

# COMMUNITIES AND CLIMATE CHANGE: VULNERABILITY TO RISING SEAS AND MORE FREQUENT FLOODING

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Janet Stephenson, *Centre for Sustainability & University of Otago*; Caroline Orchiston, *Centre for Sustainability & University of Otago*; Wendy Saunders, *GNS Science*; Suzi Kerr, *Motu Research & Victoria University of Wellington*; Alex MacMillan, *University of Otago*; Leigh McKenzie, *University of Otago*; Maria Bartlett, *Ngāi Tahu*; Jonathan Boston, *Victoria University of Wellington*; Christopher Brankin, *Ngāi Tahu*; Stephanie Clare, *Age Concern*; Nicholas Craddock-Henry, *Landcare Research*; Bruce Glavovic, *Massey University*; Shonagh Kenderdine, *Former Environment Court Judge*; Molly Kennedy, *Multi-Cultural Learning and Support Services*; Sally Owen, *Motu Research*; Ryan Paulik, *NIWA*; Rata Rodgers, *Ngāi Tahu*; Sharon Torstonsen, *Social Equity & Wellbeing Network*; and Scott Willis, *Blueskin Energy Ltd.*

## SUMMARY HAIKU

Sea creeps up, storms surge.  
Wet feet look to higher land  
But pause, loving home.

## FOREWORD

This discussion document was developed in draft form as background information for two workshops (making up a “Deep South Dialogue”) hosted by Motu on 17 May and 19 June 2017 as part of the Deep South National Science Challenge. This final document incorporates material from expert presentations made at the dialogue, papers and reports recommended to the writing team, and direct feedback from dialogue attendees.

The six critical research questions at the end of the document emerged from the second Dialogue meeting and formed the basis of a Request for Proposals for research under the Deep South National Science Challenge. Successful projects will be undertaken over 2017-2019.

I would like to thank the Dialogue participants for their insightful contributions, which added immeasurably to the content of this document, and assisted in identifying the knowledge gaps and critical research questions. I also thank the peer reviewers for their helpful comments.

I hope that this document will continue to underpin further research on exposure, vulnerability and resilience for coastal and flood-prone settlements facing a climate-impacted future. *Janet Stephenson (lead author)*



Centre for Sustainability  
Kā Rakahau o Te Ao Tūroa



## EXECUTIVE SUMMARY

Many communities and iwi in coastal and flood-prone locations face an uncertain future because of climate change, with rising sea levels and a greater frequency and magnitude of extreme weather events.

We do not yet have a good understanding of how these long-term changes will affect people in these exposed locations, but we can learn from studies of the impacts of short-run natural hazards such as major floods and earthquakes. It is clear that individuals and households can suffer both directly and indirectly, and stressors even from single events can extend over years. These include significant financial impacts, loss of assets and resources, loss of access to valued places, loss of physical and mental health, and loss of identity and sense of belonging.

Some individuals and groups may be more vulnerable to these impacts, while others may be more resilient. It is not yet clear who will be more vulnerable, nor what kinds of steps need to be taken to build resilience for the long term.

Decision-making institutions such as councils will need to be proactive in working with exposed communities, anticipate the support that may be required, and offer equitable solutions.

Iwi and community members will need to be involved in climate change adaptation processes, and to be in a position to make informed decisions about their future.

Sometimes, people may already be facing financial, physical and mental stresses from impacts such as flooding and erosion, and at the same time may need to be involved in planning for a changing future. The social, cultural and psychological challenges could be immense, so response and adaptation processes need to be carefully designed and delivered, especially for the more vulnerable.

Law and policy need to be adjusted to be fit-for-purpose for the new challenges of climate change, including the roles of government agencies, limiting exposure to hazards, and financing of adaptation.

Knowledge gaps identified include:

- understanding vulnerability and resilience in a climate change context;
- how decision-making roles and responsibilities should be allocated especially in relation to more vulnerable people and communities;
- the extent to which flood mitigation schemes will be effective in protecting communities under climate change conditions;
- how iwi and community groups are already anticipating and responding to climate-related challenges;
- how councils are and should be working proactively to reduce impacts on the more vulnerable; and
- how information about climate change impacts can be more effectively communicated.

## 1. INTRODUCTION

New Zealand, as with the rest of the world, is already experiencing the first impacts of climate change (MfE & Stats NZ, 2017). For New Zealand's low-lying coastal and inland settlements, sea level rise and the increased intensity of storm events will lead to more frequent flooding and ponding, higher groundwater levels, bigger storm surges, higher mean sea level, and erosion of susceptible coastlines. These impacts are predicted to increase in severity over time (RSNZ, 2016).

These hazards are unlike those that Kiwis are used to facing – the occasional storm, flood or earthquake – because climate related hazards will incrementally increase over time, and at times will advance in step-changes. We have time to prepare, but not time to delay. This document outlines how communities may be impacted by climate change, particularly from sea level rise and flooding; how these impacts may be unevenly experienced across communities; and what is needed in order to respond and adapt to the challenges ahead.

People and organisations in exposed locations need to be able to respond effectively to immediate impacts such as flooding or coastal erosion, as well as to plan for and implement adaptations that will be effective in the long term, such as defences or planned retreat. This raises questions about whose role it is to carry out these activities, and how responsibilities will be shared across government and non-government organisations, businesses, households and individuals. It is important



to identify who may be affected, how, and when, and how to prepare community members for future change. Knowledge-sharing and community engagement will be a critical aspect of an effective response: sharing knowledge, communicating climate impacts and involving exposed communities in helping shape discussions about their future. Because of the potential for disruption in peoples' lives, some people and businesses may become more vulnerable, so action to build resilience will be important. Adaptation to climate change should be part of a shared vision for a positive future in which both responsive and anticipatory changes have enduring benefits for people, businesses and communities. We are aware that iwi/ hapū/whānau and Māori communities are developing their own tikanga based practises to responding to climate change. This is as a continuum of their resilience and adaptation to the historical, environmental and political circumstances that have confronted them over the centuries.

This paper has emerged from a dialogue process involving people from community organisations, local and central government, iwi, and researchers from a range of disciplines. This group explored the nature of the issues facing low lying communities, what we already know, and what we could learn through research, particularly focusing on issues for the most vulnerable. This process was used to identify useful research that could be done now as a first step toward informing decisions that allow New Zealanders and New Zealand communities to thrive as they change with our climate.

This document takes a hazards research approach structured around the three concepts of exposure, vulnerability and resilience<sup>1</sup>. To achieve an adequate response to climate change-related hazards, it will be important for decision-makers and stakeholders to be well informed about:

- the exposure of settlements to hazards;
- how to reduce the vulnerability of people, businesses and their assets; and
- how to build resilience.

The diagram in Figure 1 indicates how exposure, vulnerability and resilience are different but linked concepts. The figure is used to help structure the analysis in sections 3-5, and in the identification of research gaps in section 7 of this report.

## 2. TERMINOLOGY: HAZARD, EXPOSURE, VULNERABILITY, RISK AND RESILIENCE

It is common to use terms like hazard and risk as if they mean the same thing. They don't. We define key terms here, so that people reading this document and discussing the issues don't talk past each other.

1. Thank you to a peer reviewer who noted that the adaptation literature would usually begin with a values approach. It would be valuable for future work to apply this alternate approach to the same issue, to extend this discussion.

Figure 1: Exposure, vulnerability and resilience



**Example 1: Displacement – the experience of survivors of Hurricane Katrina, August 2005**

Hurricane Katrina devastated low-lying parts of New Orleans over 23-31 August 2005, flooding impoverished communities and forcing permanent evacuation of many residents. An in-depth study of 73 evacuated residents sought to understand how the lives of the evacuees had changed, and the support provided to them by government, non-profit and community-based organisations.

Poorer survivors who had been moved to new cities typically reported difficulty in redeveloping the social ties, mutual support systems and sense of community they had in New Orleans. They found themselves in a maze of conflicting State and Federal bureaucratic requirements, as well as having to interact with the many government, non-profit and community organisations that attempted to assist them. The support of community-based organisations in the new locality was no replacement for the informal material and social support systems of their original communities (Angel et al., 2012). To avoid scenarios like this in New Zealand, government, iwi, councils, NGOs and communities need to be proactive and well prepared.

