Social vulnerability indicators for flooding in Aotearoa New Zealand:

Research report

2019

Report prepared for the
Natural Hazards Research Platform

Environmental Health Indicators Programme
Massey University – Wellington

Acknowledgements

These social vulnerability indicators for flooding were developed by the Environmental Health Indicators team, at Massey University (Wellington), New Zealand. The project team includes Kylie Mason, Kirstin Lindberg, Carolin Haenfling, Allan Schori, Helene Marsters, Barry Borman and Deborah Read. Our collaborators on the project include Ben Popovich (NIWA), Kristie-Lee Thomas (GNS Science), Rawiri Faulkner (Tūtaiao Ltd), and James Beban and Sarah Gunnell (Urban Edge Planning Ltd). We thank our collaborators for their valuable input into this project, and their contribution to writing this report.

We would like to thank the support and time given from our stakeholders to help with the project, including Jennifer Rizzi, Whetū Bennett, and Renee Corlett (Wellington Region Emergency Management Office), Tom Kent and Jonathan Jull (Ministry for Civil Defence & Emergency Management), Robyn Steel, Wendy Barry and Stephanie Watkins (Porirua City Council), Jill McKenzie and Marie Gibson (Regional Public Health), Greg Phillips (Capital & Coast DHB), and Ray Rodrigo (Tū Ora Compass Health PHO).

The research team partnered with Ngāti Toa Rangatira to develop, implement and deliver this social vulnerability indicators research project. We thank the people of Ngāti Toa Rangatira, and particularly the community around Takapūwāhia Marae, for their support and input into this project. Tenei te mihi nunui ki a koutou kātoa.

Thank-you to Kristie-Lee Thomas (GNS Science) and Tom Kent and Jonathan Jull (Ministry of Civil Defence & Emergency Management) for peer-reviewing this report. We also thank our stakeholder group for providing feedback on earlier content of this report, particularly Jill McKenzie (Regional Public Health).

We would like to thank Porirua City Council, Wellington Water, and Statistics New Zealand for providing data for this project.

We would like to thank the Natural Hazards Research Platform for the funding of this project.

Publication details

Suggested citation: Mason KM, Lindberg K, Haenfling C, Schori A, Thomas KL, Popovich B, Faulkner R, Beban JG, Gunnell S, Marsters H, Read D, Borman B. 2019. *Social vulnerability indicators for flooding in Aotearoa New Zealand: Research report.* Wellington: Environmental Health Indicators Programme, Massey University.

Published in October 2019 by Environmental Health Indicators Programme, Massey University – Wellington, PO Box 756, Wellington 6140, New Zealand.

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For more information about this project, see the Environmental Health Indicators (EHI) website: www.ehinz.ac.nz/our-projects/social-vulnerability-indicators

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Executive Summary

This research report presents the methodology and rationale used to develop a set of social vulnerability indicators relating to flood hazards in Aotearoa New Zealand. ‘Social vulnerability’ refers to population groups who may be vulnerable to adverse impacts of a disaster on their health and wellbeing, due to pre-existing conditions, socio-demographic characteristics and circumstances.

Social vulnerability indicators are used to identify potentially vulnerable populations who are likely to be more affected by a natural hazard, and less able to anticipate, cope with, and recover from that hazard. Understanding vulnerabilities in the population can help to improve resilience through informing emergency planning and preparedness, response and recovery activities, and through risk reduction activities such as land use planning. This information is particularly valuable for people involved in disaster risk reduction to understand the risk and potential impacts of disaster on our communities. Information about social vulnerability can help inform risk reduction, readiness, response and recovery activities that address the diverse needs of the population, and ultimately reduce the risk of harm to people’s health and wellbeing.

The specific aims of this project were to:

1. develop a set of social vulnerability indicators for flooding for Aotearoa New Zealand
2. identify populations vulnerable to flooding and essential facilities and infrastructure within flood zones, in a case study using the area covered by Porirua City Council
3. implement the social vulnerability indicator data into the risk modelling software RiskScape, co-developed by NIWA and GNS Science
4. develop guidelines on how to incorporate consideration of vulnerable population groups into emergency management and land use planning.

This study focussed on flood hazard, as it is one of New Zealand’s most frequent and costly natural hazards. Flooding can have a range of impacts on people’s health and wellbeing, both during and after the event. About two-thirds of the New Zealand population live in flood-prone areas, which includes many of New Zealand’s main towns and cities. Climate change is expected to increase the intensity and frequency of flooding in New Zealand, due to more heavy-rainfall days and sea-level rise reducing the ability of floodwaters to drain to the sea.

This project used an established indicator development process to develop social vulnerability indicators for flooding. This process had three phases: a scoping phase (understanding the issue and user needs), a selection phase (creating a conceptual framework, understanding causal relationships, and identifying and evaluating potential indicators), and a design and implementation phase.

The project included a case study covering the area and population of Porirua City Council, Wellington. The case study involved stakeholder engagement and participation, to develop, test, and trial the indicator set and outputs, and identify ways in which the indicators might be used. The stakeholder group included representatives from the Wellington Region Emergency Management Office (WREMO), Porirua City Council, Regional Public Health, Tū Ora Compass Health Primary Health Organisation, Capital & Coast District Health Board, Ngāti Toa Rangatira, the Ministry of Civil Defence & Emergency Management, GNS Science, and NIWA.

This project also contributes to the Mātauranga and Taiao themes of Vision Mātauranga, through exploring the distinctive Māori approach to hazard vulnerability, including flooding, and the contribution it can make to policy, planning and community outcomes.

Understanding social vulnerability to flooding

We developed a conceptual framework for understanding social vulnerability to flooding specific to New Zealand, derived from four existing international and New Zealand frameworks and models:

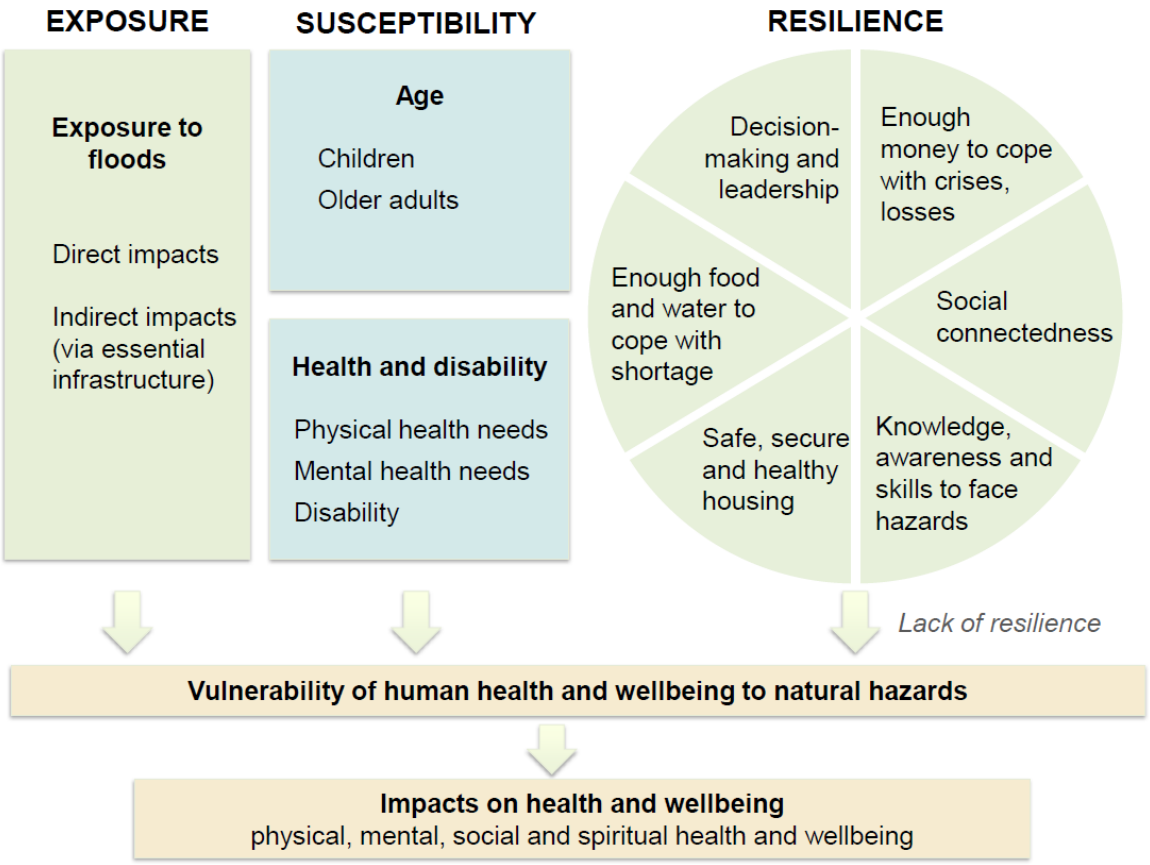
- MOVE (Methods for the Improvement of Vulnerability Assessment in Europe) framework (Birkmann et al 2013)
- circle of resilience (Wisner et al 2012)
- climate change and health conceptual model (USGCRP 2016)
- the Māori model of health and wellbeing, Te whare tapa whā (Durie 1985).

Figure 1 presents the conceptual framework that we developed, by combining the above frameworks into one. The framework defines the three main components of vulnerability as:

- Exposure (being exposed to the hazard)
- Susceptibility (being more susceptible or sensitive to the impacts of the hazard)
- Lack of resilience (determined by the capacity to anticipate, cope and recover).

For this conceptual framework, health and wellbeing were defined broadly as physical, mental, social and spiritual health and wellbeing, in line with Māori models of health.

Figure 1: Conceptual framework for social vulnerability to flooding in New Zealand



Social vulnerability indicators

Based on the conceptual framework, we identified the specific reasons for vulnerability in each dimension of social vulnerability, and from this, we identified potential indicators and data sources. Indicators were selected based on the strength of causal associations/rationale, availability of data, evaluation of the indicators against indicator selection criteria, and testing of the indicators with the Porirua case study. As part of the indicator selection process, we worked with stakeholders to identify potential uses for the indicators; these potential uses of the indicators were then also used to inform the final indicator selection.

