

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/317088723>

Economic and Social Reconnaissance: Kaikōura Earthquake 2016

Article in *Bulletin of the New Zealand Society for Earthquake Engineering* · June 2017

CITATION

1

READS

82

7 authors, including:



Joanne Stevenson
University of Canterbury

20 PUBLICATIONS 107 CITATIONS

SEE PROFILE



Nicholas Cradock-Henry
Landcare Research

20 PUBLICATIONS 61 CITATIONS

SEE PROFILE



Sarb Johal
Massey University

68 PUBLICATIONS 239 CITATIONS

SEE PROFILE



David M. Johnston
Massey University

230 PUBLICATIONS 3,250 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



The Science of Citizen Science [View project](#)



Design and Evaluation of Prototype to improve Individual and Team Situation Awareness for Decision Making [View project](#)

All content following this page was uploaded by [Nicholas Cradock-Henry](#) on 24 May 2017.

The user has requested enhancement of the downloaded file.

ECONOMIC AND SOCIAL RECONNAISSANCE: KAIKŌURA EARTHQUAKE 2016

**Joanne R. Stevenson, Julia Becker², Nicholas Cradock-Henry³,
Sarab Johal⁴, David Johnston⁵, Caroline Orchiston⁶
and Erica Seville⁷**

(Submitted *March 2017*; Reviewed *April 2017*; Accepted *May 2017*)

ABSTRACT

This paper provides a near-term reconnaissance of the economic and social impacts of the November 14th, 2016 Kaikōura earthquakes and tsunami. The effect of this event on the national economy is relatively minimal. The main impacts at the national scale include short-term falls in tax revenues from the affected regions and the Government's NZ\$1 billion spending increase for reconstruction activities. Disruptions at the regional and industry-level are far more significant. Approximately 11 per cent of office space in the nation's capital of Wellington was closed in the week following the event and cordons were erected around several city blocks due to safety concerns. Damage to transport infrastructure is having the most significant economic impact, both in terms of the direct cost of repair and the indirect impacts on businesses whose supply chains have been disrupted. The Kaikōura District's two largest industries, tourism and primary production, lost important infrastructure and essential functions were hampered by transport disruptions. In the tourism industry, ongoing safety concerns and reduced amenities for tourists will reduce trade in the coming season. Primary production businesses face increased transportation and land remediation costs and the closure of fisheries while affected shellfish habitats recover. Communities in the districts most affected by the Kaikōura earthquakes experienced the loss of critical utility services, the loss of homes, and temporary isolation. The Kaikōura earthquake has starkly highlighted the vulnerability of key infrastructure and transportation routes to natural hazards. It is also a timely reminder of the need for New Zealand to be prepared and to continue efforts to build resilience.

INTRODUCTION

Preliminary estimates of the damage caused by the November 14th, 2016 Kaikōura earthquake, tsunami, and subsequent aftershocks indicate that the event has been disruptive but not catastrophic for the region's people and economy. At the time of writing, less than four months after the initial event, significant uncertainty remains about the full extent of the damage and the rate at which the economy will be able to recapture lost productivity.

The M_w 7.8 earthquake was centred 15km north-east of the North Canterbury town of Culverden at a depth of 15 km [1]. The rupture occurred just after midnight followed by approximately two minutes of intense shaking. The aftershocks, including four over M_w 6, occurred across a complex connected series of faults in the Marlborough Fault System [2]. Moderate shaking was felt as far north as Whangarei (in the northern most region of New Zealand) and as far south as Invercargill (Figure 1). The long-duration shaking and subsequent tsunami warnings led to the evacuation of several thousand residents from numerous communities along the east coasts of the North and South Islands. A tsunami was generated which had limited impact but did cause damage to one property in Little Pigeon Bay (about 200km south of Kaikōura) [3]. The earthquake caused two deaths; one from a house collapse and another from a heart attack [4], and 580 people had Kaikōura earthquake-related injury claims accepted by the Accident Compensation Corporation [5].

An estimated 80,000-100,000 landslides were generated by the earthquake, with at least 12 damming rivers or lakes creating the risk of break-out flooding [7]. Some dams breached soon after the earthquake (e.g. one on the Clarence River north of Kaikōura on 14 November), while others have taken longer to fail [4]. The public was strongly advised by the Ministry of Civil Defence and Emergency Management to stay away from landslide-dam areas because of the high-risk they posed [7].

In the 48 hours following the event, some regions also experienced severe weather (i.e. heavy rain and winds) which added to the impacts in earthquake affected areas. For example, the Wellington Region experienced flooding in the Hutt Valley and Porirua on November 15th.

Resources had to be allocated to respond to flooding in addition to the earthquake [4, 8, 9]. In some areas, the flooding was severe enough to significantly disrupt road and rail travel and at least two homes were evacuated due to land instability [10]. This severe weather system also hampered evacuation and response activities around Kaikōura in the days following the earthquake.

This paper provides a near-term reconnaissance of the economic and social impacts of the Kaikōura earthquakes at the national and then at industry-level, focusing on three industries that were particularly disrupted in the affected regions: transport and logistics, tourism, and primary production. Throughout, sections are organised based on the

¹ Corresponding Author, Senior Analyst, Resilient Organisations, Christchurch, joanne.stevenson@resorgs.org.nz

² Department Team Leader – Social Sciences, GNS Science, Wellington

³ Senior Researcher Social Science, Landcare Research, Lincoln

⁴ Associate Professor, Massey University- School of Psychology, Wellington

⁵ Director/Professor, Massey University- School of Psychology and Joint Centre for Disaster Research, Wellington

⁶ Research Fellow/Deputy Director, University of Otago – Centre for Sustainability, Dunedin

⁷ Director, Resilient Organisations Ltd., Christchurch

relationship of disruption and loss to earthquake-related damage. Direct losses are the result of disaster-related damage, and include stock losses (i.e. physical damage to property or assets) and flow losses (i.e. business interruption or reduced productivity resulting from disaster induced damage) [11]. Indirect loss covers all flow losses that are not directly linked to damage, and do not necessarily cause a direct reduction in output. Indirect losses, for example, include decreased customer numbers or increased costs of labour or supplies

[11]. The paper then covers some early observations and reflections on the social and psychological implications of the earthquakes, particularly in Kaikōura, where residents were isolated for extended periods of time. Finally, the paper describes some of the response activities undertaken to reduce the negative impacts of the earthquakes, and reflects on the factors that will likely influence the economic recovery going forward.

