted concerns around the transfer of power away from the legislature, allowing those exercising powers under the Act to substantially define their own reach and boundaries (New Zealand Law Society 2010). The Greater Christchurch Regeneration Act 2016 was then introduced to support the ongoing process of regeneration, defined in relation to rebuilding and improving the environmental, economic, social, and cultural well-being, and resilience, of the community (New Zealand Government 2016). Its focus was to facilitate planning for regeneration, enabling community input into decisions on the exercise of powers, and providing for the leadership of local and regional councils, Te Rūnanga o Ngāi Tahu (the Māori tribal authority), and a new planning entity, Regenerate Christchurch. This created a vehicle for the direct involvement of Māori through the board of Regenerate Christchurch, which comprises seven members including one nominated by Te Rūnanga o Ngāi Tahu.

The role of Regenerate Christchurch includes leading regeneration activities, engaging with the community, and working collaboratively with stakeholders for a finite period ending 30 June 2021 (New Zealand Government 2016). In the process so far, a planning timeline has been established with three major stages; research, visioning, and design. The research phase has included gathering community proposals for future land uses together with commissioning surveys and technical studies. The visioning phase has also involved substantial community engagement. Draft vision and objective statements are being taken forward into the design phase, where they will  play a crucial role in identifying, assessing and evaluating land use options (Regenerate Christchurch 2017).

The development of this combination of arrangements can be seen as an example of distributed and evolving governance in action. Characteristics of the approach have included attention to information acquisition, iterative assessment of land -use options, and a wide variety of opportunities for community participation. Challenges have included a protracted decision-making process with accompanying transaction costs, and a high requirement for coordination.

## 4. Dimensions of ecosystem governance

### 4.1 Implementing an ecosystems approach

The global move towards an 'ecosystems approach' in governance contributes to sustainable development objectives by assisting the integration of natural environment and human well-being objectives (Millennium Ecosystem Assessment 2005; UNEP/GPA 2006). The spatial aspects of ecosystems offer a lens for planning and management that can readily include human dimensions and patterns of use (McLeod & Leslie 2009). A focus on ecosystems is also conducive to the effective management of human impacts on biodiversity and the reversal of degradation trends (Hoekstra et al. 2005; Keith et al. 2015).

In New Zealand, key ecosystems are identified in conservation and biodiversity strategies (Canterbury Biodiversity Strategy Partners 2008; Department of Conservation 2016), and a variety of planning documents. Several ecosystem types found in the OARC are the subject of statutory protection (Table 1). The protection mechanisms used sit within a hierarchical arrangement of methods that include legislation, national and regional policy, and the identification of management areas and objectives in statutory plans.

**Table 1**. Examples of ecosystem types with statutory protection that occur in the study area.

| Ecosystem type | Protection mechanisms | References |
|---|---|---|
| Estuaries, wetlands,<br>saltmarsh ecosystem,<br>lowland forest remnants,<br>active and stable dune remnants | Resource Management Act 1991<br>New Zealand Coastal Policy Statement 2010<br>Canterbury Regional Policy Statement 2013<br>Canterbury Land and Water Regional Plan 2017<br>Christchurch District Plan 2015 | New Zealand Government (1991)<br>Department of Conservation (2010)<br>Environment Canterbury (2013)<br>Environment Canterbury (2017)<br>Christchurch City Council (2015) |
| Natural waterways | National Policy Statement for Freshwater Management 2017<br>Canterbury Land and Water Regional Plan 2017<br>Christchurch District Plan 2015 | Ministry for the Environment (2017)<br>Environment Canterbury (2017)<br>Christchurch City Council (2015) |
| Spawning grounds of freshwater fish | Conservation Act 1987<br>Resource Management Act 1991<br>New Zealand Coastal Policy Statement 2010<br>Canterbury Land and Water Regional Plan 2017 | New Zealand Government (1987)<br>New Zealand Government (1991)<br>Department of Conservation (2010)<br>Environment Canterbury (2017) |

In New Zealand, a purposeful focus on ecosystems management has been a relatively recent development (Park 2000). A variety of ecosystems typologies have been proposed though a consistent approach to classification has yet to be realised (Singers & Rogers 2014) Although this creates challenges for efforts to apply ecosystems approaches, consistency issues do not undermine the validity of a focus on local ecosystems and their services within a particular area (Carpenter et al. 2009).