Our final set of social vulnerability indicators for flooding in New Zealand is presented in Table 1. This table shows the different dimensions of social vulnerability, the rationale for each dimension, and the final indicators within each dimension. Data for these indicators are available in a national indicator dataset, at the territorial authority, area unit, and meshblock level (where possible).

Table 1: Final set of social vulnerability indicators for flooding in New Zealand

Social vulnerability dimension	**Rationale**	**Social vulnerability indicators**
Exposure (direct)	People who live in flood hazard zones are at higher risk of experiencing adverse impacts from floods. Additionally, people working, studying, or spending time in flood hazard zones may also be affected.	People usually resident in an area Households in an area
Exposure (indirect)	Flooding can indirectly affect people through exposure to impacts on essential lifeline infrastructure and services, including road networks, public transportation, emergency services, electricity, water, gas, telecommunications, fuel supplies and contamination.	People who commute outside of the area People who use public transport to get to work People living in rural or remote communities * Households reliant on electricity for heating
Children	Children are more susceptible to the health impacts of flooding, including drowning, infections and gastrointestinal illness. They are also dependent on adult caregivers to keep them safe, and to move them out of harm's way.	Children aged 0-4 years Children aged 0-14 years Households with at least one child aged 0-4 years Households with at least one child aged 0-14 years Households with at least one child aged 5-16 years Households with at least one child aged 0-16 years
Older adults	Older adults tend to be less mobile, more likely to have hearing and/or vision loss, and are more likely to require more assistance to evacuate and/or clean-up. They have higher prevalence of pre-existing health conditions. They may also have limited social networks and be socially isolated, particularly if they live alone.	Older adults aged 65+ years Older adults aged 75+ years Older adults aged 85+ years Households with an older adult (65+ years) living alone
Physical health needs	People with pre-existing health conditions are more susceptible to health impacts (such as heart attacks) from flooding, due to excess activity from evacuation and clean-up activities, stress, and lack of access to medication and/or essential health services. A lack of access to healthcare services and/or essential medication is likely to have an adverse impact on these people.	Pregnant women * People with a pre-existing health condition (including heart disease, diabetes, respiratory conditions, immunosuppression) * People requiring essential medications or health services (such as angina medication, insulin, inhalers, epilepsy medication, immunosuppressant drugs, anti-HIV drugs, dialysis, home oxygen therapy)
Mental health needs	People with mental health issues are more susceptible to the impacts of flooding, as they may have more difficulties in coping with the stress of flooding. Additionally, people taking medication for mental health conditions are more susceptible to adverse effects, if they do not have access to medication or health services. People with substance abuse problems are at higher risk of increased substance use due to stress.	People with a psychological or psychiatric impairment * People accessing mental health services in the past year * People requiring essential medication for mental illness (anti-depressants, anti-anxiety medication, anti-psychotics, opioid substitution treatment)
Disability	People who are restricted in daily activities by a physical, learning or mental disability are more susceptible to the impacts	People with a disability

Social vulnerability dimension	Rationale	Social vulnerability indicators
	of a flood. They may have difficulties in evacuating, moving, and/or understanding instructions, and they are more likely to be dependent on caregivers to help them.	People with a physical disability People with a hearing disability People with a vision disability People with a psychological or psychiatric impairment
Having enough money to cope with crises/losses	People or households with low income often do not have the money to protect themselves from flooding (through insurance, flood protection materials or works, or having sufficient emergency food and supplies). After a flood, recovery can take a long time for these people, and they may end up staying in damp and mouldy houses through an inability to find other accommodation. Financial stress can also lead to mental health impacts.	Socioeconomic deprivation (NZDep2013) Single-parent households Unemployed people People who are not in the labour force People with minimal education Households with no access to car People working in the primary industries * People living in low-income households
Social connectedness	Having strong social connections, networks and kinship ties can be very beneficial for coping during and after a natural hazard. By contrast, social isolation is an important aspect of vulnerability for people, as it means that people may not have others to help them if needed, including for evacuation, and clean-up.	People who are new to the neighbourhood (within the previous year) Households with an older adult (65+ years) living alone Single-parent households Single-person households Households living in rental housing Neighbourhoods with fewer households with children Recent immigrants
Knowledge, skills, and awareness of natural hazards	Understanding information is important for being able to prepare, understand early warnings, know where to evacuate to, and how to cope and access services after an emergency. People who have limited proficiency in English, or who are new to the country, may have difficulties. Additionally, a lack of awareness is an important cause of vulnerability to flooding. People who are new to the area, or who are tourists, are also vulnerable.	People who are new to the neighbourhood (within the previous year) Households with no access to the internet Households with no access to a mobile phone Households with no access to a telephone People with limited English proficiency Recent immigrants
Safe, secure and healthy housing	Housing quality and safety can have a significant impact on people's vulnerability, through quality of building construction, floor heights not being above floodwater levels, and overcrowding. People living in rental housing are at risk of having a lack of housing after a flood if the owners need to do repairs. Homeless people are particularly vulnerable. Emergency shelters are also important in a community; for example, marae have played this important role in previous disasters in New Zealand.	Households living in rental housing Crowded households People living in crowded households People who are homeless or severely housing deprived
Enough food and water (and other essentials) to survive	Having enough food and water is essential for survival. Floods can affect the ability to produce food from the land, particularly in rural areas and/or isolated communities. Food insecurity (a lack of access to safe, nutritious and affordable food) pre-disaster can increase the risk of people not having sufficient food after a disaster. Having access to safe drinking water is also important for protecting health and wellbeing.	*Proxy indicators for not meeting emergency preparedness guidelines and/or being food insecure:* Households living in rental housing Single-parent households Socioeconomic deprivation * People living in low-income households
Decision-making and leadership	Decision-making and leadership (including flexible decision-making, access to decision-makers, self-efficacy and autonomy) play an important role in resilience. People without access to decision-makers or involvement in decision-making are likely to be left out of the process, and not have their needs listened to or fully met.	Level of voting participation in the community ** Inclusion of local iwi and hapū in civil defence emergency management response and recovery planning ** Inclusion of population groups with vulnerabilities in civil defence emergency management response and recovery planning

Social vulnerability dimension	Rationale	Social vulnerability indicators
Other individual-level factors of social vulnerability	Other factors that may increase vulnerability include being a healthcare worker and/or first responder (who are at higher risk of psychosocial impacts), people who own or are responsible for animals, people who have previously experienced domestic violence (as this is one of the main contributors to experiencing domestic violence again after a natural hazard), and people in institutions (who rely on others to look after them).	Healthcare workers and first responders Households with a healthcare worker and/or first responder Registered dog owners Registered dogs

* Still to be developed; these indicators are needed for reflecting the conceptual framework, but are yet to be implemented.

** Requires local data; these indicators are needed for reflecting the conceptual framework, but require assessment in a local context.

Point locations

To complement the social vulnerability indicators, we also identified point locations that are important to include when assessing local social vulnerability. These point locations are particularly useful to interpret in the context of flood hazard zones, to understand flooding risk. These point locations may relate to both resilience and vulnerability; for example, schools have a vulnerable population (children), but are also an important community network and may act as Civil Defence Centres during disasters.

Point locations associated with vulnerability and/or resilience include:

- schools and early childhood education centres (ECEs)
- rest homes and retirement villages
- marae
- Civil Defence Centres and Community-Led Centres (these are often schools and/or marae)
- emergency services facilities
- hospitals
- primary health care centres
- pharmacies
- justice facilities and youth justice facilities
- child care and protection facilities
- residential and respite care facilities for people with disabilities
- visitor accommodation
- temporary housing (such as boarding houses)
- social housing
- food stores and food banks
- emergency water supplies (such as community emergency water tanks)
- houses and buildings on Māori land.

Additional supporting information

The indicators in the national dataset are a starting point for understanding social vulnerability in an area. The indicators work best when they are combined with local knowledge and expertise. We identified a range of additional information that could be included in a local social vulnerability assessment. This additional information includes:

- flood hazard information
- additional potential indicators using local data sources
- information about the population and societal context
- information about the environmental and institutional context
- potential future vulnerability relating to climate change.

Outputs from this project

The outputs from this project include:

- indicator datasets
    - a national dataset of social vulnerability indicators (and supporting population demographic data) in Excel, by territorial authority, area unit and meshblock (where possible)
    - a heatmap, showing a visual summary of the indicators at a glance for area units in each territorial authority, as well as a summary table of indicators by territorial authority
    - spatial datasets (shapefiles) with the indicator data
- case study for Porirua
    - an online interactive map (Story Map) for the case study area of Porirua, to show how the indicators can be used in practice for flooding
    - a case study document, with static maps of the social vulnerability indicators for Porirua, at the area unit level
- RiskScape resource layer
    - inclusion of social vulnerability indicators into a resource layer in RiskScape
    - a tutorial for how to use the social vulnerability resource layer in RiskScape 2.0 (command-line interface)
- indicator toolkit and guidance for end-users
    - a toolkit document explaining the indicators, how to assess social vulnerability, and presenting potential uses of the indicators
    - a document identifying, for each social vulnerability dimension, the rationale for vulnerability, indicators and other potential data sources, examples of how to use the indicators, and case studies from around New Zealand
    - a factsheet explaining health impacts from flooding
- land use planning guidance
    - a document identifying ways of including social vulnerability indicators into land use planning and local government processes, including through District Plans.

For access to these resources, see the Environmental Health Indicators website: www.ehinz.ac.nz/our-projects/social-vulnerability-indicators

Potential uses for the social vulnerability indicators

Key end-users for these social vulnerability indicators include:

- civil defence emergency management (CDEM) groups and CDEM staff in local and regional councils
- Ministry for Civil Defence & Emergency Management (MCDEM)
- local and regional councils, including land use policy planners, infrastructure managers, and decision-makers
- emergency planners in the health sector (including district health boards, primary health organisations, and ambulance services)
- public health units and District Health Boards
- Māori iwi, hapū and marae

- the housing sector (particularly social housing providers)
- the education sector (particularly schools and ECEs)
- lifeline organisations (such as water, electricity and communications)
- non-governmental organisations likely to be part of disaster response efforts (such as Red Cross)
- RiskScape users and disaster risk reduction scientists
- local community groups (including ethnic and cultural communities, and groups concerned with health, wellbeing and disaster response).