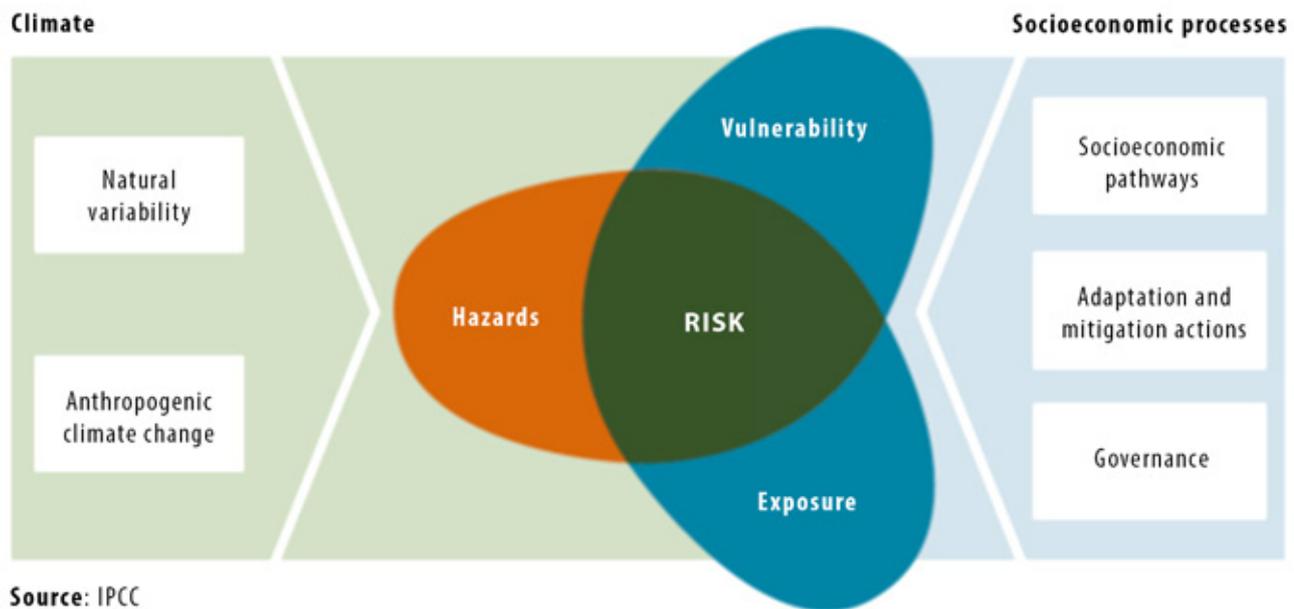
Climate-related hazards include sea level rise and increasing frequency and severity of storm events, leading to greater potential for flooding. This is the focus of this paper.

Exposure refers to the ‘presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected’ (Flood & Lawrence, 2016, p. 2).

Vulnerability is a predisposition to be adversely affected, and refers to ‘the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards’ (UNISDR, 2015, p. 10). It includes ‘sensitivity or susceptibility to harm as well as a lack of capacity to cope and adapt’ (Birkmann, 2006, p. 18). Here we focus on vulnerability of people.

Risk (to individuals or settlements) arises from the interaction of hazards, exposure and vulnerability (Figure 2). The more exposed and vulnerable people are to hazards, the greater the risk.

**Figure 2: Risk as the interaction between hazards, exposure, and vulnerability**



Source: IPCC

Resilience is the capability to cope with, adapt to, recover from, and develop/learn from the demands, challenges and changes encountered before, during, and after an event (Paton, 2007).

It is important to note that people, businesses and communities can be vulnerable and resilient at the same time – vulnerable to some impacts, and resilient to others.

**3. EXPOSURE: CLIMATE CHANGE HAZARDS AND AT-RISK SETTLEMENTS**

New Zealand’s annual average temperature has risen by one degree celsius since 1909, consistent with much of the rest of the world (MfE & Stats NZ, 2017). In the same period, sea levels on our coastlines have risen by up to 22 cm, depending on location (ibid.), and will continue to rise due to the effect of past greenhouse gas (GHG) emissions (RSNZ, 2016). The

### Example 2: Flooding in South Dunedin, 3 June 2015

Higher groundwater levels can increase pressure on drainage systems, thus increasing the chances of water ponding on the ground surface, causing flooding (Hilton, 2010; PCE, 2015; Rekker, 2012). This was observed in South Dunedin in 2015 when a high tide coincided with an extreme rainfall event, flooding an estimated 800 homes (Telfer, 2015) and giving rise to \$28.2 million in insurance claims (ICNZ, 2017). There were also some issues with the ability of the stormwater system to handle the volume of water during the event.

Some households could not return to their dwellings for weeks or months, causing financial and personal distress, and many of the flooded households were already vulnerable based on socio-economic measures: New Zealand's Social Deprivation Index uses a scale of 1-10, where 10 is the most deprived. Most of the lowest lying areas in South Dunedin have social deprivation scores of between 8 and 10 (McKenzie, Stephenson & Orchiston, 2017).

This kind of outcome is likely to be experienced more frequently in exposed settlements as a consequence of severe storm impacts coupled with aging infrastructure. These areas will face ongoing challenges from the impacts of future hazard events, along with the need to plan and find funding for any adaptations required.

severity of future sea level rise depends on the future trajectory of global emissions. Based on the most optimistic scenarios with rapidly falling emissions, the Intergovernmental Panel on Climate Change (IPCC) suggests a minimum of a further 44cm of sea level rise is likely by 2100, but rises of around 1 metre are likely under more realistic scenarios (Church et al., 2013). Sea levels will continue to rise after 2100, and in the longer term, if ice sheets in the Antarctic continue to melt, this could add several metres to global sea levels (RSNZ, 2016).

Other hazards arising from climate change will also increase risks for many of New Zealand's low-lying settlements, both coastal and inland. These include more frequent extreme rainfall events in some regions, more intense storms, and more prolonged and intense westerly winds and thus more frequent and heavier swells. The compound effects of these hazards will increase the likelihood of flooding, coastal erosion, and higher groundwater levels (PCE, 2015).

Low-lying areas near waterways are likely to be particularly exposed because they do not drain well. Low-lying coastal areas have the additional challenge of sea level rise. A recent study (covering only the more populated parts of New Zealand), identified 43,683 homes and 1,448 commercial buildings as being within 1.5m of the present average spring high tide (Bell et al., 2015). However, height above sea level is only one of many factors that will determine the potential exposure of any given location. Other factors include the shape of the coastline and its exposure to swells; the physical makeup of the shore (e.g. rocks, sand dunes); the local hydrology (e.g. waterways and ponding areas); whether the land is sinking or rising; the interplay between sea level rise and ground water (i.e. water table) levels; and the existence of man-made infrastructure (e.g. sea walls, storm water systems) (PCE, 2015). Because of this interplay, some lower-lying areas may be less at risk than others, and some higher areas may be threatened by other hazards such as coastal erosion.

Even a modest increase in sea level rise of a further 10cm will increase the frequency and magnitude of coastal hazard events in New Zealand in future (PCE, 2015; ORC, 2012; Lawrence et al., 2016). Communities located in areas that have multiple risk factors (e.g. coastal erosion and high ground water and flood prone) will be more exposed to impacts (PCE, 2015; ORC, 2012; RSNZ, 2016).



### Example 3: Flooding in Edgecumbe, 6 April 2017

Edgecumbe lies on the Rangataiki River flood plain. The impact of the April 2017 floods are a good example of how some communities will be affected by the increased severity of storm events predicted as a result of climate change. Cyclone Debbie hit the Bay of Plenty coast bringing significant rainfall and a flooded river, resulting in breaching of the aging Rangitaiki stopbank and catastrophic flooding of Edgecumbe. A full evacuation of township's 2000 residents was ordered, and maintained for eight days. Dairy and kiwifruit farms were extensively damaged.

Edgecumbe township has a social deprivation index score of 9, where 10 is the most deprived, and 1 the least. Many families are likely to face a slow and difficult journey to recovery, and the community as a whole now faces an uncertain future. Climate change will 'shift the goalposts' in the extent and frequency of flooding, which may require reconsideration of the town's current location. Local councils have limited options with a low rates-based income and aging flood protection infrastructure.

New Zealand is likely to experience more events like this as the climate continues to change. Communities will need to become more aware of the risks they will face living behind flood protection infrastructure that is aging, and was originally built to deal with less severe events.

### 3.1 Long-term implications for exposed communities

The impacts of sea level rise and its compounding effects with other climate change impacts are already being experienced around the world (Cramer et al., 2014), particularly in island states such as Pacific atolls, coastal cities such as New Orleans, and low-lying regions such as southern Bangladesh. Sea level rise is affecting livelihoods, food security, water quality, culture, identity and traditional systems of governance, and threatens community cohesion (Adger et al., 2013; Islam et al., 2014; McCubbin et al., 2015; Nunn, 2013).