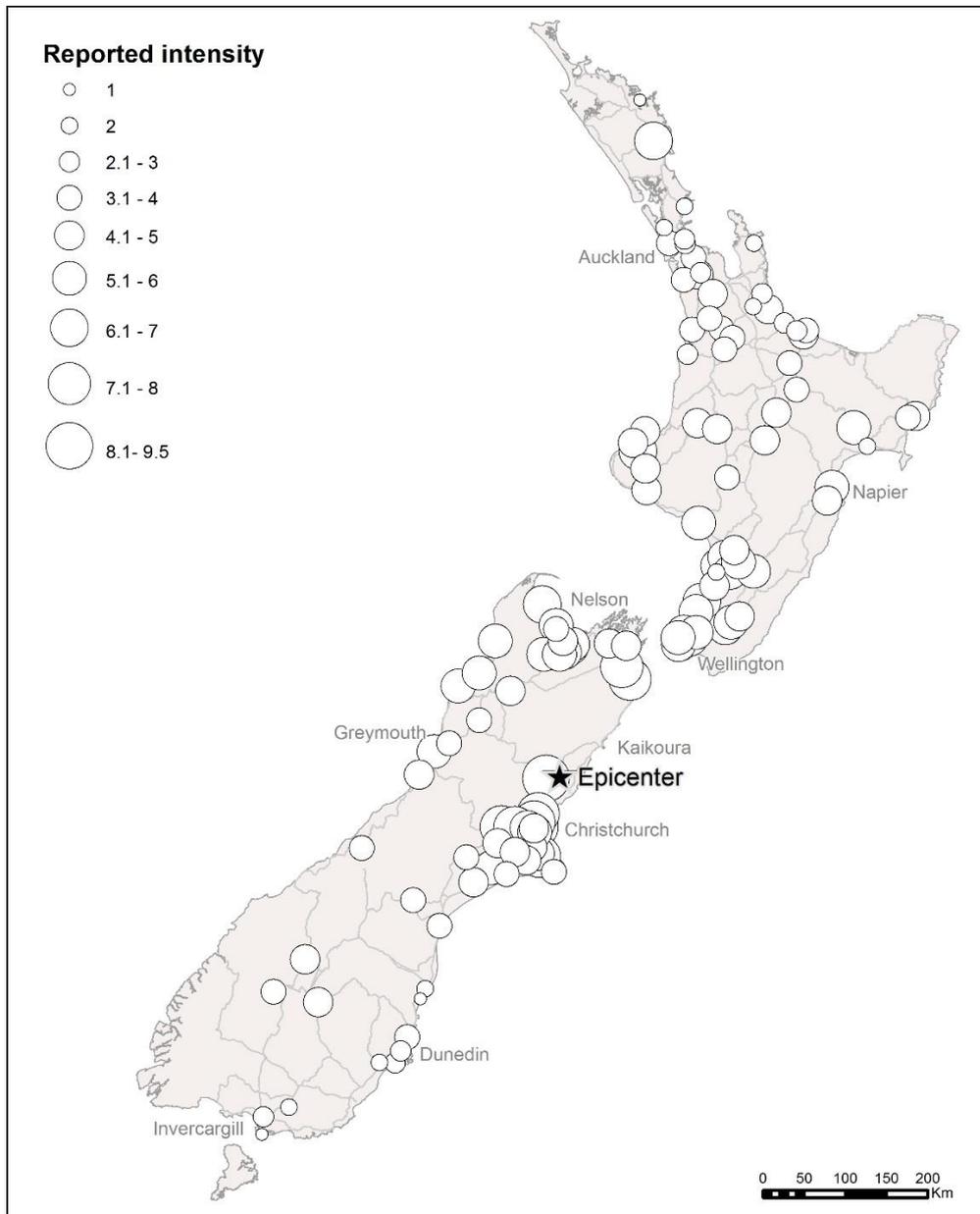


Figure 1: Shaking intensity (Modified Mercalli Intensity Scale) reported by the public using GeoNet Felt Reports following the Kaikōura earthquake [1].

EARTHQUAKE IMPACTS

Direct (Infrastructure and Building) Damage

Electricity and communications outages were relatively contained. Despite nearly 7,000 homes and businesses being without power and over 10 breaks in the fibre optic cable along State Highway 1 in North Canterbury, nearly 90 per cent of North Canterbury residents had power and almost all areas had cell service within two days of the event [12]. Similarly, power was restored to the estimated 55,000 affected homes in the Wellington Region within 24 hours of the earthquake [13].

As of April 2017, the vast majority of homes and businesses had water and sewerage supply, though certain areas continue to have boil water notices and Kaikōura residents are being encouraged to reduce the strain on sewerage services where possible [14, 15]. There were four reported Norovirus cases in Waiau, and two gastroenteritis cases in Kaikōura leading to encouragement by public health for good hygiene and a recommendation to boil water [16, 17].

Damage to transport infrastructure was the most severe impact of the earthquake. Both roads and bridges in North Canterbury and Marlborough were significantly damaged by

fault ruptures and shaking, liquefaction, and slumping induced damage. Landslides created access issues throughout the affected region [12]. Several large (100,000 – 500,000 m³) landslides blocked both State Highway (SH) 1 and the South Island main trunk railway to the north and south of the Kaikōura district [18]. The town of Kaikōura was completely cut off along both coastal and inland routes for two days until access for military four wheel-drive vehicles was established along SH 70 on 16 November for the delivery of critical supplies. Full access for two-way traffic was reinstated 35 days after the main earthquake, and partial access during the day along SH 1 took 37 days to reinstate [12]. Road access to the small town and popular tourist destination, Hanmer Springs was also temporarily cut off due to damage along SH 7 [19].

Sea and rail transport infrastructure also suffered significant direct damage due to shaking and earthquake induced liquefaction. The Kaikōura earthquake caused significant liquefaction along the Wellington waterfront and seriously damaged CentrePort infrastructure [20]. Notably, the earthquakes disabled the port's gantry (container dedicated) cranes, causing an almost complete cessation of container shipping from the port for nearly two months. Picton ferry terminals were also damaged, but to a far lesser degree [21]. Both ports were functional within 24 hours of the earthquake [21]. KiwiRail's Main North Line linking Christchurch and Picton disrupted the use of the route for freight transport and KiwiRail's Scenic Journey, the Coastal Pacific. As of May 2017, repairs are underway but commercial services have not yet recommenced [22].