From working with our stakeholders, we identified several general ideas for how end-users could use the social vulnerability indicators. The social vulnerability indicators, framework and interactive maps can help to:

- provide a structured way of thinking about and understanding social vulnerability to natural hazards
- initiate further data-gathering at the local level, and spark discussion at the local level
- contribute to the development of shared situational awareness during a response, by contributing in a way that crosses the whole CDEM response (Welfare, Operations, Logistics, Intelligence and other functions)
- target and prioritise emergency management efforts, to ensure the best use of resources and prove the best available support to the community
- provide an objective measure of social vulnerability, to inform forward-planning for response work, and to support equitable outcomes in emergency preparedness, planning, response and recovery
- stimulate preparedness planning for individuals, businesses, health services, welfare networks, marae, educational facilities, aged care facilities, and government agencies
- provide evidence to support other important risk reduction strategies, including infrastructure upgrades and hazard mitigation works, and addressing underlying drivers of vulnerability (such as housing quality).

Additionally, land use planning has a key role to play in reducing exposure and susceptibility to natural hazards, by managing the location and design of land use activities. A number of mechanisms are available to land use planners through the Resource Management Act 1991 (RMA), including:

- restriction of development in areas subject to natural hazards, either by reducing existing risk (eg managed retreat), avoiding future development, or mitigating the potential effects (eg raised floor levels in areas of flood inundation)
- restricting the location of critical buildings (eg hospitals) and vulnerable land uses (eg early childhood education facilities, schools, rest homes) in areas subject to natural hazards
- protection of natural flood buffers during the planning process (eg requiring esplanade strips to protect riparian margins under section229(a)(v) of the RMA)
- requiring urban design that promotes resilience (eg connectivity of routes for evacuation, installation of emergency rainwater tanks, communal open space areas to encourage social connectedness)
- recovery planning to promote resilience in rebuilding after an event has occurred

- ensuring policies facilitate emergency/temporary housing solutions, for example at schools, marae and public places.

Social vulnerability indicators can also be incorporated into land use planning through consideration of vulnerable land use activities (such as schools, early childhood education facilities and aged care facilities). We identified two potential methods for including social vulnerability into District Plans, using adaptations to the risk-based planning approach to natural hazards previously developed by Saunders et al (2013). Social vulnerability information could also be used in local council plans, policies and strategies to inform decision-making, particularly around infrastructure upgrades and hazard mitigation.

Implications for New Zealand

This project provides valuable information to support the approach of the new National Disaster Resilience Strategy, in particular by helping to understand risk and population vulnerability to natural hazards. This project has produced the first nationally-available dataset of social vulnerability indicators for New Zealand at the territorial authority, area unit and meshblock level (where possible). This dataset will allow all regions across New Zealand to access and explore their own data. In this way, this project provides an important advancement, by providing New Zealand with a tangible dataset to quantify potential social impacts of natural hazards, which will provide those involved in disaster risk reduction with risk information to help make informed decisions.

Additionally, this project supports the central theme of the National Disaster Resilience Strategy, that *we all have a role to play in a disaster resilient nation*. We identified that, in addition to the CDEM sector, the health sector and housing sector (particularly social housing) also play an important role in reducing vulnerability to natural hazards. This project also identified how local government processes could be used to address social vulnerability, through including consideration of social vulnerability in District Plans and other local government processes. This provides an important pathway forward for risk reduction in New Zealand, in particular through land use planning.

Finally, this work has highlighted the critical strengths that Māori, and Te Ao Māori, bring to resilience to natural hazards in New Zealand, in particular through marae, social connectedness, Māori cultural values and practices, and existing leadership structures. However, Māori also face unique challenges, such as the location of marae and houses on Māori land in flood hazard zones.

Recommendations for future work

These social vulnerability indicators could be extended in the future in a number of ways, including: updating indicators with up-to-date data (including from the 2018 Census), implementing proposed health indicators, implementing indicators for the Māori population, investigating multiple vulnerabilities, creating interactive Story Maps for the whole of New Zealand, and broadening the applicability of the indicators to other natural hazards (including others relevant to climate change).

Conclusion

This project has successfully developed a set of social vulnerability indicators for flooding in New Zealand, and met the research objectives. We have produced a set of indicators for the whole country, as well as identifying additional information that could be included at a local level, to enhance understanding of local vulnerability and resilience. The indicators are built on the foundations of a solid conceptual framework, which takes into account the interplay between social vulnerability and resilience, multiple aspects of resilience, and a Māori perspective on health and

wellbeing. The indicator toolkit, data outputs and case study outputs (including the interactive Story Map) will help end-users to be able to access and use the indicators, to help reduce vulnerability to flooding in their local area. The results of this study highlight the importance of considering social vulnerability in order to inform emergency preparedness, resilience-building, and risk reduction activities in New Zealand.

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1. Introduction

Summary

- This project aimed to develop a set of social vulnerability indicators for flooding in Aotearoa New Zealand. This research report describes the process we went through, and the rationale used, to develop the indicators.
- In particular, this report describes the following activities that we carried out:
  - following a robust indicator development process
  - developing a conceptual framework for understanding social vulnerability to flooding
  - developing a set of social vulnerability indicators
  - testing the indicators using a case study of Porirua, Wellington
  - implementing the social vulnerability indicator resource layer into RiskScape
  - developing guidelines on how to incorporate social vulnerability into emergency management and land use planning.
- The outputs from this project will be useful for a range of end-users, including CDEM groups, local and regional councils, the health sector (particularly emergency planners at District Health Boards and Primary Health Organisations), Māori iwi/hapū, the housing sector, the education sector, and local community groups.

Aim of this document

This research report presents the methodology and rationale used to develop a set of social vulnerability indicators for flooding for Aotearoa New Zealand, and describes the main outputs of the study.

This report summarises the development process for the indicators. This includes the approach, assumptions, and thinking that informed the indicator selection. We provide our rationale for selecting the specific indicators included in the final set. We also provide suggestions for additional data sources and indicators that could be considered in a social vulnerability assessment.

Overview of this project

Project summary

The aim of this project was to develop a set of social vulnerability indicators for flooding in New Zealand. These indicators will help identify, at the small-area (meshblock and/or area unit) level, people who are most at-risk of experiencing adverse impacts on their health and wellbeing during, and after, a flood.

Flooding is the focus of this project, as it is one of the most frequent and costly natural hazards in New Zealand, and is expected to become more frequent and severe as a result of climate change (Royal Society of New Zealand 2016). This study used the area covered by Porirua City Council as a case study to test the application of the indicators.

We also identified ways that social vulnerability indicators can be used by end-users (including policy-makers, decision-makers, local councils, and civil defence and emergency management (CDEM)) to reduce the negative social impacts of flood events, and to be better prepared and more responsive to people's needs in a flood. We have produced guidelines and a toolkit to help end-users to use this information.

Rationale and background

Social vulnerability indicators are used to identify vulnerable populations who are likely to be more affected by natural hazards, and less able to cope or adapt to a hazard (Cutter 1996). While there is no universal definition of social vulnerability, it broadly refers to pre-existing conditions, characteristics or risk factors of the population that affect their ability to prepare for, respond to, and recover from hazard events (Cutter et al., 2003).

Measuring social vulnerability can help us to understand the potential for loss, and the vulnerabilities that communities face towards natural hazards, to then address these needs to reduce the risk. While a number of social vulnerability indicator sets have been developed previously (Atyia Martin 2015, Birkmann et al 2013, Cutter 1996, Cutter et al 2003, Flanagan et al 2011, Rasch 2016, Tapsell et al 2002), no indicator set exists specifically for flooding in New Zealand. Kwok (2016) identified a set of potential social vulnerability indicators for earthquakes, and Khan (2012) compared different approaches for measuring social vulnerability to flooding. Additionally, indicators or indices have been developed for socioeconomic deprivation (NZDep2013) (Atkinson et al 2014), social fragmentation (Ivory et al 2012) and resilience (New Zealand Resilience Index) (Stevenson et al 2018). The NZDep2001 has been tested as a vulnerability index for natural hazards in New Zealand (Paton et al 2006). Additionally, some New Zealand studies have identified theoretical factors relating to social vulnerability, resilience, and social capital using qualitative methods (Kwok et al 2019, Kwok et al 2016, Kwok et al 2018). However, no indicator dataset has been developed or produced to assess social vulnerability to flooding, to identify people who are most at-risk of experiencing adverse impacts on their health and wellbeing during and after a flood.

The social vulnerability indicators will provide an important quantitative base of information to inform CDEM Group Welfare Plans, as well as local welfare plans, and the risk assessment that CDEM groups need to include in their CDEM Group Plan. Additionally, this project gives guidance and examples of how social vulnerability indicators can be applied in land use planning and the civil defence sector, to reduce exposure to flooding, and the risk of adverse impacts, for more vulnerable groups.

This work also helps contribute to meeting New Zealand's commitments under the Sendai Framework for Disaster Risk Reduction. While this project focuses on flooding, this work on social vulnerability indicators is also likely to be relevant to other natural hazards.

Key aims and outputs

The specific aims of the project were to:

- develop social vulnerability indicators for flooding
- identify populations vulnerable to flooding and important facilities and infrastructure within flood zones, in a case study using the area covered by Porirua City Council
- investigate the implementation of the social vulnerability indicator data into Riskscape, a national research programme co-developed by NIWA and GNS Science that assesses

potential impacts of natural hazards on our communities to inform risk-based disaster risk reduction decision-making
- develop guidelines on how to use social vulnerability indicators in emergency management and land use planning.

In addition to this research report, the outputs of our project include:
- a list of social vulnerability indicators for flooding in New Zealand
- indicator data for New Zealand, available in Excel and shapefile formats
- a case study for Porirua, including online mapping tool for exploring the social vulnerability indicators for Porirua
- integration of social vulnerability indicators into RiskScape
- a toolkit for users, about the social vulnerability indicators and how to implement and use the indicators at a local level
- guidance for land use planners on how to include consideration of social vulnerability into District Plans and local government processes.