### 4.2 Socio-ecological resilience and disaster risk reduction

Resilience is an important perspective for the maintenance of biophysical and human values in the achievement of sustainable development (Gunderson et al. 2010; Holling 1973). It typically requires simultaneous attention to different aspects of socio-ecological systems (Folke 2006). Disaster risk reduction (DRR) involves a focus on building resilience to both recurring and ‘extreme’ events (Partnership for Environment & Disaster Risk Reduction 2010). The emerging field of Eco-DRR considers ecosystem management as a key activity in effective DRR (Estrella & Saalismaa 2013).

Changes in patterns of risk are evident in the OARC, with a particular concern being the long-term effects of land subsidence (Figure 7). Large areas are now more vulnerable to flooding (Figure 8) from both rainfall events and coastal inundation (Hughes et al. 2015). Consequences for land-use planning include the need to reassess risk exposure to a variety of natural hazards (Department of Conservation 2010; Ministry for the Environment 2008), and the migration of ecosystems to new locations (Orchard et al. 2018). On the other hand, government land acquisition has created a multitude of options for risk reduction, particularly through spatial planning and decisions on new land-use patterns. Opportunities include incorporating natural ecosystems as soft defences to reduce the potential impacts of disaster events, thereby securing biodiversity gains and building socio-ecological resilience (Orchard 2014; Spalding et al. 2014).

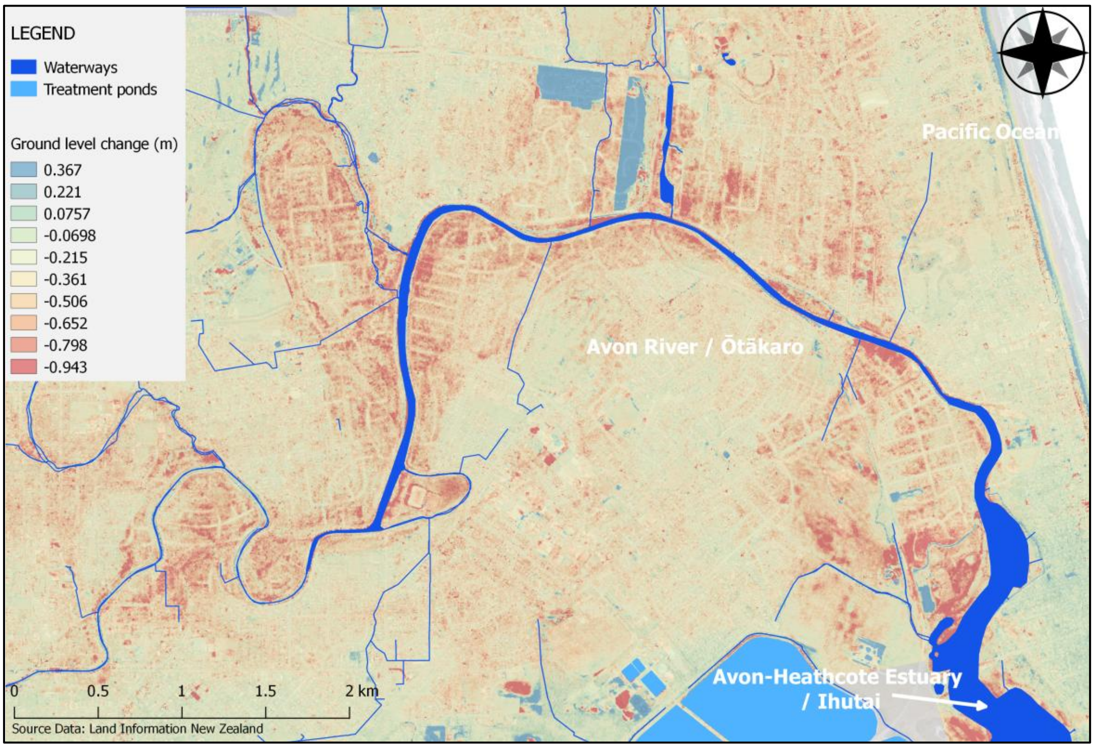


**Figure 7**. Elevation difference map showing pre-2010 to post-2011 ground level changes derived from LiDAR data. Small areas of uplift (in blue) are the result of land-fill activities during earthquake recovery works between the LiDAR acquisition dates.