Unlike the February 2011 Christchurch earthquake, which resulted in the loss of thousands of commercial and residential buildings and resulted in two catastrophic building failures that killed 115 people, known building losses are modest relative to the magnitude of the Kaikōura earthquake. In the northern South Island, early engineering assessments showed moderate to severe non-structural damage to residential buildings in Seddon, Hanmer Springs, and Waiiau and structural damage to at least four historic buildings in Rotherham and Waiiau [23]. In rural areas of the Hurunui and Kaikōura Districts, there was significant damage to farm infrastructure including milking and woolsheds, feed bins and platforms, and fences as well as farmers' and staff members' houses.

Additionally, as of early December 2016, approximately 11 per cent of Wellington office space was closed. Three buildings in Wellington and Lower Hutt were slated for demolition due to damage resulting in disruption and temporary loss of access for nearby businesses and residents [24]. Shortly after the earthquake, cordons were also erected around five city blocks in Wellington and two city blocks in Lower Hutt due to safety concerns [25]. Four areas surrounding damaged buildings were cordoned in Wellington city through January 2017, and access continues to be restricted in areas where demolitions need to occur [24]. While no single industry bore the brunt of this disruption in Wellington, the concentration of Government agencies in the nation's capital is an ongoing concern as detailed engineering evaluations uncover further damage.

ECONOMIC IMPACTS

Direct Impacts

Preliminary estimates of the direct cost of the earthquakes are between NZ\$2 to \$3 billion (less than a tenth of the estimated direct costs of the 2010/11 Christchurch earthquakes) [26]. This figure includes institutional operating expenses (e.g., the Earthquake Commission claims costs) and capital expenditure

(e.g., rebuilding infrastructure) [26]. The Government will meet a large proportion of these costs through existing budget allowances, funds, and insurance. Thus, the net cost of the earthquakes is estimated at \$1 billion, which will modestly reduce the Government's operating balance before gains and losses (OBEGAL) and increase net debt [26]. It is possible for the direct cost estimates to increase if additional damage is uncovered during ongoing assessments or further damage is caused by subsequent aftershocks.

Indirect Impacts

At the time of the Kaikōura earthquake in November 2016, the New Zealand economy was performing well with sustained growth in recent years and an OBEGAL surplus expected for the year ending in June 2017 [26]. There will be short- to medium-term adverse effects on the affected districts and their industries regionally; however, there is relatively little disruption at the national scale [26]. The main impacts at the national scale include short-term falls in goods and services tax (GST), PAYE (income tax), and other tax revenues from the region. These tax losses are likely to be mostly offset by economic activity in the construction sector and the estimated \$1 billion spending increase for reconstruction activities [26].

It is difficult to quantify the impact of the earthquake on organisational productivity or to tie job losses directly to the effects of the earthquake. There are indications, however, that organisations in the Hurunui District, Kaikōura, central Wellington, and Lower Hutt have experienced losses in productivity, profitability, and, in some cases, have had to lay off staff. Event Cinemas in Lower Hutt, for example, had to lay off 39 employees before the cinema building was demolished in December 2016 [27]. Less clear are the losses caused by relocations and decreased visitor numbers. Guest nights in Kaikōura fell 80 percent (from 40,000 to 8,000) for the month of December 2016 compared to December 2015 [28], which would have had serious negative impacts across the local economy, including lost revenue and an inability to retain staff for tourism operators, retailers, and hospitality businesses. In Wellington, at least nine buildings housing Government agencies and several other buildings housing private companies required closure and temporary or permanent relocation of thousands of staff [29]. Many of those organisations would have lost productive output while relocating, and as much of the vacant buildings into which organisations moved are lower quality, there may be ongoing challenges to optimal organisational performance [30].

Impacts on Industries and Organisations

Kaikōura and the Hurunui districts make up around 0.4 per cent of all households nationally, and their largest industries are tourism and primary production (seafood, dairy, beef, and lamb) [31]. In Kaikōura, 15% of businesses and 26% of employees are engaged in accommodation and food sector businesses (5% and 13% respectively in the Hurunui District). Agriculture, forestry, and fishing account for approximately 27% of businesses and 10% of employees in the Kaikōura District, and 45% of businesses and 38% of employees in the Hurunui District [32].

The most costly and widespread impacts throughout the region were caused by disruptions to transportation infrastructure. Therefore, we begin this section with a summary of the disruptions to the freight and transport logistics industry across New Zealand as a result of the Kaikōura earthquakes, and then discuss the more localised impacts on the tourism and primary production sectors in North Canterbury.

Freight and Transport Logistics

The extensive damage to rail and road networks had significant repercussions for the safe and efficient transport of people and goods throughout the affected regions. While SH 1 was closed to non-essential traffic, cars and trucks were rerouted on SH7 via Lewis Pass, increasing the length of the journey from Christchurch to the port town of Picton (the entry point to the South Island by ferry/car) from 330km to 580km, effectively doubling the time required to move freight through the South Island. This necessarily increased transport costs for affected businesses. There is some evidence that businesses along the busier SH7, SH63, and SH70 routes benefited from increased custom, yet road degradation caused by the increased traffic will later create disruptions for these same businesses when the damage is repaired [19].

Freight and transport companies themselves have also been affected by the earthquakes. KiwiRail (a State-Owned Enterprise) reported reduced revenue and an increased cost of \$3 million due to earthquake damage [22]. Domestic freight was worst affected due to the closure of the Main North Line, however, the cancellation of passenger services on the Scenic Journeys' Coastal Pacific route has also caused an estimated loss of \$1 million [22].

Sea transport was also affected by the earthquakes. Wellington's CentrePort is small but regionally important, handling just over four percent of container traffic in New Zealand [33]. Due to damage at CentrePort and the loss of the gantry crane, ships needed to divert to other ports, increasing costs and causing delays. Although crane repairs will take an estimated six months, CentrePort has partnered with a company with a geared ship that can drop off and pick up containers with its own cranes on a weekly basis to retain or recapture market share in a highly competitive shipping environment [34].

Backlogs created by disruption to CentrePort in Wellington and road transport in the South Island have led to increased coastal shipping through other ports to meet freight demand. Ports of Auckland and Lyttelton Port of Christchurch increased container capacity and are collaborating with KiwiRail to increase rail services to inland hubs [35]. Napier Port handled the majority of imports that had to be rerouted from ports in Wellington and Palmerston North [36] and a smaller amount was being rerouted through Port of Tauranga as needed [37].