This project ultimately aims to contribute to reducing the negative impacts of flooding on the physical, mental and social health and wellbeing of all New Zealanders, particularly the more vulnerable in society and those with diverse needs.

Working with key stakeholders and end-users

We worked with key stakeholders on this project, including:
- Ministry for Civil Defence & Emergency Management (MCDEM)
- Wellington Region Emergency Management Office (WREMO)
- GNS Science
- NIWA
- Porirua City Council (PCC)
- Ngāti Toa Rangatira (the local iwi of Porirua)
- Regional Public Health (the local public health unit in the Wellington region)
- Tū Ora Compass Health PHO (a Primary Health Organisation in Porirua)
- Capital & Coast District Health Board.

The key end-users include:
- CDEM groups, and CDEM staff in local and regional councils
- Ministry for Civil Defence & Emergency Management (MCDEM)
- local and regional councils, including policy planners and decision-makers
- emergency planners in the health sector (including District Health Boards, Primary Health Organisations, and ambulance services)
- public health units and District Health Boards
- Māori iwi and hapū
- the housing sector (particularly social housing providers)
- the education sector (particularly schools and early childhood education (ECE) facilities)
- lifeline organisations (such as water, electricity and communications)
- non-governmental organisations likely to be part of disaster response efforts
- RiskScape users and disaster risk reduction scientists
- local community groups (including ethnic and cultural communities, and groups concerned with health, wellbeing and disaster response).

About the term ‘vulnerable populations’

This report sometimes uses the term ‘vulnerable populations’ (or ‘vulnerable groups’ or ‘vulnerable people’) to refer to people with vulnerabilities.

In this study, ‘vulnerable populations’ refers to people who have a specific vulnerability to flooding, as defined by our conceptual framework and social vulnerability indicators.

So for this report, the term ‘vulnerability’ does not denote that a vulnerability is innate or internal to a person, or that it represents an overarching attribute of an individual. Rather, we identify vulnerabilities that people may be experiencing, that put them at greater risk of harm to their health and wellbeing for a variety of reasons, including social, political and environmental influences. In this way, we consider vulnerability something that could potentially be addressed at an organisational and policy level (for example, through the CDEM and health sectors), to ensure the needs of these ‘vulnerable’ population groups are met.

Additionally, vulnerabilities can occur due to a range of different factors, as can resilience. This means that people can be both vulnerable (due to a specific reason, such as a chronic health condition), and resilient (for example, due to being prepared for disasters) at the same time. Consequently, we consider it important to consider each specific cause of vulnerability, to help identify pathways to better meet people’s needs, and ensure an equitable response and maximum avoidance of harm from floods.

2. Overview of methods

Summary

- We aimed to develop a set of indicators of social vulnerability to flooding for New Zealand. An indicator is something that points to, measures, or otherwise provides a summary overview of a specific concept.
- Our overall approach to indicator development was to use a concept-driven approach (that is, based on a conceptual framework and the importance of indicators), rather than a data-driven (statistical) approach.
- We used a three-stage process to develop the indicators:
  - Scoping: understanding the issue; identifying key end-users and their needs
  - Selection of indicators: developing a conceptual framework; identifying potential indicators; evaluating indicators against selection criteria
  - Design and implementation: designing technical elements of indicators; testing indicators with end-users; and final implementation.
- We used a case study of the area covered by Porirua City Council, to test the indicators in the local context.
- We included stakeholder input throughout the indicator development process.
- We incorporated Mātauranga Māori in this research project, including through (i) working with the local iwi in Porirua, Ngāti Toa Rangatira; (ii) including Māori health in the conceptual framework; and (iii) incorporating strengths and resilience of Māori to natural hazards.

This chapter gives an overview of the process we used to develop the social vulnerability indicators. This process included developing a conceptual framework.

For the purposes of this project, the following broad definitions were used.

- An *indicator* is defined as something that points to, measures or otherwise provides a summary overview of a specific concept (Harvey 2012).
- A *conceptual framework* helps to bring together a range of concepts and relationships, and shows the way ideas are organised and relate to each other.

Our process for developing indicators

We used our established indicator development process used in the Environmental Health Indicators Programme (Mason et al 2018). Figure 1 presents our methodology for developing environmental health indicators.

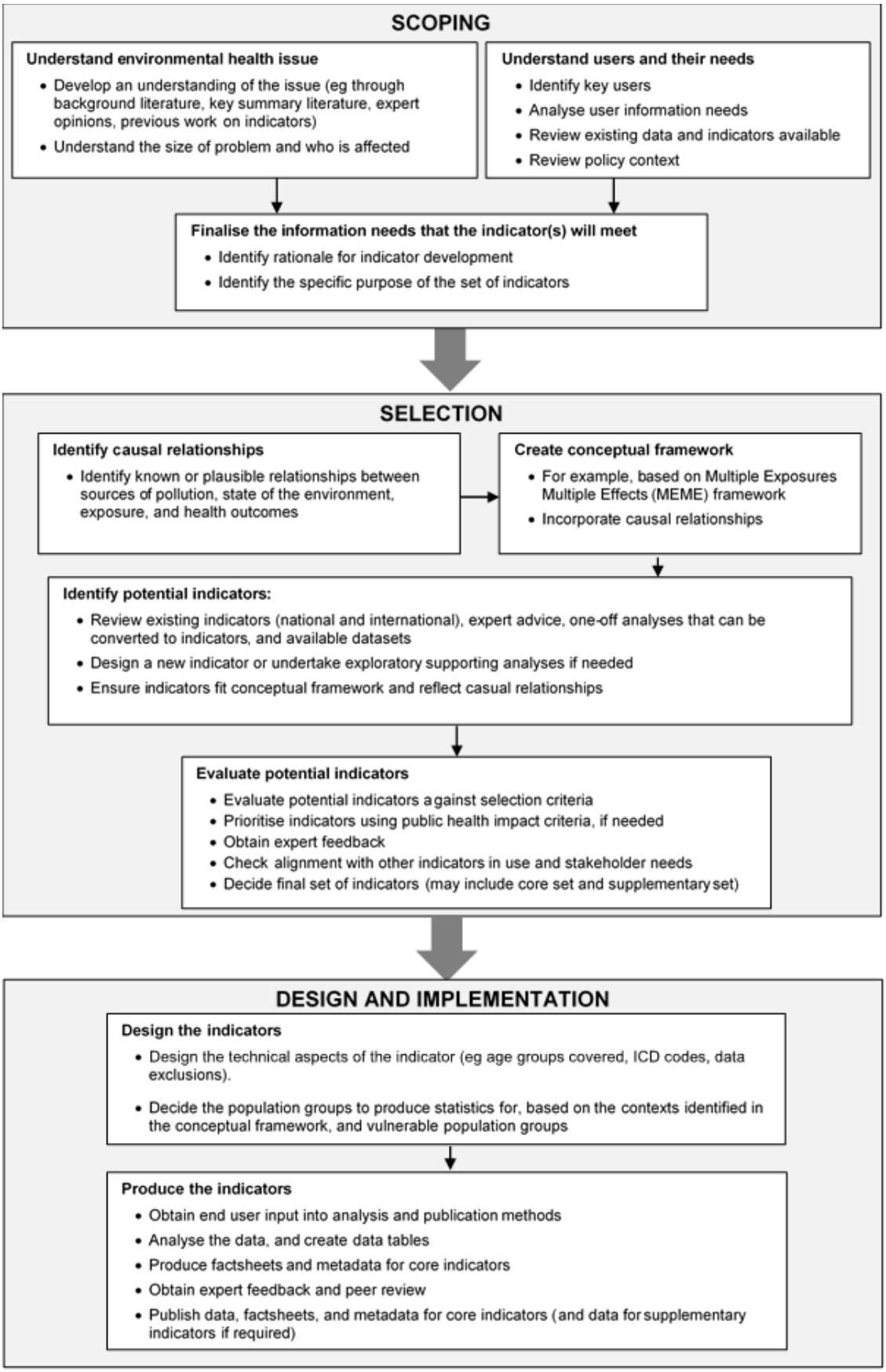
The indicator development process includes three stages:

(i) a scoping stage, which includes a literature review of how flooding impacts on human health, and identifying end-users and their needs

(ii) a selection stage, which includes a conceptual framework based on the literature and evidence-based causal links, identifying potential indicators, and evaluating indicators against selection criteria

(iii) a design and implementation phase.

Figure 2: Process for developing a set of environmental health indicators



Source: Mason et al (2018)

The final indicator selection process took into account a range of factors, including the needs of end-users, learnings from previous social vulnerability studies, the conceptual framework, data availability, and indicator selection criteria.

Further details of our methods for developing and disseminating the indicators are included in:

- Chapter 11: Indicator selection process
- Chapter 20: Disseminating the indicator information and data

Case study of Porirua

We used a case study of the area covered by Porirua City Council in this project. This case study helped to inform the indicator selection, and test out the indicators and project outputs. We worked with stakeholders from Porirua throughout the project.

In particular, this case study included:

(i) meeting with Ngāti Toa Rangatira at Takapūwāhia marae, to discuss their experiences and concerns about flooding in their area, to help our understanding of the impacts of flooding, and factors influencing vulnerability and resilience to flooding

(ii) working with key stakeholders from the Porirua area throughout the project

(iii) testing the draft indicator set in the Porirua context

(iv) using the newly-updated Porirua flood hazard maps to test ways of presenting social vulnerability indicators alongside hazard data, in order to provide meaningful insights to stakeholders

(v) using Porirua as an example for brainstorming ideas for how to end-users could use indicators in CDEM and emergency preparedness activities

(vi) using Porirua as an example of how social vulnerability can be incorporated through land use planning into District Plans.

We have not developed the indicators specifically for the Porirua context. Rather, we tested the national social vulnerability indicators within the area of Porirua to see how they might work, and to get feedback from our stakeholders. For this reason, our indicators are relevant to other areas across New Zealand.