In New Zealand, the effects on exposed communities, businesses and families will range from occasional inconvenience (e.g. temporary ponding on roads), to short term problems (e.g. flooding leading to minor disruption), through to permanent changes which may make some places unusable for their current purposes. Flooding, erosion and higher water tables may eventually make buildings uninhabitable and community facilities unusable, permanently damage roads and other infrastructure, and cause closure of businesses (PCE, 2015; Sweet & Park, 2014). For additional information on climate impacts see Rouse et al (2016). There is likely already a human influence behind New Zealand's extreme flooding events. For example, the risk of an extreme rainfall event over Northland, New Zealand, such as was observed in early July 2014, has likely increased due to the human influence on climate (Rosier et al., 2015).

Climate change-related impacts can affect people in many ways, both in the short and long term, including the following:

**Assets and infrastructure:** Impacts on property can directly affect households and businesses, for example through flooding or landslips. Damage to essential infrastructure such as sewerage or storm water drainage can create unsafe or insanitary conditions (White et al., 2017). Damage to transport infrastructure may make it difficult for people to get to work or school, or may reduce patronage at businesses (Benson & Clay, 2004). Incremental changes over time, such as increasingly high water tables or gradual erosion, may eventually make buildings unsuitable for use and unliveable areas (Neumann et al., 2015).

All of these impacts have financial implications for people who own property as well as those who rent, but will affect them differently. Owners of houses and businesses may find the value of their assets declining and at the same time may need to undertake unanticipated repairs or alterations. More well-off people will be in a position to buy elsewhere, but less wealthy people may find this challenging. If they seek to sell their property they are likely to find that its value has declined. In some cases they may be unable to afford the repairs and end up living in substandard housing.



Tenants may find themselves living in increasingly substandard conditions if landlords see little value in investing in maintenance or upgrades due to the declining value of their asset (Barnett et al., 2015). There is a risk that tenants with little economic power will either stay on as the properties decline in quality, or move in because they are attracted by low rents, thereby increasing the stratification of neighbourhoods.

**Physical and mental health:** People can suffer direct health impacts through injuries from hazard events, and also experience water and food shortages or price increases (Bennett et al., 2014; McKim, 2016). Dampness from flooding or high water tables can lead to cold and mouldy homes, increasing the likelihood of respiratory infections, asthma and rheumatic fever (EHINZ, 2017, Howden-Chapman et al., 2009).

Individuals and families may also be emotionally affected through impacts on their livelihoods (e.g. their businesses, food gathering, or ability to access their employment); the costs of trying to restore their property after hazard events or to protect it from future events; the loss of wellbeing and comfort; and anxiety and uncertainty about future events.

Negative mental health outcomes resulting from the long-term consequences of repeated crises and associated impacts could be significant. For example, the mental health impacts from the 2011 Canterbury earthquakes are still significant six years later, and are placing pressure on Christchurch mental health services. Many Cantabrians still require medical assistance for chronic stress, including post-traumatic stress disorder, depression and anxiety, driven by feelings of uncertainty, insecurity, hyper-vigilance and disturbed sleep (Gluckman, 2011). Individuals' abilities to adapt to these pressures are highly variable, with some social groups more likely to be negatively affected, particularly those with pre-existing vulnerabilities, low incomes or those with a physical health condition (Morgan et al. 2015). Others who coped with initial pressures are now seeking help for the first time after years of repeated crises triggered by the earthquakes (job loss, marriage break-ups, housing issues).

Australian research on a rural population after a decade-long drought found an increase in anxiety and depression, concerns about financial and work-related issues, a loss of hope for the future, and a sense of powerlessness or lack of control (Polain et al., 2011). Where people have to move from their homes they can suffer trauma as a result of leaving familiar surroundings, the breaking of social and cultural bonds, and the challenges of resettlement (Loughry, 2010).

**Loss:** Impacts on culturally valued places and practices (e.g. wahi tapu, mahinga kai, historic places) will affect the people and communities for whom these are an important part of identity and heritage. Some impacts may be felt by much wider populations: for example, if schools or community facilities are temporarily or permanently closed, if people are unable to use recreational facilities and parks, or if beaches and fishing grounds are degraded, it may affect people across the entire town or city. For example, this was found in recent work investigating Whitianga (Blackett et al., 2010). Degradation of the local environment, alterations of natural ecosystems, and loss of valued structures and places can lead to the erosion of long-established bonds between people and place, leading to distress and anxiety (Albrecht et al., 2007; Ageyman et al., 2009).

**Retreat:** Some locations may become unliveable, giving rise to people having to move away, leaving their community behind and moving to new locations (IPCC, 2014b). This may be part of a planned retreat, or may happen incrementally. In either case this can be very challenging for people shifting to new locations and new communities. People moving may lose their local support networks (see Example 1, Hurricane Katrina) and communities receiving them might be unwelcoming of new and different community members. Negative impacts on the receiving environment should also be considered, and the cascading effects of these. It will be important to plan well ahead for the social and economic implications of retreat as well as the plan for potential locations to which people might move.



#### Example 4: Kaikōura earthquake, 14th November 2016

The magnitude 7.8 earthquake in November 2016 resulted in Kaikōura being cut off by road, and left 1200 tourists isolated as well as locals. In the aftermath of the quake, Ngāti Kuri established Takahanga Marae in Kaikōura as a welfare centre. They provided approximately 1200 meals three times a day to stranded Kaikōura residents, emergency response personnel and tourists as well as to their own whānau. Their efforts were supported by Ngāi Tahu (iwi for the majority of the South Island), who flew in supplies and personnel to assist throughout, together with the Red Cross who nominated the marae as a distribution centre for relief efforts. This continued for six days, until all of the evacuees were flown out of the township.

The response by Takahanga marae has been hailed as an exemplar of resilience. Ngāti Kuri are experienced and logistically set up to host large numbers of people on the marae, with large kitchen facilities, dining room and sleeping areas frequently used for tangi, weddings and a range of other gatherings. Their level of preparedness is very high, with large stocks of food and the ability to mobilise their people to support a response quickly and efficiently. Other marae around New Zealand have also been working on their disaster preparedness. For example marae in the Bay of Plenty have produced a Marae Resilience Toolkit (with support from Bay of Plenty Regional Council) to assist with disaster planning and response efforts for communities throughout the region.

### 3.2 The situation to date in New Zealand

Until recently, the consequences of climate change on low-lying areas in New Zealand have been difficult to detect. A number of settlements have experienced impacts that are equivalent to what would be expected with climate change, but given the natural variability of weather patterns and coastal processes it is difficult to prove a direct causal relationship. However it is useful to pay attention to these examples as they represent impacts that are likely to be increasingly experienced in future. These include Granity and Waitara/Urenui where homes are being undermined or swamped by wave action; and major flood events in low-lying south Dunedin (Example 2), Edgumbe (Example 3) and Lower Hutt/Petone (Ramsay, 2006; Wilkinson, 2016; McNeilly & Daly, 2015; Mussen, 2015).

A study of coastal communities at Urenui, Mokau, Marokopa, Muriwai, and the Bay of Plenty that have experienced beach erosion events shows that parks, recreational facilities, housing and community values have been affected (Blackett et al., 2010). Māori communities are concerned about erosion impacts on wahi tapu as well as threats to the long-term liveability of traditional coastal settlements and marae (King et al., 2010; 2012). Archaeological sites are also already being impacted by erosion (Bickler et al., 2013).

Floods are likely to increase in intensity with climate change (MfE & FRRCR, 2008; RSNZ, 2016). A report on future flooding found that most of the government's investment in flood risk management is on the response and recovery phases, and that more investment was needed to effectively manage flood risk and prepare for climate change (MfE & FRRCR, 2008). The report recommended an adaptive management approach that is responsive to change over time and optimises sustainable structural and non-structural solutions as well as emergency management plans. Communities should be well informed about the nature of the risks, and be involved in helping to determine what mitigation measures to adopt and levels of acceptable risk (MfE & FRRCR, 2008). Some places have flood mitigation schemes (including protective structures and provisions to control or limit building in flood plains), but it is unclear whether all existing mitigation schemes are designed to be adaptive to climate change, and whether schemes are being developed for areas that are likely to face increased hazards as a result of climate change.

The future implications of climate-driven hazards for exposed settlements will vary depending on specific hazard and exposure factors such as the physical characteristics of a given location, any locally-specific changes in sea and weather patterns, and the nature of local infrastructure and assets. However even if similar conditions prevail, some communities, businesses, families and individuals may suffer more than others.