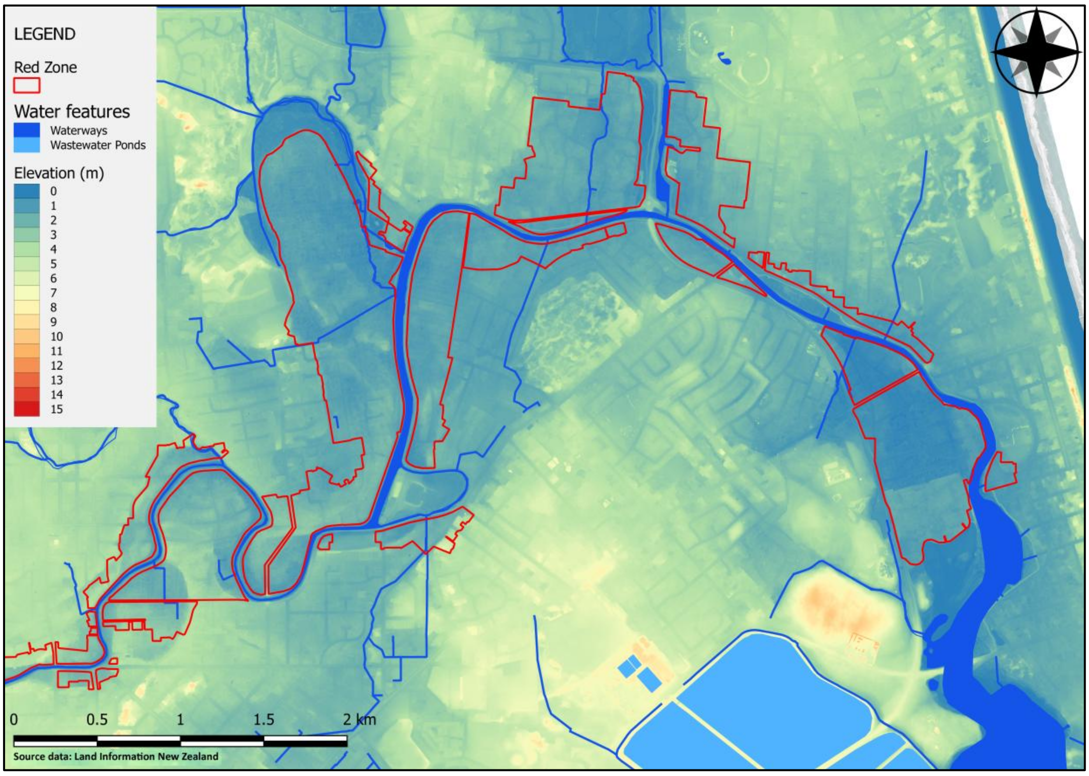


**Figure 8.** Post-earthquake ground elevations in the study area showing its low-lying nature, as derived from LiDAR data using the New Zealand Vertical Datum 2016. The 'Red Zone' is the area of government property acquisition. The Ōtākaro Avon River Corridor (OARC) planning area includes the Red Zone and adjacent waterways.

### 4.3 Climate change adaptation

Climate change is a critical issue for ecosystems governance since it is expected to slowly but surely alter the spatial configuration of ecosystems (and other levels of biodiversity) at many different scales (Bellard et al. 2012). It is imperative that society find ways to adapt while ensuring sustainability (IPCC 2014; Yohe et al. 2007). The UN Framework Convention on Climate Change (UNFCCC) identifies the need for ecosystems to adapt in the face of change (McMullen & Jabbour 2009). A related and prominent theme is a focus on the role of ecosystems in assisting people and communities to themselves adapt to change (IUCN-WCPA 2009).

Scenario models of sea level rise under climate change indicate that much of the OARC will be exposed to inundation within a relatively short period of time (Figure 9). Additionally, saltwater intrusion simulation shows marked changes in the position of mixing zones in the wider catchment system (Figure 10). In combination these effects can be expected to drive major shifts in the distribution of saltmarsh ecosystems, for example, with implications for biodiversity values, carbon sequestration, and other ecosystem services.