Tourism

Approximately 1,200 tourists were evacuated from Kaikōura in the days following the event. The Ministry of Foreign Affairs and Trade fielded enquiries via embassies from overseas relatives of people in New Zealand that they could not contact following the earthquakes, and helped locate missing foreign nationals [9].

The tourism industry in Kaikōura and the Hurunui districts account for less than one per cent of tourist spending nationally, or \$250M in 2016 [31]. SH1, which runs along the Kaikōura coast is an important tourist corridor, linking the Picton ferry terminal and the North Island with Christchurch and the rest of the South Island. The popular TranzCoastal railway also runs parallel with SH1 along the Kaikōura coast. The closure of SH 1 and the rail network, both north and south of Kaikōura, and the inland route (SH 70), changed patterns of travel across the northern South Island. Visitors were unable to reach Kaikōura by road, and were diverted to the alternative routes of SH 63 via Blenheim and SH6 via Nelson. SH 63 quickly became congested with heavy traffic transporting fast moving consumer goods and tourist vehicles. Tourists traveling through the country, like the transport and logistics

industries, faced additional cost and travel delays cause by this diversion of traffic.

Tourism operators in Kaikōura are facing significant ongoing challenges as a result of the earthquake. In the months following the quakes, apart from the positive inflow of response personnel, Kaikōura has experienced an unprecedented drop in visitor numbers due to road closures and the negative perceptions of travel during a period of high seismicity. The southern and inland routes reopened just before Christmas, however the township's ability to host visitors was compromised due to sewerage and potable water disruptions.

Damage to critical tourism infrastructure continues to hamper the recovery of tourism businesses in Kaikōura. Uplift of the coastline resulted in shallowing of the marina and channel area, which stopped whale-watching and dolphin encounter business activity. The inability to provide these experiences has had negative flow-on consequences for other tourism and hospitality operators in the township, including the 44 accommodation providers in Kaikōura [31].

At the time of writing, the impact of the earthquakes on traveller motivations to return to Kaikōura is unknown. Research in the aftermath of the Christchurch earthquake sequence suggests there are likely to be long term implications on visitor demand, particularly from international tourists [38]. The Kaikōura Earthquake Tourism Action Group (KE-TAG), a multi-agency tourism coordination group, alongside the Kaikōura Tourism Recovery Group, a local tourism recovery initiative, are working to lobby for tourism to be prioritised during the recovery effort. The summer season of 2016/17 was predicted to be one of the busiest on record, with tourism booming around New Zealand over the previous two years [39].

Kaikōura must now reconsider its future, given potentially negative long-term visitor perceptions of safety following the earthquake, and the challenging process of reinstating critical tourism infrastructure in the township. The Canterbury earthquakes (2010/2011) caused a prolonged reduction in international visitor arrivals, with the Australian market still not back to pre-quake levels [40]. Fortunately, the natural marine resources of the Kaikōura district, particularly the whale and dolphin populations, have remained in the local area. A government support package (\$870,000) was announced in late February 2017 to support tourism promotion for the 2017/18 summer season [29]. Communication efforts will need to focus on rebuilding the reputation of Kaikōura as a safe destination, to accelerate the return of domestic and international tourists to the Kaikōura coast.

Primary Production

The Hurunui and Kaikōura District's other major industry, primary production, have also been affected by transport disruption and land damage. Pastoral farmers in North Canterbury have already been under considerable stress due to long-term (> 3 years) drought conditions. Impacts of the earthquake have compounded existing stresses relating to personal well-being, animal health, productivity, and yield. The earthquake response prioritised human welfare, making sure famers and families were looking after one another, and their communities, animal welfare and restoring water supplies.

The earthquake resulted in immediate farm infrastructure and housing losses, which were compounded by lack of road access. It took over three weeks to resume milk collection from 22 farms in the Kaikōura District, which were disposing of several hundred thousand litres of milk daily [41]. In other earthquake-affected regions, collection resumed relatively quickly. Fonterra's milk tankers were unable to collect from

farms in North Canterbury for three days, after the quake, while farms supplying Synlait had their milk collected two days after the quake [42]. Cows needed to be milked continuously, regardless of collection, otherwise they go dry and farmers would lose almost a season's worth of production.

Slips and crevasses made moving stock much harder and slower. Stock water infrastructure (pipes, storage and some irrigation and reticulation schemes) and effluent systems were also badly affected, and a priority for recovery. Because of the drought, few natural springs or ponds were available and so farms relied on tankers to top up reservoirs. Power outages meant electric fences were not working. Landslips and surface faulting are affecting farms throughout the area [43]. Extensive remediation will be needed to minimise erosion and, where possible, restore some land to productive agriculture.

Furthermore, due to the loss of road access, farms that produced fodder crops could not harvest because contractors were unable to get into the district. Breeding programmes were disrupted, as farms without bulls were in the middle of the artificial breeding season and technicians were unable to gain access. Limited road access also meant that sale and finishing stock were travelling longer distances at higher transport costs.

In addition to immediate financial and productivity losses, there are longer-term implications for sheep, beef, and dairy farmers. The earthquake happened at a crucial time in the production cycle, only three weeks into dairy cow mating. Technicians need to travel between farms to artificially inseminate the cows and if they cannot get access to farms on time it jeopardises next season's production. Feed shortages combined with the need to reduce animal stress necessary to get them into calf, meant farmers dropping from twice- to once-a-day milking, reducing total output. Additionally, livestock farmers unable to shift animals to the meat works or finishing farms struggled to keep animals sufficiently well-fed. Without feed, stock live weights drop daily, reducing farm returns. Decreased productivity is difficult to recoup in the primary sector, and lower breeding rates of breeding success can take several years to recover from.

The bee keeping industry in the region is also expected to be disrupted for several months. Apiarists are reliant on hives located on farms and in the high country, however many public roads and farm tracks are still inaccessible. Hives toppled over in the quake, and a cool spring and summer meant many were reliant on supplemental feeding. A lack of road access has compounded these issues, and hives have suffered.

The Kaikōura earthquake also caused extensive damage to the Marlborough wine growing region, with an estimated loss of 5.3 million litres of wine and a loss of 60 million litres, or 20 percent of total wine tank storage capacity [44]. In Marlborough, the district that account for approximately 70 percent of New Zealand's wine industry, the immediate effects of severe ground movement also included plant and equipment failure, damage to vines, structural damage to buildings and other infrastructure [45].