## 4. VULNERABILITY: SUSCEPTIBILITY TO IMPACTS

Vulnerability refers to where an individual, a community, a business, and/or their assets are more susceptible to the impacts of exposure to climate-related hazards than others. Reasons for greater vulnerability of individuals or families may include low income, age (e.g. children and elderly), poor health, low quality housing, lack of social connectedness, low levels of education, and under-employment (UNISDR, 2015). Many of these characteristics are captured by New Zealand's Socioeconomic Deprivation Index (SocDep Index), which is an aggregate measure of Census data on employment income,

## DIALOGUE PARTICIPANTS

Dr Janet Stephenson (co lead), *Otago University - Centre for Sustainability*; Dr Suzi Kerr (co lead), *Motu Research*; Dr Caroline Orchiston, *Otago University - Centre for Sustainability*; Leigh McKenzie, *Otago University*; Hannah Tuahine, *Motu Research*; Ryan Paulik, *NIWA*; Carl Walrond, *Parliamentary Commissioner for the Environment*; Maria Bartlett, *Te Rūnanga o Ngāi Tahu*; Christopher Brankin, *Te Rūnanga o Ngāi Tahu*; Rata Rodgers, *Te Rūnanga o Ngāi Tahu*; Nick Orbell, *Dunedin City Council*; Shonagh Kenderdine, *Former Environment Court Judge*; Emma Lemire, *Ministry for the Environment*; Stephanie Clare, *Age Concern*; Scott Willis, *Blueskin Resilient Communities Trust*; Sharon Torstenson, *CASS*; Molly Kennedy, *Migrant Communities*; Dr Bruce Glavovic, *Massey University*; Dr Nicolas Cradock-Henry, *Landcare Research*; Dr Jonathan Boston, *Victoria University*; Dr Wendy Saunders, *GNS Science*; Dr Alex Macmillan, *Otago University*; and Trish Hall (facilitator), *Thought Partners*

income from benefits, levels of employment, qualifications, home ownership, communication, support, living space, and transport. However, just because people have a low ranking in the SocDep Index does not necessarily mean they are more vulnerable to climate change impacts – they may have skills, knowledge, and networks that provide resilience which others lack. Also, there may be other factors that we don't yet understand which further exacerbate vulnerability to climate-related impacts.

Some Māori communities may be disproportionately vulnerable because of their socio-economic characteristics, and heavily exposed because of their reliance on coastal mahinga kai, and the proximity of housing and community infrastructure to active coastal processes such as erosion (King et al., 2010; Smith et al., 2014). There are disparities between Māori and non-Māori in health, education, employment, and housing, and these factors are also likely to increase the sensitivity of Māori society to climate change impacts and risks (Manning et al., 2015; NZIER, 2003; King et al., 2010). Vulnerability will also vary between Māori living in small rural settlements and those who live in regional centres or larger urban areas (Manning et al., 2015). However the strong social bonds and long-established processes for nurturing others in Māori communities may make them more resilient in other ways (see Example 4 – Kaikōura earthquake). There are also likely to be differences in resilience and vulnerability among tangata whenua and Māori living outside their rohe.

Former refugees may be more vulnerable to impacts from climate change related events. Many former refugees have the additional difficulty of language barriers, socioeconomic barriers, and are still in the process of integrating into New Zealand's formal and informal institutional and social structures. This can increase vulnerability during disasters. Communities with former refugees may also be more vulnerable due to previous traumatic experiences. The 2011 Christchurch Earthquakes are an example of how former refugees may be disproportionately affected during disasters. Many of the earthquakes sounded similar to explosions and some of the refugees who had fled war torn nations suffered significant stress and re-traumatization as a result. Conversely, former refugees may be more resilient due to coping mechanisms learnt from experiences of survival, and from strong community networks. In the immediate aftermath of the February 2011 earthquakes, a large number of former refugees used community texting and mobile networks to find out how to get free flights out of the city. This demonstrated an impressive ability to work together as a community and respond quickly to the situation. However, this was both an act of resilience and a demonstration of inability to access accurate information. In many cases, those who fled evacuated houses that were safe to live in and went to destinations which weren't prepared for the evacuees. However, the inaccessibility of information about local safety and services, combined with misinformation (including the Ken Ring 'moon man' predictions reported by media) contributed to the exodus.

All climate impacts on exposed settlements have the potential to be more severely experienced by those who are already vulnerable. The impacts can also make people more vulnerable by increasing the very characteristics that cause vulnerability in the first place, such as ill health, lack of social connections, and financial distress. People who are vulnerable have less capacity to act to reduce their exposure to hazards, and less ability to repair their lives afterwards.

In order to avoid increasing inequities, it is essential to develop strategies that identify the more vulnerable, build their resilience, provide support, and include them in planning for the future. Vulnerability can be reduced in the long term through adaptation strategies that help to redress socio-economic and health disparities, and have ongoing co-benefits, such as improving the quality of housing, reducing dampness, and strengthening social connectedness (Hopkins et al., 2015; McKim, 2016).

At the same time it is important to recognise that people who are vulnerable may also have strengths such as locally-specific knowledge, practical skills, and strong community bonds. Any adaptation response should draw from, support and build such strengths.

In seeking to understand relative vulnerability, a number of international studies have used indicators to define aspects of vulnerability and have mapped this across regions or municipalities. There are not yet any standardised approaches, and



problems to date include the use of subjective variables, lack of transparency, and failure to reflect the dynamism of variables (IPCC, 2014b). In Australia a rapid assessment of socio-economic vulnerability has been developed and tested in an area likely to be increasingly affected by flooding, using a small number of factors that are measured with empirical data (Smith et al., 2016).

## 5. RESILIENCE: RESPONDING POSITIVELY TO STRESSES

Resilience and vulnerability are separate but linked concepts. Resilience is the ability to withstand and/or recover quickly from sudden impacts or long-term stresses, and learning from these events to prepare and adapt to future impacts. Ten years ago, the resilience and disaster literature described vulnerability as a pre-event condition, which was a function of exposure and sensitivity; resilience was considered a responsive action following a shock, in terms of how a system copes and re-organises itself (Cutter et al., 2008). However, resilience is now understood to be: 1) an inherent state (of a person or community) which exists during ‘business as usual’, and 2) an adaptive and responsive process, exercised during a crisis. A third type of resilience can be described as an outcome; for example after the Kaikōura earthquake, the response of the runanga in Kaikoura was described as ‘resilient’ (see Example 4). Importantly, a resilient process or outcome is agile and adaptive, rather than slow and unresponsive.

International research has shown that some groups and individuals have a higher capacity to adapt than others, and are inherently more resilient, which can be seen in their ability to anticipate, absorb and recover from the effects of events (Shaughnessy et al., 2010; Felsenstein & Lichter, 2014).

Personal resilience (compared to community resilience) is shaped by many psychosocial factors which play a role in how individuals perceive risk, and also how capable they feel to cope and respond to crises. These include demographic attributes, social learning (e.g. prior experience of adversity), self-efficacy and locus of control. For example, if people have an internal locus of control they believe they should look after themselves during a crisis, and, coupled with strong self-efficacy, consider themselves to be capable of responding appropriately. In contrast, a person with an external locus of control will believe others are responsible for their safety, and will expect assistance from external parties during a crisis.

Resilience within households is an important component of societal resilience, and is influenced by a range of factors, including financial resources, level of education and health, social connectedness and networks (Deloitte, 2017). A recent report on resilience in New Zealand defined households as ‘people residing together, often – but not always – as a family unit, who have shared resources and an interdependent standard of living’ (ibid. p. 8). Alongside the risks posed by natural hazards, New Zealand households are frequently under pressure in many other areas of their daily lives, including rising costs of housing and food, and job insecurity, all of which have a negative effect on their collective ability to overcome future shocks.

Communities and businesses can also have varying levels of resilience, and respond with greater or lesser belief in their own ability to find solutions and respond effectively. Community resilience is often driven by excellent leadership and social cohesion within the group. The Student Volunteer Army’s response to the February 2011 Christchurch earthquake was generated by a strong leader (Sam Johnson, Young New Zealander of the Year in 2012), uniformity of purpose (the desire to help people affected by the earthquakes), and a strong sense of social connectedness within the University of Canterbury student body. Students came together in their thousands to help remove liquefied silt deposits from streets and gardens across the city.