Stakeholder engagement

Our process for developing indicators has a strong emphasis on identifying key end-users and their needs, and incorporating their feedback throughout the process. As such, we have developed these indicators with potential end-users in mind.

We worked with a range of key stakeholders on this project, including:

- Ministry for Civil Defence & Emergency Management (MCDEM)
- Wellington Region Emergency Management Office (WREMO)
- GNS Science
- NIWA
- Porirua City Council (PCC)
- Ngāti Toa Rangatira (the local iwi of Porirua)
- Regional Public Health (the local public health unit in the Wellington region)
- Capital & Coast District Health Board
- Tū Ora Compass Health PHO (Primary Health Organisation).

We included these stakeholders throughout our indicator development process. Stakeholder engagement included:

- scoping stage
    - a stakeholder meeting at the start of the project (February 2018), to discuss important considerations for the project, and the likely direction of the project
    - a hui at Takapūwāhia marae (June 2018) to discuss flooding impacts in the local area with Ngāti Toa
    - a meeting with Wellington Water to discuss their flood hazard mapping for Porirua (June 2018)
- selecting the indicators and testing the outputs
    - consulting with stakeholders (December 2018) on the first draft set of indicators and the indicator development process
    - a stakeholder meeting (March 2019) to discuss the draft indicators and the Porirua case study document, and to start discussing their needs as end-users
    - a meeting with the Resource Management Manager at Ngāti Toa (March 2019), to discuss the project and draft indicators
    - consulting with stakeholders on the Porirua case study document, with the draft indicators (March 2019)
    - a meeting with WREMO's Community Resilience and Recovery Manager, to discuss the project (May 2019)
    - presenting the draft indicators to the regional natural hazards' planners meeting (June 2019)
    - sending an updated draft list of social vulnerability indicators to stakeholders for peer review (June 2019)
    - sending an interactive online map (Story Map) of Porirua flood hazard zones and the draft social vulnerability indicators to stakeholders for their feedback (July 2019)
- identifying ways that the indicators could be used, and finalising the indicators
    - a brainstorming workshop with stakeholders to discuss potential ways that the indicators could be used in CDEM and emergency preparedness activities (August 2019)
    - sending a proposed list of ways that the indicators could be used across the 4 Rs to stakeholders for their feedback (August 2019)
    - a series of meetings with key stakeholders to finalise the content of the toolkit (September 2019)
    - sending the draft toolkit and research report to stakeholders for their feedback (October 2019)
    - finalising the indicators and completing the project (October 2019).

Our approach to indicator development

Public health approach

We have used a public health approach throughout the indicator development process.

- We have taken a holistic view of health and wellbeing, which incorporates aspects of physical, mental and social wellbeing, rather than a narrow focus of injuries and deaths.
- We have used conceptual frameworks to help understand how natural hazards impact on human health, and how social vulnerability influences the severity of impacts experienced due to natural hazards.
- We have included consideration of Mātauranga Māori (Māori knowledge), Māori concepts of health and wellbeing, and aspects of resilience from Māori experiences with previous natural hazards, and applied them to flooding.
- We have proposed a set of final indicators on the basis of the importance of indicators (eg causal relationships, evidence from the literature, logic, conceptual frameworks, and the potential for practical implementation and policy change), rather than using a statistical approach to deciding the key indicators. In this way, we have taken a concept-driven approach, rather than a data-driven approach.
- In collaboration with key stakeholders, we have suggested potential uses for the social vulnerability indicators. These suggestions included those learned from the public health sector's experience in supporting population health and wellbeing.

Including climate change and future vulnerability

We considered climate change impacts on flooding as part of this project, to help understand future vulnerability to weather-related natural hazards such as flooding. Our conceptual framework for understanding social vulnerability allows for the consideration of climate change. For the flood hazard zones, we included future projections taking into account climate change, in particular the likely increased intensity and frequency of flooding, and the likely impact of sea level rise on flood waters' ability to drain to the sea.

However, the scope of this project does not include gradual coastal inundation and sea level rise. Vulnerability to these hazards is a longer-term, graduated process. Therefore, there are likely to be different factors at play with gradual inundation in terms of vulnerability, than for flood events, which are generally sudden in nature.

Fitting into work currently being done on resilience

This work on social vulnerability is designed to complement existing indicator work on vulnerability and resilience in New Zealand. This study has identified that social vulnerability and resilience relate to similar but not identical concepts. This suggests that a vulnerability assessment is useful in its own right, in particular to inform resilience-building work.

Incorporating Mātauranga Māori

A key component of our project is incorporating Mātauranga Māori (Māori knowledge). We have incorporated Mātauranga Māori into this project in a number of ways, including:

- holding hui with local iwi, Ngāti Toa Rangatira, as part of the Porirua case study, to discuss the impacts that flooding has on their health and wellbeing and that of their iwi and community, and factors that lead to vulnerability or resilience to flooding in their area
- incorporating Māori concepts of health and wellbeing
- identifying key aspects of resilience and vulnerability for Māori, as identified by local iwi, Māori researchers and the literature

- reviewing the literature of Māori-focussed research into flooding, natural hazards and climate change, and previous experiences of Māori during and after natural hazards, and lessons learned
- considering local Māori iwi and hapū as key stakeholders and end-users of the information.

Taking a national approach with local implementation

The scope of this project was national, so the indicators were developed with the whole of New Zealand in mind. This means these indicators needed to be relevant for flood hazard zones occurring across the country, and in different communities. However, for local communities, not all the indicators will be relevant to their local population. Given this, the research outputs include guidance on how end-users might use social vulnerability indicators that are relevant for them.

Implementing the indicators into RiskScape

A key aim of this project was to implement the social vulnerability indicators into RiskScape, a risk modelling software (https://www.riskscape.org.nz). This part of the project was implemented by disaster risk reduction scientists Ben Popovich (NIWA) and Kristie-Lee Thomas (GNS Science).

RiskScape is an open access tool that lets users assess risk to buildings, infrastructure and people from natural hazards. The tool brings together information about assets (such as houses, infrastructure or people), hazards (such as a flood scenario), and vulnerability functions that estimate damage and loss. The modelled outputs from RiskScape, such as direct damage, reinstatement cost, fatalities and injuries, can be used to inform risk-based decision-making.

A range of end-users use the outputs of RiskScape, including:

- central government
- local government
- emergency management
- lifeline/asset managers
- planning or policy
- insurance/reinsurance
- risk consultants
- researchers.

Recently, EQC, NIWA and GNS Science have joined forces to re-develop and upgrade the RiskScape software. Software development for RiskScape version 2.0 has been underway since May 2018, and involves redeveloping the core engine. Currently, RiskScape 2.0 is operational by command-line interface (requiring computer coding skills), with a user-interface in development. Users of the command-line interface include risk scientists at NIWA and GNS, PhD students and researchers, as well as current clients such as CDEM Groups who request risk assessments from NIWA and GNS using RiskScape.

For the purposes of this project, we focused on:

- identifying how to include social vulnerability indicators into RiskScape, so that the data works alongside the existing models
- preparing a tutorial for how to use the social vulnerability indicators in the command-line interface of RiskScape

- promoting the indicator dataset and tutorial through the website and RiskScape newsletter once user license agreements have been established.

Further details about the implementation of the indicators into RiskScape are included in Chapter 18 (Implementing the indicators into RiskScape).

Implementing social vulnerability into local government processes

This project also investigated how to implement the social vulnerability indicators into local government processes, including land use planning. This part of the project was implemented by specialist land use planners, James Beban and Sarah Gunnell (Urban Edge Planning Ltd).

Social vulnerability indicators have the potential to inform actions during all four phases of emergency management, namely readiness, response, recovery and risk reduction. This part of the project identified some ways for incorporating social vulnerability into land use planning functions of local government. It considered that three key pieces of legislation to enable this are the Resource Management Act 1991 and the Local Government Act 2002. As part of this project, methods were identified for including vulnerability into the District Plan. The case study of the proposed Porirua District Plan was included, to demonstrate one potential method of addressing social vulnerability by controlling the location of activities that accommodate vulnerable people, such as aged care facilities, schools and early childhood education and social housing.

Further details about the implementation of social vulnerability into local government processes are included in Chapter 19 (Implementing the indicators into local government processes and land use planning), and in the guidance document for local government that has been developed as part of this project (Beban & Gunnell 2019).

3. How flooding can impact on health and wellbeing

Summary

- Flooding is a common natural hazard in New Zealand. Climate change will lead to increased flooding frequency and intensity in New Zealand.
- Health effects due to flooding are wide-ranging, and include drowning, hypothermia and waterborne diseases, exacerbation of pre-existing conditions, mental health impacts, and domestic violence.
- Flooding can also affect people indirectly, through disruptions to roads and public transport, power, drinking water supplies, and access to medication and health services. These disruptions can also have a range of impacts on people's health and wellbeing.
- Health and wellbeing impacts can occur at all stages of a flood: during the flood, in the days and weeks after the flood, and even months or years after a flood.
- In terms of climate change, this project focuses on the hazard of flooding, and includes the impacts of climate change on flooding. However, gradual coastal inundation is not part of the scope of this project.

This chapter describes flooding as a natural hazard, and how flooding impacts on health and wellbeing. These were important concepts to understand before investigating social vulnerability to flooding.

Flooding as a natural hazard

Flooding is one of New Zealand's most frequent natural hazards

New Zealand has many natural hazards. The New Zealand HazardScape report (2007) identified 17 types of hazards, which included natural and man-made events:

- Weather-related: floods, severe winds, snow, droughts, wildfires, coastal hazards
- Geological: earthquake, volcanoes, landslides, tsunami
- Biological: animal and plant pests and diseases, infectious human disease pandemics
- Man-made events: infrastructure failures, hazardous substances incidents, major transport accidents, terrorism, food safety.

There have been a number of major natural hazards affecting the New Zealand population in recent years, and which have required a substantial civil defence response. These include major flood events in Manawatu-Whanganui (2004), Matatā (2005), the lower North Island (including Porirua) (2015 and 2016), and Edgecumbe (2017), as well as earthquakes in Christchurch (2010-2011), Seddon (2013), and Kaikōura (2016).