Disruptions to transport infrastructure have also affected the wine industry. Individual wineries' roads were damaged – making it difficult to access, assess and repair damaged vineyards – and damage to state highways disrupted wineries' conveyance routes to Christchurch and the port in Wellington. As an export-dependent industry, wineries were concerned about delays in servicing markets, as well as being unable to receive supplies of dry goods needed for packaging: transferring glass from the port to wine bottling companies, and bottled wine from those businesses back to the port.

For several wineries, the damage to transport infrastructure has also impacted on tourist visitation, which is an important distribution channel for wine and for building brand recognition and loyalty. Many Marlborough wineries receive significant portions of their revenue from self-drive tourists, passing through on their way from Picton towards the lower South Island. The ongoing closure of SH1 north of Kaikōura continues to affect those traffic flows, and there is little opportunity for these providers to reorganize for this by diversifying - at least in the short term.

Finally, fisheries have been significantly affected by land disruptions. Just over four percent of businesses and only one percent of employees in the Kaikōura District are in the commercial fishing sector [32]. Crayfish is, however, one of the most valuable stock animals in the area, with an annual harvest value of around \$23 million and pāua around \$1.5 million, which does not account for people coming to the area to participate in recreational fishing [46]. The earthquake uplifted the seabed several metres, exposing previously submerged pāua and rock lobster fishery habitats. The shaking also initiated enormous underwater mudslides that have devastated marine life in the Kaikōura Canyon marine reserve [47]. Rock lobster fisheries were closed for a month while impacts were assessed and have since reopened. The Ministry of Primary Industries has extended the closure of other shellfish (excluding rock lobster and scampi) and seaweed species for a further nine months to facilitate the recovery of these fisheries [48]. An estimated 20 per cent of adult pāua habitat in the closed portion of the fishery was lost. Some fishing quota owners and holders of allowable catch entitlements in the affected areas may lose income over the next year.

SOCIAL AND PSYCHO-SOCIAL IMPACTS

Social Infrastructure Disruption

Early estimates indicated that approximately 600 people needed emergency relocation or shelter in the first 24 hours from Hurunui District, primarily from Hanmer Springs and Amberley [4]. People were also evacuated from Kaikōura.

Communities in the districts most affected by the Kaikōura earthquakes experienced the loss of critical utility services, the loss of homes, and temporary isolation due to loss of road access (e.g. Kaikōura, Hanmer Springs). Access was by air and sea due to damage from road and rail networks [4].

Key health services in affected areas remained operational throughout the event and response, including the hospitals in Kaikōura and Marlborough Districts. Aged care facilities in the affected areas were also able to manage without evacuating residents [4]. Some pharmacies did experience damage (e.g., in Kaikōura) but were still available to dispense medications [16].

Reports indicated that following the earthquake on November 14th more than 100 schools were closed in Wellington, 91 in the Nelson-Marlborough region, and 81 in Canterbury. All six schools in the Kaikōura District were closed [49]. Closures facilitated initial building assessments. Following initial assessment, most schools opened the following day except for schools where more detailed building assessments needed to be carried out or where essential services were not available (e.g., water and sewerage in Kaikōura). Most educational facilities were open approximately one week after the earthquake [50].

Community Support Response

A total of 449 people from Kaikōura were evacuated via ship to Lyttelton Port on November 15th and 16th [51]. A further 363 people were evacuated from Kaikōura by helicopter on

the same dates [51]. Further requests for evacuation from Kaikōura occurred in the following days [7, 50], and approximately 100 people chose to evacuate privately [50, 16]. As of the 20th November, approximately one week after the earthquake, a total of 1,264 people had been evacuated by sea, air, or other private means [17].

Shortly after the event, a welfare centre opened at Takahanga Marae in Kaikōura [4]. An estimated 700 people spent the night of the 13/14th in the evacuation centre at Kaikōura, and approximately 200 people (mainly tourists) also spent the following night (14/15th) in the evacuation centre [9]. By Wednesday night around 35 tourists and residents remained at the marae evacuation centre [7]. The evacuation centre closed one week after the earthquake.

On November 17th, it was also necessary to open a welfare centre in Wellington to accommodate those evacuated from central Wellington buildings deemed unsafe [50]. Other self-evacuations occurred in coastal areas in response to the tsunami in districts such as Christchurch, Selwyn, Ashburton, and Timaru. Many of these evacuees did not require long term shelter and could go back to their homes after the tsunami threat had passed.

Early situation reports from Civil Defence indicated that isolated communities had critical needs for water, fuel, food and other essential household items [4]. Items, including over 1000 portable toilets, were delivered to Kaikōura a few days after the earthquake from Christchurch [50].

Within days of the earthquake the MBIE temporary accommodation team began identifying accommodation stock in Christchurch to house evacuees [52]. Further individual needs assessments were carried out in the week following the earthquake with some success [16]. Federated farmers assisted with contacting isolated rural households [17].

Longer-Term Psychosocial Impacts

Looking to the future, as with the Canterbury earthquake sequence in 2010-11, there is a risk that those affected by the earthquakes may experience psycho-social consequences, though the majority will recover without complications. The Kaikōura and Hurunui Districts, however, can be distinguished from the greater Christchurch City area by relatively few road and rail routes in and out of the area. This differentiates the vulnerabilities of these populations from those in the greater Christchurch area. The relative isolation as roads were cleared and stabilized meant that people could not move in and out of the region freely, if at all. This meant that one of the major coping and mitigating factors reported for those involved in the earthquakes - the ability to leave the area for respite [53]- was not available for residents in the Kaikōura District.

Psychosocial impacts may differ according to where people experienced the earthquakes. For example, the evacuations and cascade of building damage being revealed as time progresses in the Wellington region may have the consequence of eroding confidence in the built environment. There may also be a growing sense of complacency associated with the fact that those that have been identified as 'earthquake-prone' by the city council were not damaged as badly as some people anticipated.

In addition to the earthquake impacts, the long-duration shaking and subsequent tsunami warnings led several thousand residents from numerous communities along the east coasts of the North and South Islands to evacuate. Communities experienced confusion and anxiety associated with a lack of clarity around the risk and appropriate responses. Community-based research is underway to explore the range of tsunami warning responses at an individual and community level. Initial analysis of the data collected so far

shows the positive response to the "natural warning" in many locations, but highlights confusion generated by the later "official warnings" in some communities [54].

The complex nature of the earthquake and its impact on the built environment in different regions is still being examined by engineers and scientists and has not been easy to explain to affected populations. The challenge of communicating the ongoing risks without increasing anxiety and further lowering trust in the built environment and decision-making institutions remains a difficult task.