Resilience is also shaped by the built, socio-ecological, and political environments. This was clearly illustrated by the Edgumbe floods (Example 3) where there was catastrophic stopbank failure. If the flood protection had been engineered differently, and residual risks understood and planned for, the community's resilience would not have been tested to such an extent. However the social and political environments did not provide the level of protection required. Resilience must also be considered in the context of long term sustainability, such that even the most resilient communities may not be sustainable in the long term due to the impact of the rising seas on their communities (Saunders & Becker, 2015).

Resilience can be enhanced by developing readiness (planning and preparedness) and building risk awareness. Communities are stronger and more resilient if they are cohesive and engaged with each other. Households and businesses will be more resilient if causes of vulnerability (e.g. poor housing, low incomes) can be addressed, people are well informed, and have the potential to help shape the decisions that will affect their future. Involving local organisations (e.g. schools, health providers, social services) is also critical as they are important elements of the community as a whole.

Levels of resilience change over time, and also vary from place to place. There are also many different sub-communities within communities, all of which may have different levels of vulnerability and resilience. Care is needed to ensure that a focus on resilience of the community as a whole does not preclude taking action that would benefit vulnerable sections of society.

As well as individual and community impacts, the institutions that support them may also face resilience challenges. If costly response and adaptation is needed in areas with few resources, local governments and non-governmental institutions may be unable to respond effectively. Even if they are able to respond, equity issues may arise if costs are disproportionately borne by some groups, or some groups benefit over others.

A great deal of research has been undertaken on developing resilience to single hazard events (e.g. earthquakes, floods), but resilience to ongoing and increasing stressors such as climate change impacts presents new challenges for research, policy and practice. An effective climate response approach requires dual capability within and among institutions: the ability to deal effectively with more frequent immediate impacts such as flooding or coastal erosion, as well as the ability to plan for and implement adaptations that will be effective in the long term, such as defences or planned retreat.

## 6. ADAPTATION: EFFECTIVE RESPONSES AND RESPONSIBILITIES

### 6.1 Current institutions for addressing climate risk and resilience

Responsibility for responding to sea level rise is largely devolved to local and regional authorities, although the Ministry for the Environment has provided future projections to inform adaptation planning. It recommends consideration of the consequences of a mean sea level rise of 0.8 m by 2100, and an additional allowance of 10 mm per year beyond 2100 (MFE, 2016).

The Resource Management Act 1991 (RMA) is the main Act through which regional and district councils are currently required to consider natural hazards. It requires that adverse effects on the environment arising from human activities are avoided, remedied, or mitigated, and this includes effects from the use of natural resources, exposure to natural hazards, and effects from trying to manage hazards (Reisinger & Lawrence, 2016). Under the RMA, regional councils have an overarching responsibility for "the control of the use of land for the purpose of [...] the avoidance or mitigation of natural hazards" (section 30(1)(c)(iv)), and territorial authorities' functions include "the control of any actual or potential effects of the use, development, or protection of land, including for the purpose of [...] the avoidance or mitigation of natural hazards" (section 31(1)(b)(i)).



Amendments to the RMA in April 2017 mean that the management of significant risks from natural hazards are now a matter of national importance under section 6, and therefore must be considered in all planning processes. However, as yet there is no direction as to the interpretation of “significant risk”. Section 7 of the RMA requires all persons exercising functions and powers under the Act to, amongst other things, have particular regard to the effects of climate change. The New Zealand Coastal Policy Statement (2010) identifies, as one of the key issues facing the coastal environment, “continuing coastal erosion and other natural hazards that will be exacerbated by climate change and which will increasingly threaten existing infrastructure, public access and other coastal values as well as private property”. Objective 5 of the NZCPS is particularly relevant to climate-related hazards, stating: “To ensure that coastal hazard risks taking account of climate change, are managed by:

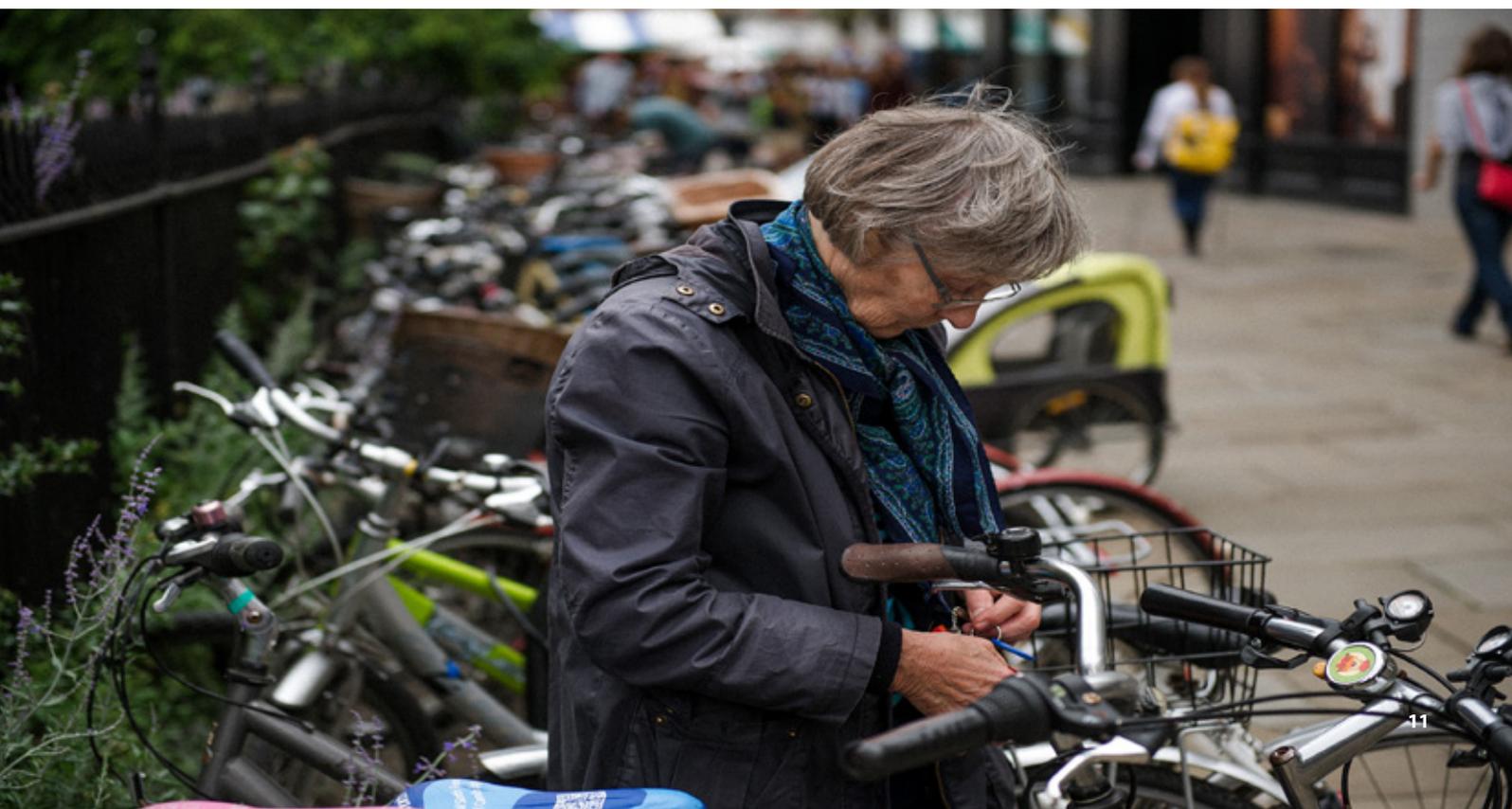
- Locating new development away from areas prone to such risks;
- Considering responses, including managed retreat, for existing development in this situation; and
- Protecting or restoring natural defences to coastal hazards”.

Unlike other planning regimes (e.g. Norway, Mexico, Taiwan (Saunders et al., 2015)), the New Zealand planning framework does not explicitly include vulnerability. The only oblique reference is Policy 25 in the NZCPS on subdivision, use and development in areas of coastal hazard risk: “In areas potentially affected by coastal hazards over at least the next 100 years [...] avoid increasing the risk of social, environmental and economic harm from coastal hazards”. This is not an active requirement to address issues that will be faced by the more vulnerable, or to build resilience, but does not preclude such action.