However, flooding is one of New Zealand's most frequent and costly natural hazards (NIWA 2015, Royal Society of New Zealand 2016). On average, a major flood occurs every eight months in New Zealand. The total costs of flooding in New Zealand are estimated to be more than $125 million per year (MCDEM 2010).

About two-thirds of the New Zealand population live in flood-prone areas (Royal Society of New Zealand 2016), and many of New Zealand's main towns and cities are built on floodplains. In Auckland alone, an estimated 137,000 buildings (including 52,000 homes) are in flood hazard zones. Development and population growth continue to grow on floodplains, increasing the number of people and properties at risk (Ministry for the Environment 2008).

Flooding often occurs in storms, which means that other hazards may occur at the same time: intense rainfall, extreme wind, landslides, and infrastructure failures (such as impacts on public transport and the road network). Additionally, coastal hazards may also affect properties near the sea, through sea level rise, storm surges, coastal erosion, large waves, and king tides.

Previous flood events in New Zealand

There have been numerous flood events in New Zealand history. For example, in the ten-year period from 2009 to 2018, there were 28 flood-related events where insurance damages were more than $1 million (inflation adjusted) (ICNZ 2018).

These floods had substantial impacts on people's lives in the short-term, and often in the longer-term as well. Flooding impacts included drownings, mass evacuations, rescues, property damage, disruption to key infrastructure (including roads, public transport, water supplies and sewerage systems), and long recovery periods. Farming impacts included landslides, sediment deposits and livestock deaths. Floods can also have major environmental impacts, such as washing rubbish from old landfills downstream, which can in turn impact on people.

Flooding and climate change

Flooding is expected to worsen in the future in New Zealand due to climate change. In fact, flooding is recognised as one of the key risks of climate change in the 21st century in New Zealand (Reisinger et al 2014).

Climate change is expected to worsen the impacts of flooding on New Zealand, through the following ways:

- **More heavy rainfall days**: This will increase both the intensity of floods, and the likelihood of flooding.
- **Sea-level rise:** This will reduce the gradient fall to the sea, so river floods will take longer to drain.
- **Coastal hazards:** These hazards may cause flooding or water drainage issues near the coast, and include sea-level rise, bigger and more intense storms, erosive waves, sediment supply increases or decreases, and coastal erosion.
- **More damaging windstorms:** If occurring at the same time as heavy rainfall days, windstorms could damage buildings (eg roof damage or windows due to wind, tree fall and debris) and infrastructure (eg power lines), which may exacerbate flood impacts.
- **More frequent and more intense droughts in eastern areas:** This will mean that rainwater will tend to run off the land, rather than absorbed into the ground, which can lead to flash floods.

Additionally, there may be societal impacts from climate change. These may include:

- **Insurance coverage:** People may find it more difficult to get insurance for their home and contents, as insurance companies start to pull out of insuring properties in high-risk areas.

- **Climate change refugees:** New Zealand may experience an influx of climate change refugees (eg from the Pacific Islands); if this increase in population growth is not well planned for, it may lead to an increase in the population living in flood hazard zones in New Zealand.

This project focuses on the hazard of flooding, and includes the impacts of climate change on this type of flooding; however, gradual coastal inundation is not part of the scope of this project.

How flooding can impact on health and wellbeing

This section outlines the wide range of ways that floods can impact on people's health and wellbeing.

Flooding impacts on health and wellbeing

Flooding can have a range of impacts on people's health and wellbeing, which can begin during the flood event but may continue for months and years afterwards.

A recent review of flood impacts on health found that flooding adversely affected mortality, physical health and mental health. The most substantial impact on health from floods was death by drowning (Rufat et al 2015). Flood deaths occurring in vehicles tend to be one of the more common flood-related deaths (Du et al 2010), and were primarily due to unnecessary and risky behaviour that often result in drowning, or accidents associated with alcohol or drug use (Rufat et al 2015). However, about one-third of all deaths during flood events occurred away from floodwaters – they were the result of dehydration, stroke, lack of medical supplies, and health issues often overlooked prior to flood events. Deaths that occurred from flood-related illness were related to age, gender, disruption of medication, and public water consumption (Rufat et al 2015).

Health impacts from flooding include hypothermia due to exposure to the elements, and blunt trauma injuries due to the amount of debris in the water (March 2002). Other health impacts of flooding include stress effects, risks associated with the damage done by the water, infectious diseases, and diseases associated with displaced populations and mass evacuations (Du et al 2010). Additionally, people with pre-existing health conditions can have their health condition aggravated by the flood event. Mass evacuations of communities can also lead to total disruption of an individuals' person coping mechanisms, as well as disruptions to health care and social connections, and therefore can have health impacts. Table 2 outlines the specific impacts that floods can have on health and wellbeing.

Table 2: Specific impacts of floods on health and wellbeing

Flooding impacts	Description
Drowning and trauma injuries	Drowning and trauma injuries can be a direct cause of flooding, in particular getting caught in flood waters. Injuries can be caused by fast-flowing water, and debris caught in the water.
Hypothermia	Exposure to cold water can lead to hypothermia at any time of the year, but particularly in winter months when outdoor temperatures are cold.

Flooding impacts	Description
Electrical injuries, burns, explosives injuries	Electric injuries (electrocutions) are a risk if standing water is near electrical power lines, circuits or equipment. Burns and explosions are a risk if floodwaters disrupt propane or natural gas lines, tanks, power lines, or chemical storage tanks. Oil and other similar liquids may spread fires on the surface of floodwaters (Du et al 2010).
Carbon monoxide poisoning	Carbon monoxide poisoning can be caused during flood events and the recovery phase by unventilated gas-powered electrical generators, gas-powered pressure washers, unventilated cooking tanks, and house fires started by candles (Du et al 2010).
Waterborne diseases	Floodwaters can contaminate drinking water supplies and damage the sewerage system, resulting in contaminated surface flood waters. Contaminated flood waters increase the risk of waterborne infectious diseases, such as gastrointestinal illnesses, hepatitis A and E, leptospirosis, rotavirus, shigellosis, cholera, and typhoid fever (Alderman et al 2012). Contaminated water can also cause eye, ear, nose and throat symptoms.
Exacerbations of pre-existing health conditions	Flood events can worsen the health of people with pre-existing health conditions. For example, during and directly after flood, the exertion caused by escaping flood waters, and then multiple days of clean-up, can lead to heart attacks in people with existing heart disease (March 2002). Respiratory conditions (such as asthma and allergies) can also be aggravated by flooding and the resulting damp environment (March 2002). Additionally, access to health services and/or medication, and power supplies, can impact on people who depend on these for their health.
Mental health impacts	Floods can also take a heavy toll on the mental health of individuals involved, due to grief, loss, and stress. Mental health impacts of flood events include anxiety, depression and post-traumatic stress disorder (PTSD). People who have existing mental health conditions are more susceptible to mental health impacts; additionally, people on medication for mental illness can suffer a worsening of their mental health if they do not have access to their medication. Mental health impacts can also be seen through substance abuse (including excess alcohol use and drug use), and suicidal thoughts.
Vector-borne diseases	Stagnant water can provide a breeding ground for many vectors (such as mosquitoes), resulting in vector-borne diseases such as dengue fever and malaria, where mosquitoes carrying these diseases exist (Du et al 2010). Vector-borne diseases are not currently an issue in New Zealand, as high-risk mosquito species are currently not established here. However, in the future climate change may lead to the establishment of these mosquito species, which would increase the public health risk.

Additionally, flooding can have other, more indirect, impacts on health and wellbeing (Table 3). These impacts may lead to food insecurity, poor living environments, stress, and difficulties accessing key services and infrastructure, which in turn can affect people's health and wellbeing.

Table 3: Indirect impacts of floods on health and wellbeing

Flooding impacts	Description of impact on health and wellbeing
Disruption to transport networks and public transport	Flood waters may make some roads (particularly low-lying roads in flood zones) difficult or impossible to pass, leading to some communities or properties becoming isolated. Heavy rainfall events can also lead to slips, which can close road networks. Road closures and flooded roads can make it difficult for emergency service vehicles to reach callout addresses for emergencies and rescues. People may also put themselves at risk of drowning or injuries if they decide to walk or drive through flooded areas. Many people also rely on public transport to commute to and from work/ school and home, and may be unable to get home as a result of disruptions. Disruptions to the road network and/or public transport can leave people stranded in a different part of the city or far from home, and unable to reach their home or their children at schools or early childhood centres, which can increase stress levels and cause disruption. Additionally, people may be unable to reach health services.
Power outages	Power outages can affect people who rely heavily on power for medical reasons (such as dialysis patients and people using home oxygen therapy). Power outages can affect provision of health services (including access to patient electronic records), communications (including TVs, and cellphone recharging), heating sources reliant on power (including electric heaters and heat pumps), and can lead to food spoilage (in fridges and freezers) if power is cut for more than a day or two.
Disruptions to communications	Communications outages can make it difficult for family members to communicate with one another, or to check on one another. Disruptions to communications can also impact on service provision and coordination of response indlcuding welfare groups.
Disruption to health services	Disruption to health services can have a large impact on health during and after a flood, particularly for: (i) people who are critically injured or become ill as a result of the flood, and for (ii) people with pre-existing health conditions (affecting physical and/or mental health) who need ongoing medication, access to services, or whose health conditions will worsen if untreated as a result of the flood. Health services that may be affected include hospitals, GP clinics, mental health units, dialysis units, emergency services (such as ambulance and fire service), medical supply depots and storage facilities, as well as medical personnel.
Property damage	Properties and material belongings can be badly damaged by flood waters. This can have health impacts through the clean-up process: • contact with contaminated water and belongings • physical exertion bringing on health conditions such as heart attacks • losing essential material belongings and food. Dealing with insurance companies can also lead to ongoing stress for homeowners and individuals.
Damp and mouldy housing	After a flood event, flood waters or dampness may remain under houses if they are in low-lying areas with poor drainage. This can lead to damp and mouldy housing, which is known to increase the risk of asthma in children and is associated with respiratory diseases (Prezant & Douwes 2011).