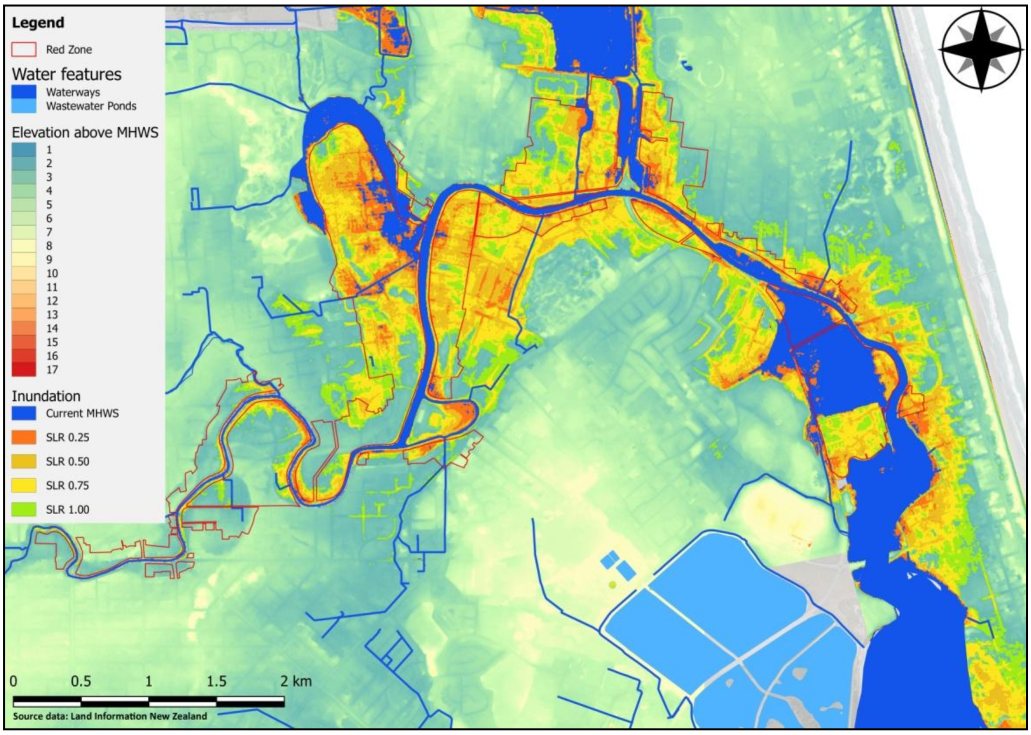


**Figure 9.** Sea level rise scenarios simulated in 0.25 m increments from the current Mean High Water Springs (MHWS).

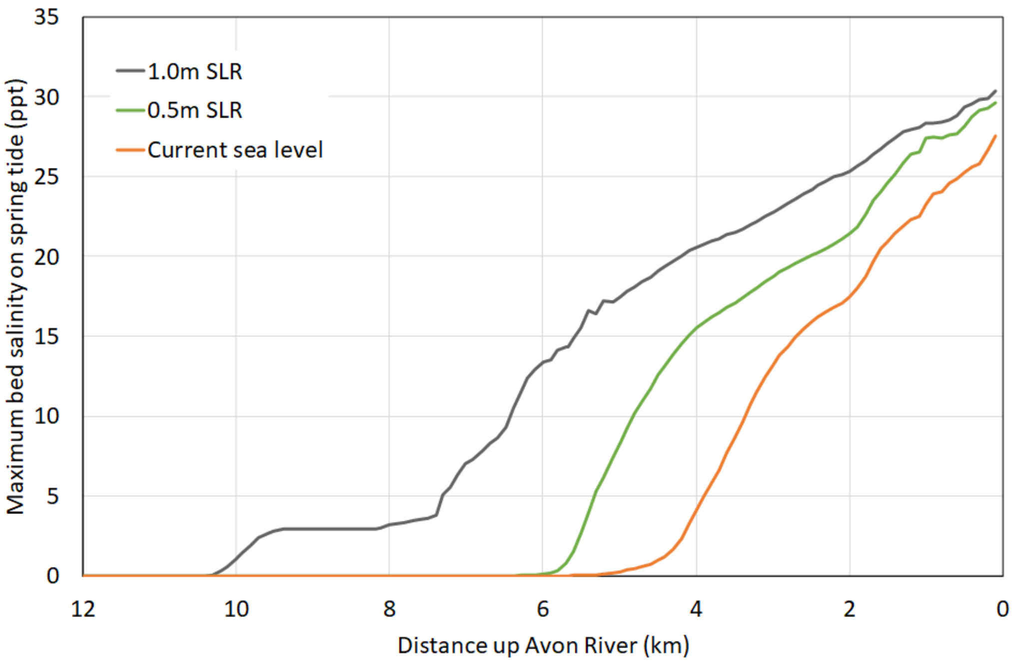


**Figure 10.** An example of salt water intrusion effects on peak bed salinity in the Avon River mainstem under sea level rise. This simulation is for a river flow of 2.07 $m^3/s$ corresponding to the flow exceeded 20% of the time under current conditions (Orchard & Measures 2017).