Regional and territorial local authorities’ functions and powers more broadly are laid out in the Local Government Act 2002. In performing their roles they must have particular regard to the contribution that the avoidance and mitigation of natural hazards makes to their communities (Section 11A(d)). They are guided by a number of principles including that “in taking a sustainable development approach, a local authority should take into account (i) the social, economic, and cultural interests of people and communities; and (ii) the need to maintain and enhance the quality of the environment; and (iii) the reasonably foreseeable needs of future generations” (Section 14(1)(h)). Again, the legislation does not explicitly require local authorities to take an active role in anticipating the implications of climate impacts on the more vulnerable, but at the same time it arguably provides an enabling environment for local authorities to plan for long-term hazards and to be proactive in working with communities for solutions.

Responses to short-term natural disasters are the responsibility of the Ministry of Civil Defence and Emergency Management, who play a coordination role in the welfare of affected people and communities during a disaster response and in the recovery phase alongside partner agencies (e.g. health, emergency services, iwi, social services). Apart from this, the social welfare system is the main support for many of the more vulnerable members of communities, together with (in some instances) support from local authorities and non-governmental organisations.

The Earthquake Commission (EQC) insures private residential property (including services up to 60m from the home) and contents from damage by earthquake, volcanic eruption, hydrothermal activity, landslip, tsunami, or fire caused by natural disaster. EQC land cover extends the range of perils to include storm and flood hazards but excludes coastal erosion. EQC



does not cover damage to residential structures or contents from storm or floods (or coastal erosion). For storm, flooding and landslip damage (most pertinent in light of sea level rise), limited residential land is covered. Land must be under the home or outbuildings (e.g. shed or garage), within eight metres of the home and outbuildings, or under or supporting a main accessway up to 60 metres from the home (excluding driveway surfacing). However, there is an excess of 10% of the amount payable for a land claim, with a minimum of \$500 per dwelling. Furthermore, this insurance is only accessible provided the house is covered for fire insurance (over 90% of private residential homes in New Zealand are estimated to be covered (Owen & Noy, 2017)), and does not cover consequential losses after a disaster (such as theft or vandalism) or the cost of staying elsewhere while work is carried out.

EQC also does not provide renters insurance or business insurance. In this paper we are interested in businesses because of the people relying on them: owners, employees and customers. Businesses affected by natural hazards can sometimes access financial support from their own insurance companies, and in some instances central government may assist in other ways. For example, New Zealand's employee wage subsidies while a business is in recovery have helped employees to delay involuntary job loss following the Christchurch earthquakes (Fabling, Timar & Grimes, 2016).

The implications of climate change for residential insurance have been discussed in another Motu Note (Noy et al., 2017). However, wider questions of other forms of funding and compensation may need to be explored, particularly as many of the more vulnerable may not be in a position to own their own home or to pay standard excesses, and given exposed properties will in time become uninsurable.

For longer-term and slow-onset hazards, new approaches will be required to ensure that responsibilities are clearly demarcated for the multiple societal challenges of climate response. This might include preparedness for more intense hazard events, building greater individual and collective resilience, sharing knowledge about likely climate challenges, and engaging people in planning for long-term adaptation, including those who are more vulnerable.

## 6.2 Insights on effective adaptation from international studies

**Adaptive planning.** The concept of 'adaptation pathways' has recently emerged in an attempt to move decision-making from focusing on near-term issues and incremental responses, to looking at the longer term responses and incorporating the possibility of transformative social change as part of an inclusive adaptation process (Wise et al., 2014). Haasnoot et al., (2013) developed the concept of Dynamic Adaptive Policy Pathways, an approach for planning under conditions of deep uncertainty, which has been adopted and applied to New Zealand to a local decision-making process for flood risk management in New Zealand (Lawrence & Haasnoot, 2017). Pathways planning approaches can assist communities, sector bodies and local government agencies in exploring possible climate futures, and the management and adaptation decisions that may be needed to ensure resilience. Pathways planning has the potential to enhance stakeholders' agency, by providing a structured process to consider a range of possible adaptation options, their suitability, and flexibility under different climate scenarios (Kwakkel et al., 2015).

Such inclusive approaches show some promise for more vulnerable communities, but also have the potential to be most attractive to people with greater agency and self-efficacy (i.e. the less vulnerable), leaving the more vulnerable in a position of having their future determined by others. Additionally, simply involving community members in decision-making may not be the only approach required – it is important to look more widely at the challenges faced by the more vulnerable, acknowledge that they may not necessarily wish or be able to be engaged in future planning, and identify a range of measures that can reduce their vulnerability in the face of climate change.

Another important priority is raising awareness and improving communication and education on climate change adaptation, so that people are aware of risks and the possible approaches to manage those risks (Leal Filho, 2017).

**Maladaptive processes.** Adaptation itself (e.g. policies, processes and investment decisions) can lead to inequitable outcomes if not carefully planned and managed.. For example, adaptation may result in wealth becoming even more concentrated in a few hands, or cause vulnerable people to become more vulnerable. Sovacool et al. (2015) identified four categories of maladaptive processes:

- Enclosure – process that transfers public assets into the hands of profit-driven corporations, or extends the role of such corporations into a public sphere as part of a strategy of wealth accumulation.
- Exclusion – where adaptation projects constrain vulnerable stakeholders from accessing resources that are important to them, or marginalise a particular group of stakeholders in the decision-making process.
- Encroachment – when adaptation interventions intrude or infringe on protected areas, parks, wildlife reserves, or interfere with the healthy functioning of an ecosystem.
- Entrenchment – where adaptation projects aggravate political, socio-economic or cultural inequalities or the disempowerment of disadvantaged groups.

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Decision-making agencies should actively consider whether any maladaptive processes might occur as a result of adaptive actions (e.g. protective structures, planned retreat, re-allocation of red-zoned land, policies). This will require analysis and foresight as to any potential inequitable outcomes, and an understanding of the communities of interest that may be affected.

**Adaptive actions.** Responses to the threat of sea level rise and increased flooding are highly variable across the globe, but many countries are undertaking actions such as building shoreline defences. Others are introducing setback distances from the shoreline for structures, grants for strengthening coastal infrastructure, construction of resilient housing, or land acquisition programmes in at-risk coastal zones. (Mimura et al., 2007; El Raey, 2004). Some states and nations are already implementing forms of managed retreat, including ‘rolling easements’ whereby property enters public ownership as sea level rises (Dyckman et al., 2014; Nettleman et al., 2016). The Netherlands, long known for its hard defences against the sea, is now moving dikes to allow the Rhine River to flood across its historical flood plain, and requiring owners of houses closer than one metre elevation to the a high water mark to sell to the government, which then builds the land higher and allows people to rebuild (Bentley, 2016). New Zealand’s range of adaptive responses is currently largely limited to shoreline defences and setbacks in a few locations, but other options will be required in future. There is some pressure to include sea level rise risk in Land Information Memorandum (LIM) reports for residential housing stock, but this has not yet been implemented.

**Inclusive decision-making processes.** Because of the societal implications of climate-related hazards and any adaptive responses, it is critical that any implications for communities including more vulnerable people and businesses are understood. Most literature encourages the involvement of community stakeholders in helping develop options for the future so that decision-making is better informed and more democratic (for local examples see BRCT, 2014). The UNISDR (2015) Sendai Framework 2015-2030 for global disaster risk reduction states that the responsibility for reduced disaster risk must be shared between local government, the private sector and ‘other stakeholders’. Participatory risk assessments are one way of achieving such collaboration, whereby community members are engaged in learning about, observing and assessing hazards, exposure and vulnerability (Lasco et al., 2008; Asare-Kyei et al., 2015). Other approaches emphasise social learning and adaptive governance, where formal and informal institutions respond and evolve as societal and environmental conditions change, thereby strengthening resilience (Brunner & Lynch, 2013; Nursey-Bray et al., 2016). Some argue that involving vulnerable people in designing and deciding on future options can help build their resilience because it empowers, and also because it is likely to lead to inclusive solutions (Adger et al., 2013). Involving the community plausibly leads to smoother implementation of changing planning approaches. For example, in Blueskin in the Otago region of New Zealand, local residents responded mostly positively to flood-hazard zones proposed by the local council. There had been a great deal of community-led and supported work prior to this, likely a contributing factor.

**Legal issues.** Climate change impacts are quite different from most other hazards because they are slow-onset, incremental, and likely to increase in severity over time, and therefore may require new legal approaches. Sea level rise in particular raises new legal challenges such as the future abandonment or loss of coastal property. An Australian review (Macintosh et al., 2013) identified the range of legal tools and instruments that can be used to influence the spatial distribution and nature of land use and development and hence the exposure of settlements to climate hazards. The seven categories of instruments identified are not limited to traditional land use planning, but offer a broader range of tools that can influence the location and nature of land use and development.