INTERVENTIONS TO MITIGATE THE COSTS OF THE EARTHQUAKE

Drawing on strategies developed in the aftermath of the Canterbury earthquakes, the Government almost immediately offered an Earthquake Support Subsidy for small businesses affected by earthquakes. The \$7.5 million ESS package is paid to employers at a rate of \$500 gross per week for full-time employees and \$200 gross per week for part-time employees and is intended to help small businesses retain staff while the region recovers [55].

Tourism and primary production businesses have also been offered targeted support from the Ministry of Business, Innovation, and Employment (MBIE) and the Ministry of Primary Industries (MPI) respectively. MBIE allocated \$350,000 for tourism operators in Hanmer Springs and the Hurunui District - \$250,000 of which will pay for marketing primarily geared at domestic tourists and \$100,000 of which will support regional tourism organisations to employ extra staff where needed [56]. Hanmer Springs had very little direct damage from the earthquake, but was affected by a sharp downturn in visitors in the immediate aftermath [56].

The Primary Industries Earthquake Relief Fund of approximately \$4 million was made available to affected businesses in the Hurunui, Kaikōura, and Marlborough Districts. Priority was given to those that needed to cover repairs to uninsurable infrastructure that supports essential business functions (e.g., fencing, access tracks, and stock water supplies). Funds can also be used to restore or re-establish uninsurable pasture, crops, and forestry and to clean up silt [57].

KEY ISSUES FOR RECOVERY

The effects of the earthquake are geographically widespread, with each region experiencing effects in different ways. Each region has its own recovery arrangements, and distinct differences in terms of size, and therefore, financial and resource bases from which to draw.

Kaikōura's recovery trajectory will likely be dominated by three key issues: the restoration time and eventual reliability of transportation routes into and out of the area; the restoration time for key tourism; and the degree and nature of impacts the earthquake and coastal uplift have had on the local fisheries. For the rural farming areas, the Kaikōura earthquakes have come on the back of three years of drought for the region. The compounding impacts of the earthquake on top of already strained financial resources may create challenging dynamics during the recovery, with high debt servicing costs, repair requirements, and the potential of reduced productivity. Wellington's recovery is likely to be dominated by issues associated with damage to some tall buildings and those located on poor soils, and potential loss of confidence in the performance of the city's building stock in future large earthquakes.

It is not possible to know at this stage how those three issues will unfold. Previous experience, however, indicates that four

important ‘levers’ will influence the pace and cost of recovery. These levers include the:

- Extent of the reconstruction work required,
- Availability of labour and materials,
- Availability of Government funding, and
- Public perceptions and business confidence.

First, the extent of the work required will unfold as investigations reveal the amount of the damage, and insurers and asset owners gauge the need for asset replacements and upgrades. Additionally, aftershocks are expected to continue in the coming months and could cause further damage and delays.

Second, the availability of labour will partly be determined by the extent of the reconstruction work required and rates of training and skilled labour immigration. Additionally, there are competing demands for construction labour throughout the country. For example, the Auckland residential building value is projected to grow by approximately \$3.3 billion in 2017, representing 53 per cent of the total national construction growth [58].

Third, the availability of materials will also be affected by construction demand. A 2015 report stated that construction sub-contractors were concerned about critical shortages of materials including bitumen and asphalt, caused by the Canterbury rebuild [59]. There are also concerns that current shortages of building supplies are already causing contractors to substitute sub-standard materials with far-reaching implications for building longevity and safety going forward [60].

Finally, the rate and capacity of government spending can determine the quality and speed of reconstruction. Following the Canterbury earthquakes, public spending was split approximately 60/40 between the Crown and local governments respectively. As of May 2015, however, the Crown had only spent \$16.5 billion or 40 per cent of the estimated \$40 billion cost of reconstruction following the Canterbury earthquakes [26]. Canterbury earthquake claims to the Earthquake Commission also almost exhausted the insurance levy-supported Natural Disaster Fund – and thus, it is possible that claims resulting from the Kaikōura earthquakes will be borne by the government [61]. The cost of the Kaikōura earthquakes is only a fraction of the cost of the Canterbury earthquakes, and funds are already being committed to the rebuild.

From a broader New Zealand perspective, the Kaikōura Earthquake has starkly highlighted the vulnerability of key infrastructure and transportation routes to natural hazards. It is also a timely reminder of the need for our nation to be prepared and to build resilience.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Resilience to Nature’s Challenge – National Science Challenge and QuakeCoRE for their support of our ongoing research. We also extend sincere thanks to Wayne Tyson from the Geospatial Research Institute at the University of Canterbury, Toni Wi from Resilient Organisations Ltd., and contributing staff from GNS Science for their support in the preparation of this manuscript. This is QuakeCoRE publication number 0175.