## 4.4 Ecosystem-based adaptation

Ecosystem-based adaptation has been defined as "adaptation that integrates ecosystem services and biodiversity into a strategy to limit the adverse impacts of climate change" (UNEP 2010). This approach recognises that climate change adaptation includes managing effects on natural ecosystems (Betts et al. 2009). Additionally, the functions and services of natural environments can play useful roles for people (Chan et al. 2006). In the OARC, there is considerable potential for ‘natural solutions’ (Dudley et al. 2010) to assist with climate change responses. This is currently being facilitated by iterative integrated assessments of broad scale options, and has the potential to incorporate ecosystem services and related approaches to trade-off assessment in more detailed planning ahead (Orchard 2017b). Although these aspects are in the early stages of development, an enhanced riparian corridor has been included in all land-use options developed to date. As has been found elsewhere, relatively fine-scale assessments may be useful to identify opportunities for integrating land uses with conservation elsewhere in the planning area (Guarnieri et al. 2016). A governance model enabling transitional land uses and adaptive management is likely to offer benefits in this case.

## 5. Conclusions and transferable learning

The OARC presents a unique context for applying the latest thinking on ecosystems governance, adaptation, and resilience. Despite this, the earthquake recovery situation has many similarities with other examples of natural disasters that present opportunities for redesigning land-use practices in the affected lands. In this case, adaptation was urgently required following the disaster event. Due to interactions between land subsidence, hydrology, and the coastal floodplain location, climate risks also increased. Many of the management challenges offer transferable learning for other floodplain contexts worldwide (Box 1).

Opportunities presented by post-disaster recovery may challenge orthodox approaches and traditional ‘western’ thinking on land use and re-development strategies, especially in the vicinity of waterways. In doing so, there is the potential to reverse historical degradation trends. In this case, the disaster event also raised the awareness of risk and illustrated the poor resilience of previous land use decisions. These social learning outcomes are likely to play an important role in re-imagining the future of the affected lands. In addition, temporal aspects of ecosystems management and resilience remain fundamental issues for the wider region looking ahead. Maturation of the evolving transitory model towards an enduring framework will be critical to realising the benefits of the governance innovations to date.

**Box 1**. Transferable learning from this case.

- The modification and degradation of peri-urban floodplains is common worldwide. Human dimensions of ecosystems management include recognising, managing, and re-imagining relationships with these areas, together with facilitating community engagement in decision-making around the issues involved. The case highlights opportunities for redefining urban-rural relationships with floodplains, and the critical need to assess trade-offs in the design of sustainable and equitable options for natural resource management and land use.

- Governance must be able to respond to contexts that include indigenous people's perspectives, legacy issues from past management practices, and the contemporary values and aspirations of a variety of stakeholder groups. Unique aspects of this case include the incorporation of indigenous Māori knowledge and perspectives at multiple levels in planning processes, and in the governance institutions themselves.

- Temporal aspects of socio-ecological change require ecosystem governance approaches that can address multiple drivers and rates of change. In this case the context involved interactions between tectonic events, climate change, and localised human-induced environmental change. Similar combinations of physical and social drivers occur elsewhere, and also require governance to provide for adaptation to slow change as well as sudden shocks such as disasters and other periodic events. Synergies between the two create a strong basis for holistic risk management and for building socio-ecological resilience over longer time frames.

- In many ways this case presents a natural experiment in how a socio-ecological system may respond to an adaptation challenge. Due to the magnitude and rapidity of earthquake impacts the new governance and decision processes evolved over a relatively short time frame. The unique context presents a major learning opportunity with many of the biophysical and societal outcomes being readily observable in this case. This learning may be usefully applied to longer term governance challenges such as adaptation to climate change.

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