1. Framing instruments – objectives, principles and strategy for state, regional, local policies.
2. Information instruments – communicate information on climate hazard risk to property owners and renters (future and current).
3. Regulatory instruments – legally enforceable restrictions on land use and development for each property. Fixed regulatory instruments include permits, zones and compulsory insurance. Flexible regulatory instruments are for facilitating changes in land use development in response to changing hazards.
4. Compulsory acquisition instruments – the State can acquire property for public work. This can be combined with leasing land back until hazards materialise so that costs to the Government are lowered.
5. Voluntary instruments – positive incentives to control or encourage what and how land use/development is done. Reduce sensitivity and exposure to hazards but do not compel compliance or participation. E.g. financial inducements to mitigate climate hazards, voluntary buy-backs, land swaps, transferable development rights.
6. Taxes and charges – Elevated taxes/council rates on particular land uses in high risk areas. Can also raise funds for adaptation.
7. Liability shield instruments – these can offer exemption (partial or full) from legal liability for particular actions/failing to act in response to climate hazards. This is to prevent people from unjustly pursuing governments for legal compensation when hazards arise.



Each of these will have different implications for people in climate-impacted locations. Policy choices will need to consider how community members may be differentially impacted, in order to avoid inequitable outcomes.

**Governance and financing.** Related to the legal framework, climate change impacts also raise new issues for governance and financing. A strong focus of international literature is on the need to develop new or adjusted forms of governance that suits an adaptive response, and also the need for multi-level governance with clear roles and an integrated approach (Amundsen et al., 2010; Archer et al., 2014). Sources of funds will also need to be accessed to use for adaptation and response to climate impacts. Linnerooth-Bayer and Hochrainer-Stigler (2015) differentiate between low-level risks that can largely be met by risk-reduction measures, and medium level risks that can't be cost-effectively reduced and need to be addressed through risk sharing and risk transfer (e.g. insurance). High-level low-likelihood risks may need to be met by governments or donor organisations.

## 7. IDENTIFYING RESEARCH PRIORITIES

### 7.1 Existing New Zealand research on vulnerability and resilience

Within New Zealand, public sector agencies (particularly local government) have strong awareness and knowledge of the implications of sea level rise (Lawrence et al., 2016), and some are already working with communities on sea level rise issues. However, whether and how they are identifying and addressing vulnerability is unknown. Until recently the private sector has lacked focus on the ways climate change may impact their operations, and little research appears to have been undertaken on business vulnerability, apart from in the primary sector. There appears to be a growing interest in climate change and climate-related risks amongst businesses (e.g. the annual Climate Change and Business Conference).

Land use planning arrangements in New Zealand have traditionally used a likelihood-based approach for natural hazard risk (e.g. a one-in-fifty year likelihood of a flood event of a certain size) (Saunders & Kilvington, 2016). This approach can overlook the consequences associated with hazard events, especially where event frequency and impacts increase over time, thus increasing risk for communities and developments. Saunders and Kilvington (2016) suggest a risk-based planning approach which supports a full assessment of the consequences and likelihoods of future events, and includes a process for engaging and communicating with communities.

A challenge for land-use planning is the definition of acceptable and tolerable/intolerable levels of risk for affected communities, particularly measuring changes in acceptable risk perceptions over time (Saunders & Kilvington, 2016). Kilvington and Saunders (2015) led an innovative approach to public engagement on risk acceptability, and in doing so highlighted the importance of considering community perspectives to inform decision-making. However, the more mentally taxed the brain, the more difficult it is likely to become to make effortful and deliberate decisions (see Kahneman, 2011). For example, groups under significant pressure (such as people already marginalised) might be more prone to hyperbolic discounting, probabilistic and judgemental errors, or other biases that affect decision making (Schilbach et al., 2016). This phenomenon, discussed in behavioural economics, has implications for measuring risk perceptions for the vulnerable. As the impacts of climate change continue, it will be important that communities are well informed about the nature of risks, how they may change over time, and the implications in the short and longer term.

Public engagement is also an important aspect of Living at the Edge, part of the National Science Challenge, Resilience to Nature's Challenges. Decision-making for hazard response can be highly charged, with conflicts already developing in some hotspots in New Zealand. The Edge programme is located in Hawke's Bay, where the research aims to 'enable communities to meaningfully engage, understand and contribute to the resolution of intense conflicts in high-risk locations, especially those exacerbated by changing climate, environment, socio-economic and land-development scenarios'. The Edge programme is a co-creation laboratory, where stakeholder engagement contributes to forming the research agenda, and participatory research methods are used to understand the complexities. The ultimate goal of the programme is to explore 'policy, governance and community transitions' to develop a resilient future for at-risk communities. Most recent efforts have been focused on the Clifton-Tangoio Coastal Hazard Strategy, a collaboration between local and regional governments in the Hawke's Bay.

A systematic review undertaken by McKim (2016) looked at past studies that had implications for policy and management, and tools to support adaptation decision making in New Zealand. She found that much of the recent research effort has focused on governance and institutions, coastal processes, biodiversity, and primary industries. Studies categorised as 'health, well-being and culture' were for the most part on health topics, including equity issues relating to the health impacts of climate change, and the increased vulnerability to health issues of sub-sections of the population such as children, the elderly, and those in poverty (McKim, 2016). Vulnerability issues that were not directly health-related do not appear to be well studied.

Judy Lawrence and others in the Deep South National Science Challenge are currently researching the cascading impacts of climate change, with a particular focus on how different climate change impacts interact, who is affected, where inter-dependencies and co-dependencies occur, and how far impacts might extend across multiple sectors, including businesses.



Two studies carried out by social services agencies in Christchurch after the Canterbury earthquakes also provide rich insight into community vulnerability and resilience and the particular challenges faced by the non profit sector (Council of Social Services in Christchurch (now named the Social Equity and Wellbeing Network/Tuia Te Oranga) 2015).

A different approach to understanding vulnerability has been taken in the economics literature for New Zealand, where several studies have explored the impacts on communities from long lived shocks. For example, Grimes & Young (2011) investigated the effect of mill closures, finding that closures in Patea and Whakatū both experienced negative population and employment impacts. However the effect on Whakatū, which is closer to a city, were temporary, while those in Patea were long-lived. Timar, Grimes & Fabling (2014) compared the pricing of earthquake-related risk following the Canterbury Earthquakes, finding that the price of known construction risk had no statistically significant change after the earthquakes in seismically active or inactive areas. However, they also found that in high seismic risk areas, there was strong evidence of a liquefaction risk discount following the earthquakes, though this only persisted for two years. As discussed earlier, the impacts of policies that aim to reduce the impact of shocks on workers have also been explored. Fabling, Grimes & Timar (2016) conclude that New Zealand’s employee wage subsidies while a business is in recovery have helped employees to delay involuntary job loss following the Christchurch earthquakes.

### 7.2 Identifying knowledge gaps

This review, together with the two dialogue meetings held with stakeholders, revealed a number of areas in which there appear to be knowledge gaps, some of which it is critical to address in the short term in order to achieve a well-functioning system of adaptive response to climate change.

We used Figure 1 to structure the identification of knowledge gaps. The inner parts of the diagram (a, b, and c for each topic) identify high-level topics that have been discussed in the earlier parts of this report and during the dialogue. The table below uses this structure to:

- identify what dialogue participants considered New Zealand needs to know to forge a pathway into this uncertain future (in the left hand column), and
- summarise some potential research topics that could be tackled in the short term (in the right hand column).

Knowledge we would like on Exposure	Research gaps
a. Identification of locations exposed to climate change impacts: <ul style="list-style-type: none"> <li>• Which settlements will be exposed to sea level rise, flooding and other climate change related hazards.</li> <li>• The specific hazards faced by these settlements.</li> </ul>	Mean Sea Level and sea level rise scenarios mapped for more than just main centres.  Mapping for all settlements of potential impacts that will exacerbate with SLR and other climate change impacts – coastal erosion, ponding, flooding, storm surges
b. Implications for risks to people and place: <ul style="list-style-type: none"> <li>• Levels of risk, plausible scenarios and rough time-frames, to support adaptive planning.</li> </ul>	Development of scenarios to develop (adaptable) advice for local authorities and communities as to what to expect.  How are businesses and other organisations (including schools) likely to be affected, and how can we determine which are the more exposed and what support they may require?  To what extent are flood mitigation schemes comprehensive across all exposed areas, and do they allow for incremental climate impacts?
c. Roles and responsibilities: <ul style="list-style-type: none"> <li>• Legal rights and responsibilities;</li> <li>• making law fit for purpose;</li> <li>• financing of adaptation;</li> <li>• any compensation arrangements for losses; and</li> <li>• who is responsible for forward planning in the short and long term (e.g. planned retreat), and for guidance on how and when this should occur.</li> </ul>	What financing arrangements might help to deal with both direct impacts and also to retreat from property? What options are there? What is fair and transparent and will not lead to inequities/gaming etc.?  What adjustments are needed to New Zealand’s regulatory framework?  Is the law able to deal effectively with abandoned or substandard properties resulting from incremental climate related impacts?  Who do New Zealanders think should bear the costs of reducing exposure?  How can we avoid decisions on cost bearing leading to maladaptive responses?