REFERENCES

- 1 GeoNet (2016). “*New Zealand Earthquake Report: Magnitude 7.8, Mon, Nov 14, 2016, 12:02:56 am (NZDT)*”. GeoNet. <http://www.geonet.org.nz/quakes/region/canterbury/2016p858000> (Accessed 23/01/2017).
- 2 Bradley BA, Razafindrakoto HNT and Nazer MA (2017). “Strong ground motion observations of engineering interest from the 14 November 2016 Mw7.8 Kaikōura, New Zealand earthquake”. *Bulletin of the New Zealand Society for Earthquake Engineering*, **50**(2): 85-93.
- 3 Little C (2016). “*More info on the impact of Monday’s tsunami*”. GeoNet. <http://info.geonet.org.nz/display/tsunami/2016/11/18/More+info+on+the+impact+of+Monday’s+tsunami> (Accessed 27/02/2017).
- 4 Ministry of Civil Defence and Emergency Management (2016). “*Situation Report 002*”. Hanmer Springs Earthquake and Tsunami, National Crisis Management Centre (NCMC).
- 5 ACC (2017). “*14 November 2016 Earthquake Claims*”. Internal Memo: Operations Services, Analytics Reporting (23/03/2017) Ref: 41510.
- 6 Balfour N (2016). *Landslides and Landslide Dams cause by the Kaikōura Earthquake*. GeoNet. <http://info.geonet.org.nz/x/2YA5AQ> (Accessed 27/02/17).
- 7 Ministry of Civil Defence and Emergency Management (2016). “*Situation Report 009*”. Kaikōura Earthquake and Tsunami, National Crisis Management Centre (NCMC).
- 8 Ministry of Civil Defence and Emergency Management (2016). “*Situation Report 003*”. Hanmer Springs Earthquake and Tsunami, National Crisis Management Centre (NCMC).
- 9 Ministry of Civil Defence and Emergency Management (2016). “*Situation Report 004*”. Hanmer Springs Earthquake and Tsunami, National Crisis Management Centre (NCMC).
- 10 RNZ (2016a). “*Rain brings commuter chaos to capital highways*”. Radio New Zealand News. <http://www.radionz.co.nz/news/national/318094/rain-brings-commuter-chaos-to-capital-highways> (Accessed 30/01/2017).
- 11 Rose A (2004). “*Economic Principles, Issues, and Research Priorities in Hazard Loss Estimation*” in *Modeling spatial and economic impacts of disasters*. Springer, Berlin Heidelberg, 13–36.
- 12 Liu Y, Nair N, Renton A and Wilson S (2017). “Impact of the Kaikōura earthquake on the electrical power system infrastructure”. *Bulletin of the New Zealand Society for Earthquake Engineering*, **50**(2): 300-305.
- 13 RNZ (2016b). “*Earthquake: What you need to know*”. Radio New Zealand News. <http://www.radionz.co.nz/news/national/318005/earthquake-what-you-need-to-know> (Accessed 23/01/2017).
- 14 Hurunui District Council (2017). “*Hurunui District Council: Community partnership in growth and wellbeing*”. <http://www.hurunui.govt.nz/services/water-and-sewerage-services/earthquake-related-updates/> (Accessed 23/04/2017).
- 15 Kaikōura District Council (2017). “*Kaikōura District Council: Latest News*”. <https://www.Kaikōura.govt.nz/latest-news/earthquake-update/> (Accessed 23/04/2017).
- 16 Ministry of Civil Defence and Emergency Management (2016). “*Situation Report 0011*”. Kaikōura Earthquake and Tsunami, National Crisis Management Centre (NCMC).
- 17 Ministry of Civil Defence and Emergency Management (2016). “*Situation Report 012*”. Kaikōura Earthquake and Tsunami, National Crisis Management Centre (NCMC).

- 18 Little C (2016a). "Landslides and Landslide dams caused by the Kaikōura Earthquake". GeoNet. <http://info.geonet.org.nz/display/slide/2016/12/02/Landslides+and+Landslide+dams+caused+by+the+Kaikōura+Earthquake> (Accessed 24/01/2017).
- 19 NZTA (2017). "Kaikōura Earthquake Response". New Zealand Transport Authority. <https://www.nzta.govt.nz/projects/Kaikōura-earthquake-response/> (Accessed 25/04/2017).
- 20 Cubrinovski M, Bray JD, de la Torre C, Olsen MJ, Bradley BA, Chiaro G, Stocks E and Wotherspoon L (2017). "Liquefaction effects and associated damages observed at the Wellington Centreport from the 2016 Kaikōura earthquake". *Bulletin of the New Zealand Society for Earthquake Engineering*, **50**(2): 152-173.
- 21 Cooper E (2016). "First look – Quake-damaged Wellington port riddled with cracks and liquefaction". One News Now, Sunday 20th November 2016. <https://www.tvnz.co.nz/one-news/new-zealand/first-look-quake-damaged-wellington-port-riddled-cracks-and-liquefaction> (Accessed 24/01/2017).
- 22 KiwiRail (2017). "KiwiRail Media – News and Press Releases". <http://www.kiwirail.co.nz/media.html> (Accessed 23/04/2017).
- 23 Dizhur D and Giarretton M (2016). "Preliminary update - Mw 7.8 Kaikōura Earthquake: Upper Part of South Island". Kaikōura, New Zealand Earthquake Clearinghouse. <http://www.eqclearinghouse.org/2016-11-13-Kaikōura/files/2016/11/Prelim-observations--overall-PART-2.pdf> (Accessed 23/04/2017).
- 24 Wellington City Council (2017). "Earthquake Recovery Map". <http://wcc.maps.arcgis.com/apps/MapJournal/index.html?appid=d511e3019f5f44ecb33871d3e02b2951&webmap=692c4e14f4d44bc988ddb934521fc9b3> (Accessed 24/01/2017).
- 25 Henry RS, Dizhur D, Elwood KJ, Hare J and Brunson D (2017). "Damage to concrete buildings with precast floors during the 2016 Kaikōura earthquake". *Bulletin of the New Zealand Society for Earthquake Engineering*, **50**(2): 174-186.
- 26 The Treasury (2016). "Budget Economic and Fiscal Update 2016". The Treasury: Kaitohutohu Kaupapa Rawa, Wellington, New Zealand. <http://www.treasury.govt.nz/budget/forecasts/befu2016> (Accessed 30/01/2017).
- 27 Nightingale M (2016). "Queensgate Cinema staff to lose their jobs". New Zealand Herald, Monday November 28th, 2016, 7:11pm. http://www.nzherald.co.nz/earthquakes/news/article.cfm?c_id=184&objectid=11756446
- 28 Statistics New Zealand (2017a). "Kaikōura guest nights down 80 percent in December as accommodation halved". 6 March 2017. http://www.stats.govt.nz/browse_for_stats/industry_sector/accommodation/AccommodationSurvey_MR-dec16_2.aspx (Accessed 26/04/2017).
- 29 MBIE (2017). "New Zealand earthquake". Ministry of Business, Innovation, and Employment. Wellington, New Zealand. <http://www.mbie.govt.nz/info-services/nz-govt-procurement-and-property/government-property-group/new-zealand-earthquake> (Accessed 26/04/2017).
- 30 CBRE (2017). "Wellington is still in a state of ambiguity as a result of the 14th of November Earthquake". CBRE Research. Wellington, New Zealand. <http://www.cbre.com/research-and-reports> (Accessed 26/04/2017).
- 31 Statistics New Zealand (2016a). "Key tourism statistics for Kaikōura and Hurunui districts". <http://www.mbie.govt.nz/info-services/sectors-industries/tourism/tourism-research-data/key-tourism-statistics-for-Kaikōura-and-hurunui-districts> (Accessed 14/02/2017).
- 32 Statistics New Zealand (2017b). "NZ.Stat: Datahub Table Viewer". Wellington, New Zealand. <http://nzdotstat.stats.govt.nz/wbos/index.aspx> (Accessed 26/04/2017).
- 33 Champion Freight (2015). "New Zealand's Largest Ports." Freight News, 25 March 2015. <http://www.championfreight.co.nz/20150325> (Accessed 30/01/2017).
- 34 CentrePort Wellington (2017). "CentrePort Wellington: News". <http://www.centreport.co.nz/index.php/information-library/news> (Accessed 25/04/2017).
- 35 LPC (2017). "Ports of Auckland, Lyttelton and KiwiRail join forces to keep South Island supplied". Lyttelton Port of Christchurch News. www.lpc.co.nz (Accessed 27/02/2017).
- 36 Napier Port (2017). "Extended Import Demurrage Relief". <http://www.napierport.co.nz/news/2016/december-16-extended-import-demurrage-relief/> (Accessed 25/04/2017).
- 37 Fryburg E (2016). "Cargo delayed as ports under strain". Radio New Zealand, 2 December 2016. <http://www.radionz.co.nz/news/national/319429/cargo-delayed-as-ports-under-strain> (Accessed 25/04/2017).
- 38 Orchiston C and Higham JES (2016). "Knowledge management and tourism recovery (de) marketing: the Christchurch earthquakes 2010–2011". *Current Issues in Tourism*, **19**(1): 64-84.
- 39 Statistics New Zealand (2016b). "International visitor arrivals to New Zealand: December 2016". http://www.stats.govt.nz/browse_for_stats/population/Migration/international-visitor-arrivals-dec-16.aspx (Accessed 14/02/2017).
- 40 Smith N, Orchiston C, Harvey E, Kim J and Brown C (2016). "Scoping Tourism Dynamics Post-quake: A Module for MERIT". NZTA QuakeCoRE Research Report.
- 41 Malthus N (2017). "Future up in the air in Kaikōura". <http://www.ruralnewsgroup.co.nz/item/11359-future-up-in-the-air-in-Kaikōura> (Accessed 15/02/2017).
- 42 Malthus N (2016). "Tankers roll into Kaikōura". <http://www.ruralnewsgroup.co.nz/item/11252-tankers-roll-into-Kaikōura> (Accessed 15/02/2017).
- 43 Morton J (2017). "Kaikōura Earthquake: 100,000 Landslides". http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11747915 (Accessed 15/02/2017).
- 44 Nicholson T (2017). "Five million litres of wine lost in Kaikōura Earthquake". <http://www.ruralnewsgroup.co.nz/item/11510-five-million-litres-of-wine-lost-in-Kaikōura-earthquake> (Accessed 24/02/2017).
- 45 Joyce S and Guy N (2016). "Govt working with wine industry to secure 2017 Marlborough vintage". The official website of the New Zealand Government: Releases, 29 November 2017. <https://www.beehive.govt.nz/release/govt-working-wine-industry-secure-2017-marlborough-vintage> (Accessed 26/04/2017).
- 46 Guy N (2016). "Temporary fishery closures around Kaikōura". Press Release: New Zealand Government, 21