Flooding impacts	Description of impact on health and wellbeing
Displacement and overcrowding	If houses are damaged badly enough, people may need to stay in temporary shelter for days, weeks, months or even years, while houses are being fixed. Displacement can be highly stressful, particularly through losing social networks and support, and impacts on children through change in routine. Additionally, overcrowding in temporary accommodation increases the risk of spread of infectious diseases.
Impacts on food supply and food gathering	Floods can impact on food supplies and food gathering. Food that has been in contact with contaminated flood waters (and is not in waterproof packaging) needs to be thrown out after a flood event. Major floods may also affect transport routes and food supply to a region. Additionally, contaminated flood waters may affect vegetables grown in the ground, and may mean that these cannot be consumed raw. Contaminated flood waters can also impact on food gathering (mahinga kai), such as collecting watercress and eel (tuna) from local rivers, and seafood (such as shellfish) from coastal areas. These are traditional food sources for Māori, and may impact on their food quality and supply, and ability to provide food for whānau and visitors/ evacuees staying at the local marae.
Lack of access to childcare services	People have reported that a lack of access to childcare services after a natural hazard (for example, schools and early childcare centres closing down temporarily) can lead to increased stress, due to parents needing to look after their children while also trying to manage the clean-up process, deal with insurance companies, and generally get back on their feet.
Loss of employment	Loss of employment can lead to financial stress. Financial stress can affect health, as it makes it difficult to provide food, shelter, and afford to replace damaged property. Financial stress can also have an impact through stress exacerbating existing health conditions, lowering people's immunity, and having mental health impacts.
Domestic violence	Studies have found that reports of domestic violence increase following natural hazards and civil defence emergencies (Clemens et al 1999), including in New Zealand (Houghton 2010). The main contributing factors tend to be prior abuse, and financial strain, for example through loss of jobs, property damage or loss, damage or destruction of homes, displacement, and absence of childcare when schools and early childcare centres temporarily closed down (Houghton 2010).

Flood characteristics

Furthermore, different characteristics of floods can influence the impact that floods have on health and wellbeing (Coninx & Bachus , Du et al 2010, March 2002) (Table 4).

Table 4: Flood characteristics and the impacts on people's health and wellbeing

Higher-risk flood characteristics	Impacts on people's health and wellbeing
Deeper floodwaters	Deeper floodwaters increase the risk of injuries and death, property damage, disruption to everyday lives, and temporary or permanent displacement. Deeper floodwaters increase the chance of drowning, particularly for people who are unable to get out of the

Higher-risk flood characteristics	Impacts on people's health and wellbeing
	water, through lack of access or mobility issues. Higher flood depths also increase the risk of anxiety.
Faster floodwater flows	Faster floodwater flows (velocity or speed of water flow) also increase the risk of injuries and death. Faster floodwater flows can be destabilising for people to walk through, and can knock people off their feet. Faster water flows can also carry more debris (eg trees), and can float vehicles, which can lead to injuries and/or death. Faster floodwater flows can also lead to substantial property damage, disruption to everyday lives, and temporary or permanent displacement.
Fast water rise (flash floods) with little warning	Flash floods (where water rises quickly), can entrap people, and lead to drowning. The greatest number of deaths and injuries occur when there is little to no warning of an impending flood (March 2002). In general, the faster the speed of the water rise, the more traumatic the events, and the greater the health effects.
Long duration	The longer that properties are flooded, the larger the damage, and the larger the disruption to households and people's lives, as well as the levels of stress that people experience. Floods that last for a long time (for example, two weeks or more) can also increase anxiety.
Contaminated water and debris	Floodwaters can be contaminated through a range of ways, including floodwaters overflowing the sewerage system, and chemical spills. Contaminated floodwaters affect health through water-borne diseases and skin infections. Contaminated floodwaters also require more clean-up, throwing out contaminated goods and foods, and lead to contamination of the environment. Flood debris (such as branches, logs, or cars) increase the risk of injuries.
Floods at night-time, or during the working day	Sudden floods at night or during the day when people are at work may be more damaging, due to a lack of time to protect properties. People may have difficulties getting home from work if a daytime flood affects the transportation network.
Floods in winter and/or colder weather	Floods in winter and/or colder weather can increase the risk of hypothermia. Winter flooding also aggravates the recovery process, since drying the house is more difficult with cold temperatures outside. If flood waters or dampness remain on properties or under houses for long periods of time, houses can become damp and mouldy, which increases the risk of health effects.
Low-lying areas, those near water (rivers or streams), in valleys, or downstream from a dam	Areas at the highest risk of floods include low-lying areas, those near water (such as rivers and streams), and/or those located downstream from a dam (Du et al 2010). Areas in a valley are more likely to experience flash floods, particularly carrying debris. Flooding occurring in mountainous areas and narrow river valley areas are associated with higher mortality rates (Du et al 2010). Low-lying areas are more likely to experience gradual inundation.

4. Understanding social vulnerability

Summary

- Social vulnerability refers to people who are more vulnerable to adverse effects from floods due to aspects of their current circumstances, such as age, health status, financial situation, social connectedness, and awareness of local hazards.
- Vulnerability occurs at the individual level, but the provision and accessibility of services and lifelines infrastructure (such as water, electricity, and transportation services) also plays an important role.
- Social vulnerability is similar to the idea of resilience (or lack of resilience), but measures a slightly different concept. *Resilience* focuses on communities' ability to cope with the natural hazard, and to be able to recover from it. *Social vulnerability* looks more broadly at which population groups are more likely to be vulnerable to the impacts of natural hazards. The two concepts are not mutually exclusive - people can be both vulnerable and resilient at the same time, for different reasons.
- Measuring social vulnerability can be useful for identifying at-risk populations, as well as for identifying where and for whom resilience-building activities potentially need to take place.

This chapter summarises current knowledge about social vulnerability to natural hazards, including what social vulnerability is, factors that influence social vulnerability, and how social vulnerability relates to resilience.

What is social vulnerability?

The adverse impacts of natural hazards on health and wellbeing are not evenly distributed throughout society. Not everyone in the population is able-bodied, can hear, see and move themselves, can understand the hazard, and can understand and carry out what they need to do to prepare or get out of the way of the hazard (Atyia Martin 2015). This means that some population groups are especially vulnerable and less able to cope than others (Team and Manderson 2011).

While there is no universal definition of social vulnerability, it broadly refers to pre-existing conditions, characteristics or circumstances of the population that affect their ability to prepare for, respond to, and recover from hazard events (Cutter et al., 2003). These conditions and factors determine and influence population-level outcomes after natural hazards, and increase people's risk of experiencing adverse outcomes due to a natural hazard.

What type of factors influence social vulnerability to flooding?

A recent review of 67 flood disaster case studies identified key characteristics of social conditions that were related to flood impacts (Rufat et al 2015). Social factors that were at higher risk of experiencing impacts due to floods included:

- **demographic characteristics** such as children, elderly, women, and special needs populations (including those who are institutionalised, with low capacity for self-care, chronically ill patients needing continued care, and nursing home residents)
    - young and middle-aged men were also vulnerable due to risk-taking behaviour, rescue activities, and temporary impairment due to alcohol or drugs
- **socioeconomic status** including household income, poverty, education and unemployment, as well as access to resources, power relationships, and diversity of economic assets
- **chronic illness** (with health outcomes also being a result of social vulnerability).

Another review found that, while no one goes through a traumatic event unchanged, some population groups were at higher risk of psychological consequences after a disaster (Shultz et al 2013). Key factors that influenced vulnerability to psychosocial consequences of disasters included:

- population demographics (such as children, older adults and women)
- culture/ethnicity/language
- family context characteristics (such as single-parent families)
- social support and adaptive skills
- psychiatric/psychological health
- physical health
- disability status
- being adversely affected by floods, either during (due to traumatising experiences), and/or after (due to the impacts and/or their experiences in the post-disaster phase).

How does social vulnerability relate to resilience?

Social vulnerability is similar to the concept of resilience but measures a slightly different aspect. Resilience focuses on communities' ability to 'bounce back' or 'bounce forward' - that is, to cope with the natural hazard, and to be able to recover from it. A lot of work has recently been carried out on resilience to natural hazards in New Zealand, including the development of the National Disaster Resilience Strategy (MCDEM 2019), and work on a New Zealand Resilience Index (Stevenson et al 2018).

Social vulnerability looks more broadly at which population groups are more likely to be vulnerable to the impacts of natural hazards. This does not mean that they are not resilient, as they may be both vulnerable and resilient. However, social vulnerability assessments can be used to identify community groups where resilience work may need to be focussed.

Social vulnerability can refer to individuals' characteristics and circumstances. Additionally, some vulnerability is due to structural influences, that is, the way resources are distributed within society. Examples include wealth and income inequality, housing availability and affordability, public policy in taxation, land use planning, and regulations governing workplace safety. Social vulnerability can also be exacerbated by civil defence and emergency management activities not reaching or being accessible to everyone in the population (Phibbs et al 2016).

Why measure social vulnerability?

Social vulnerability indicators are used to identify potentially vulnerable populations who are likely to be more affected by natural hazards, and less able to cope or adapt to a hazard. Measuring social

vulnerability can help us to understand the potential for loss, and the vulnerabilities that communities face towards natural hazards, to then address these needs to reduce the risk.

Social vulnerability indicators can help fulfil New Zealand's obligations under the Sendai Framework for Disaster Risk Reduction 2015-2030, to which New Zealand is a signatory. The Sendai framework focuses on reducing the impact of natural disasters for all people. A key priority of the framework is 'to understand disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment'.

Additionally, climate change means that weather-related hazards will become more frequent and intense in the future. The International Panel for Climate Change (IPCC) has identified that socioeconomic considerations can be used to help understand the adaptive capacity of communities. However, they have identified that currently, 'most vulnerability studies from Australasia make no or very limited use of socioeconomic factors, consider only current conditions, and/or rely on postulated correlations between generic socioeconomic indicators and climate change vulnerability' (Reisinger et al 2014, p1382). This underscores the importance of making social vulnerability indicators applicable to both disaster risk management and climate change.