Knowledge we would like on Vulnerability	Research gaps
<p>a. Characteristics of people more vulnerable to impacts:</p> <ul style="list-style-type: none"> <li>How to identify people and businesses who might be expected to be more vulnerable.</li> </ul>	<p>How do we identify people who are likely to be particularly vulnerable to climate-related impacts? Are they likely to just be those who are low in the SocDep index? What other socio-economic indicators might be relevant? Or other indicators?</p> <p>What businesses are likely to be particularly vulnerable?</p> <p>Can we develop methods of assessing and mapping relative vulnerability of families, communities, and businesses in exposed areas of New Zealand, avoiding the weaknesses of existing assessment methods?</p>
<p>b. Implications for health, equity, wellbeing:</p> <ul style="list-style-type: none"> <li>How people might be differently impacted, what those impacts might be, and the long-term implications.</li> <li>How to address these issues both in the short term and the long term (inter-generationally) as some climate impacts will take decades to become severe.</li> <li>How to work with vulnerable people throughout this process to avoid or minimise negative impacts and build resilience, recognising that as climate impacts spread, so will the scope of people impacted.</li> </ul>	<p>What are the impacts on health, equity and wellbeing likely to be and are they different for different groups of vulnerable people (e.g. elderly, young, unemployed etc.)?</p> <p>In what ways are Māori communities more vulnerable and/or more resilient than other communities? Can learnings about this help inform responses more widely?</p> <p>How might home ownership or renting have implications for greater or lesser vulnerability?</p> <p>What are the implications of financial, health and value-related impacts for communities that are already vulnerable?</p> <p>What can be done to anticipate and reduce migration-related vulnerability (for climate-related in-migration and out-migration)?</p>
<p>c. Roles and responsibilities:</p> <ul style="list-style-type: none"> <li>Clarity about roles of agencies in working with people and businesses to minimise vulnerability.</li> <li>Clarity around desired and effective methods of engagement “nothing about us without us”.</li> </ul>	<p>What gaps or shortfalls exist in the current roles and responsibilities of agencies who work with people and businesses affected by climate-related impacts? How could this be improved?</p> <p>What approaches will be effective in engaging people and businesses, including the more vulnerable, in planning for the future?</p> <p>What are the costs, benefits and co-benefits for vulnerable people in engaging in co-designing their future?</p>
Knowledge we would like on Resilience	Research gaps
<p>a. Qualities of resilience to climate impacts:</p> <ul style="list-style-type: none"> <li>A shared understanding of what it means to be resilient to sea level rise, flooding and other climate-related impacts</li> </ul>	<p>What do resilient solutions look like for New Zealand? What is the range of options, and which do New Zealanders feel comfortable with?</p> <p>How do stakeholders currently work together to develop visions for the future and adaptive pathways to get there when facing climate change or other similar situations?</p> <p>With existing New Zealand institutions for addressing climate risk, who will bear the costs associated with protecting those who are vulnerable or who need help becoming resilient?</p>
<p>b. Implications for inclusion and fairness:</p> <ul style="list-style-type: none"> <li>How the process of adaptation can build resilience, including amongst the more vulnerable, and will not create or exacerbate inequities</li> </ul>	<p>How can adaptation planning redress socio-economic and health disparities?</p> <p>How do we ensure that adaptation processes do not exacerbate inequities (e.g. in situations of planned retreat or redevelopment)?</p> <p>How can we ensure that some people are not unfairly disadvantaged over other New Zealanders just because they live in locations that now prove to be exposed?</p>
<p>c. Roles and responsibilities:</p> <ul style="list-style-type: none"> <li>If the current array of agencies and approaches is adequate to build resilience and pursue adaptive pathways</li> </ul>	<p>Do current arrangements create an integrated multi-level set of institutions with a common purpose? Are improvements needed to be fit for purpose?</p> <p>What engagement processes are being used by agencies to include stakeholders (including members of exposed communities) in adaptive planning, and how can these be improved?</p> <p>What support systems will be most effective to assist exposed settlements and vulnerable people and businesses that are impacted by slow onset hazards or may need, in time, to relocate?</p>



### 7.3 Critical research questions

Drawing from the discussion at the Dialogue, six research topics were prioritised as important and possible to address immediately. These topics formed the basis of a Request for Proposals for research under the Deep South National Science Challenge. The research teams that were successful with their proposals will undertake this research over 2017-2019.

**1. Identification of vulnerability:** Some people and communities in areas exposed to climate impacts will be disproportionately affected. What characteristics make them more vulnerable to climate change impacts?

- How will impacts be experienced differently by the more vulnerable?
- What strengths do they also have that will assist in responding to impacts and adapting to climate change?
- What methods are most useful for identifying who the more vulnerable are and where they are located?

**2. Roles and responsibilities:** What are the formal roles of different central and local government institutions in addressing climate change impacts and adaptation for exposed settlements, with a particular focus on protecting vulnerable people and communities?

- What roles have been adopted by other sectors such as the not-for-profit and business sectors?
- What gaps are there amongst these formal and informal institutions for identifying and working with exposed and vulnerable groups?

**3. Preparing for increasing intensity and frequency of flooding:** How are flood mitigation schemes managed in flood-prone settlements?

- Do all flood-prone settlements have schemes in place?
- What is the relationship between mana whenua and flood mitigation schemes?
- Do mitigation schemes incorporate adaptive approaches to flood mitigation?
- Is funding adequate?
- Are flood mitigation schemes sufficient to protect exposed communities from increased flooding due to climate change? Do they include retreat?
- Are affected communities, including the more vulnerable, involved in decision-making regarding mitigation schemes?

**4. What are examples of exposed communities who are influencing good adaptation decisions,** and how can we tell?

- What are communities doing to influence local government decision making?
- What is working well for them?
- Could participatory budgeting or pathways planning help them to guide local government?
- What are some new ideas which could help local communities in this space?

**5. When local governments are planning climate change adaptation,** how can they best focus on reducing impacts on vulnerable people and communities?

- What are existing examples of exposed local authorities who are doing this? Are they actively engaging vulnerable communities or their spokespeople? If so, how?
- How can we evaluate the effectiveness of engaging with vulnerable people and communities as a method of reducing impacts on them?



**6. How can information about climate change impacts and adaptation be most effectively communicated** in a way that facilitates positive attitudes and constructive decisions?

- Which international examples of effective education campaigns would be applicable to New Zealand?
- Could new stories be created to communicate how people have previously handled similar changes in positive ways (e.g. drawing on Kupu tuku iho (and pūrākau Māori) about communities moving over time)?
- To what extent are different communication methods needed for different individuals, organisations and communities?

## 8. CONCLUSION

Climate change is increasing the likelihood of hazards such as coastal erosion, rising water tables and flooding. It will also mean significant challenges for the communities that are exposed to these hazards. They will need to be able to be resilient to hazard events as they arise, and also plan for a changing future at a time when they may be facing financial and personal stresses from those events. The social, cultural and psychological challenges (particularly for the vulnerable in these exposed communities) could be immense unless response and adaptation processes are carefully designed and underpinned by sound information. New Zealand can learn from approaches being developed internationally, but there remain many questions which are unique to New Zealand.

Primary foci for future research include

- identifying who might be disproportionately affected, and what characteristics make them more vulnerable to climate change impacts, and
- better understanding how our institutions for addressing climate change impacts and adaptation could focus on protecting vulnerable people and communities.

Future research is also recommended in:

- understanding flood mitigation schemes and their provisions for the most vulnerable,
- identifying examples of exposed communities who are influencing good adaptation decisions,
- understanding how local governments' planning climate change adaptation can focus on reducing impacts on vulnerable people and communities, and
- how information about climate change impacts and adaptation can be most effectively communicated to facilitate positive attitudes and constructive decisions.

We hope that future research projects will be developed and supported to address these important issues.

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