- November 2016.
<http://www.scoop.co.nz/stories/PA1611/S00368/temporary-fishery-closures-around-Kaikoura.htm> (Accessed 26/04/2017).
- 47 NIWA (2017). “Massive mudslides in Kaikōura Canyon destroy seabed life”.
<https://www.niwa.co.nz/news/massive-mudslides-in-kaikoura-canyon-destroy-seabed-life> (Accessed 06/03/2017).
- 48 MPI (2017). “Proposed extension of the shellfish and seaweed emergency fishing closure along the Kaikōura and Cape Campbell coastline: Update – 20 February 2017”.
<http://www.mpi.govt.nz/newsandresources/consultations/proposed-extension-of-emergency-fishing-closure-Kaikoura/> (Accessed 6/03/2017).
- 49 New Zealand Herald (2016). “Most schools to open Tuesday following deadly earthquake”. Monday November 14th, 2016, 4:48pm.
http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11747833
- 50 Ministry of Civil Defence and Emergency Management (2016). “Situation Report 010”. Kaikōura Earthquake and Tsunami, National Crisis Management Centre (NCMC).
- 51 Ministry of Civil Defence and Emergency Management (2016). “Situation Report 008”. Kaikōura Earthquake and Tsunami, National Crisis Management Centre (NCMC).
- 52 Ministry of Civil Defence and Emergency Management (2016). “Situation Report 005”. Hanmer Springs Earthquake and Tsunami, National Crisis Management Centre (NCMC).
- 53 Johal S, Mounsey Z, Brannelly P and Johnston D (2016). “Nurse perspectives on the practical, emotional and professional impacts of living and working in post-earthquake Canterbury, New Zealand”. *Prehospital and Disaster Medicine*, **31**(1): 2-7.
- 54 Johnston D (2017). “Tsunami response behaviour during and following the 2016 Kaikōura earthquake, New Zealand”. *Manuscript in preparation*.
- 55 MSD (2016). “Earthquake Support Subsidy”. Ministry of Social Development: Work and Income.
<https://www.workandincome.govt.nz/online-services/eesp/index.html> (Accessed 30/01/2017).
- 56 MBIE (2016b). “Tourism support package for Hurunui Announced”. Ministry of Business, Innovation, and Employment, 14 December 2016.
<http://www.mbie.govt.nz/about/whats-happening/news/2016/tourism-support-package-for-hurunui-announced> (Accessed 30/01/2017).
- 57 Marlborough District Council (2016). “Primary Industries’ Earthquake Relief Fund”.
<http://www.marlborough.govt.nz/Services/Emergency-Management/Emergency-Events/EQ2016/PIERF.aspx> (Accessed 30/01/2017).
- 58 MBIE (2016a). “National Construction Pipeline Report 2016: A Forecast of Building and Construction Activity, 4th Ed”. Ministry of Business, Innovation, and Employment, Wellington, New Zealand.
<http://www.mbie.govt.nz/publications-research/research/construction-sector-productivity/national-construction-pipeline-report-2016.pdf> (Accessed 30/01/2017).
- 59 Chang-Richards A, Wilkinson S, Seville E and Brunson D (2015). “Resourcing the Canterbury rebuild: Emerging issues facing subcontracting businesses”. Resilient Organisations Research Report 2015/03.
- 60 Ryan H (2017). “Building supply shortage resulting in some substandard products”. New Zealand Herald, 10th January 2017.
http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=11779499 (Accessed 30/01/2017).
- 61 Wood A, Noy I and Parker M (2016). “The Canterbury rebuild five years on from the Christchurch earthquake”. *Reserve Bank of New Zealand Bulletin*, **79**(3).