5. Previous work on social vulnerability indicators

Summary

- Internationally, a number of social vulnerability indicators for natural hazards have been developed over the years, including the Social Vulnerability Index (SoVI).
- Several sets of social vulnerability indicators have been developed in New Zealand for natural hazards, including social vulnerability indicators for earthquakes, and indices of socioeconomic deprivation, social fragmentation and resilience. However, no indicator sets currently exist in New Zealand for flooding.
- There is currently no consensus on exactly what indicators should be in a set of social vulnerability indicators. However, some key population groups that often appear in indicator sets include the young and old, people with chronic health conditions or disability, low income, housing issues, access to car/phone/TV/radio, occupation, and ethnicity.

This chapter reviews previous work on social vulnerability indicators for natural hazards and flooding, in the international context, and then for New Zealand.

Reviewing previous indicators helps us to identify how our project fits into current and existing work, and helps to identify gaps and opportunities. This review identifies the type of indicators that have been selected previously, the rationale given for selecting these indicators, conceptual frameworks used, methodology for selecting indicators, how the indicators have been output and used, and any relevant practical implementation steps.

International work

A range of social vulnerability indicators for natural hazards have been developed internationally over the years. Some indicator sets or indices have been specifically for flooding, while others have been for natural hazards more generally. Some projects created an index, which has the benefit of summarising all the data into one value. Other projects have created sets of indicators.

We have reviewed a range of international sets of social vulnerability indicators, including the following:

- Social Vulnerability Index (SoVI) (Cutter 1996, Cutter et al 2003)
- Medical Vulnerability index (MoVI) (Cutter)
- Cologne flood indicators, using the MOVE framework (Birkmann et al 2013)
- Social Determinants of Vulnerability Framework (Atyia Martin 2015)
- Urban Municipality Flood Vulnerability Index (Rasch 2016)
- Social Flood Vulnerability index (Tapsell et al 2002)
- Social Vulnerability Index for Disaster Management (Flanagan et al 2011)

The Social Vulnerability Index (SoVI) (Cutter 1996, Cutter et al 2003) was one of the first projects to develop a social vulnerability index. The SoVI was based on the hazards-of-place model of vulnerability, and used statistical methods (principal components analysis) to reduce 42 variables to a key 11 variables. These variables were then weighted and combined to create the index, at the

United States county-level (which vary from a few hundred people, to ten million people). The variables were a mix of demographic characteristics, built environment, and infrastructure characteristics, as well as American concepts of race and ethnicity (a distinction which is not necessarily relevant in New Zealand).

Cutter also developed a medical vulnerability index, which identified aspects of health that make people more vulnerable to natural hazards. These included physical health needs, psychological health needs, healthcare access (including medical insurance), and health system capability.

The MOVE framework provided an example of social vulnerability indicators for flooding, from a project in Cologne (Birkmann et al 2013). The MOVE framework was developed to give a comprehensive vulnerability assessment for natural hazards and climate change. Vulnerability domains include social, physical, ecological, economic, cultural and institutional.

The Social Determinants of Vulnerability Framework identified key social factors that mean that people have disproportionate exposure to risk and a decreased ability to avoid or absorb potential losses (Atyia Martin 2015). A grounded theory approach was carried out, using a link analysis of social factors from the existing literature, to investigate the relationships between social factors. Seven key interrelated social factors were identified: children, older adults, people with disabilities, chronic and acute medical illness, social isolation, low-to-no income, and people of colour. Additional indicators that were also found to be important included women, lower educational attainment, limited English proficiency, renters, and a lack of a vehicle.

The Urban Municipality Flood Vulnerability Index identified a number of key indicators for urban vulnerability to floods in Brazil, then developed an index using factor analysis and an additive model to create an index (Rasch 2016). More than 25 indicators were identified, covering age, health status, education, income, work status, access to telecommunications, housing, flood preparedness, access to services (eg reticulated water). This project also considered implications for adaptation policy for climate change. As part of this assessment, they included future exposure to flood hazard as the number of projected floods in the next 100 years, by area.

The Social Flood Vulnerability Index was developed in the United Kingdom (Tapsell et al 2002). It included indicators about financial deprivation, pre-existing health problems, single parents, and the elderly. The indicators were combined using equal weights to sum to an index.

The social vulnerability index for disaster management created an index for four social vulnerability domains (socioeconomic status, household composition and disability, minority status and language, and housing and transportation) (Flanagan et al 2011). The index comprised 15 indicators, which were combined into an index for the United States.

New Zealand work

In New Zealand, a few studies have considered social vulnerability to natural hazards or to flooding. Additionally, several studies have created indicators or indices to measure related concepts, including resilience, socioeconomic deprivation, and neighbourhood fragmentation. These indicator sets are useful to review to identify what work has been done, gaps and opportunities for our indicators for social vulnerability to flooding, and potential indicators and data sources for use in our project. These indicator sets include:

- Social vulnerability indicators for earthquakes (Kwok 2016)

- Vulnerability assessment for flooding in the Hutt Valley (Khan 2012)
- New Zealand Index of Deprivation (Atkinson et al 2014)
- Using the NZDep to measure social vulnerability (Paton et al 2006)
- New Zealand Indices of Multiple Deprivation (Exeter et al 2017)
- New Zealand Index of Neighbourhood Social Fragmentation (Ivory et al 2012)
- New Zealand Resilience Index - Trajectories toolbox project (Stevenson et al 2018)
- Resilience Index New Zealand (Pearson et al 2013).

The first attempt in New Zealand to look at social vulnerability and natural hazards was by using the New Zealand Index of Deprivation (NZDep2001) and examining exposure to earthquake hazards (Paton et al 2006). This study suggested that NZDep could be used to understand vulnerability due to limited financial resources, as a proxy for social vulnerability. However, an important limitation was that socioeconomic deprivation did not tell the full story of vulnerability, and could not act as a proxy for all types of vulnerability (such as age or disability status).

A comparison of potential vulnerability assessments was carried out for flooding in the Hutt Valley, Wellington region (Khan 2012). This study identified 38 initial proxy indicators relating to vulnerability to flooding, including demographic, social and economic indicators. This study then compared results using a principal components analysis, and two composite vulnerability indices (with and without weights). This study concluded that different indices give different pictures of vulnerability (for example, focused on economics or culture), depending on the method and focus of selected indicators, and it recommended that a comprehensive vulnerability assessment is carried out.

Since then, Kwok (2016) has identified potential social vulnerability indicators for earthquakes, with the aim of assessing their utility for RiskScape's earthquake risk models. The outcomes mostly focused on earthquake losses (deaths, injuries and displacement). This study used the SoVI index (Cutter 1996, Cutter et al 2003) as the starting point for the indicators, and suggested indicators such as race and ethnicity (non-European ethnicity), and 12th grade education, as well as potential different indicator sets for different purposes (including civil defence practitioners, health practitioners, and RiskScape). The final indicator sets have not been fully implemented, as no data sources were identified, or definitions developed, for the indicators. This study concluded that social vulnerability indicators need to be context sensitive, requiring an understanding of their linkages to other physical, political, economic and environmental contextual factors. A further conclusion was social vulnerability indicators could have a wider purpose than predicting earthquake economic and human losses. The study suggested that community objectives (such as knowledge and skills, economic wellbeing, housing, health, safety, social connectedness, civic participation, and population dynamics) could be considered for future indicator development work.

As well as these social vulnerability indicator projects, a range of other related projects have looked at social vulnerability more generally. These include the New Zealand Indices of Multiple Deprivation (Exeter et al 2017), and the New Zealand Social Fragmentation Index (Ivory et al 2012). However, these indices have not been specifically developed for natural hazards.

Additionally, a project currently funded under the Natural Hazards Science Challenge is the New Zealand Resilience Index, which aims to assess and compare the resilience of place-based communities in New Zealand over time (Stevenson et al 2018). This resilience index is based on a six-capital framework, covering social, economic, built environment, natural environment, and cultural resilience, as well as governance of risk and resilience. The index comprises 15 indicators

across the six capitals (including built and natural environment), and provides baseline data at the census area unit (CAU) level. Indicators were selected from an indicator bank of more than 1000 potential indicators, based on thematic content analysis.

Furthermore, some New Zealand studies have used a qualitative approach to identify potential factors relating to social resilience with stakeholders and community groups (Kwok et al 2019, Kwok et al 2016, Kwok et al 2018). These studies have noted that the results are not necessarily able to be extrapolated to the whole of New Zealand, as factors of resilience identified by some communities may be different to those in other communities. No national indicator datasets have been identified or produced from these studies.

Appendix 1 contains more details about these previous social vulnerability indicator sets and other related studies.

Overall themes from previous social vulnerability indicator sets

Overall, a number of key themes and issues were identified from these social vulnerability indicator sets.

Approach to selecting indicators, and general themes of indicators

Social vulnerability indicator sets have been mostly selected based on reviews of related literature (Brooks et al 2005, Chang et al 2015). However, some studies have used context-specific vulnerability indicators that were identified by key informants in the community (Mavhura et al 2017).

Overall, there was no consensus on the specific variables to use when measuring social vulnerability to natural hazards. However, some key population groups appeared throughout many indicator sets:

- young children and elderly
- people who have chronic health conditions
- people with disabilities
- low income
- access to car, phone, TV, radio
- housing: rental, housing quality, crowding
- occupation
- race or ethnicity.

Other less common topics included housing density, access to main roads, piped drinking water, multi-unit housing structures, slum housing, and living in group quarters (such as correctional facilities, nursing homes, college dorms and military quarters).

Rationale for indicators

Rationale given for selecting the above population groups/characteristics as social vulnerability indicators included:

- people’s susceptibility to health impacts
- their ability to cope during the event
- their ability to get enough information about the hazard, or to understand the information
- their ability and/or transportation to escape the flood
- having enough awareness and skills to cope

- low income affecting people's ability to cope and recover financially
- being a marginalized group in society
- having a safe environment (eg through housing).

Conceptual framework

Few studies used a conceptual framework to understand the underlying reasons why people might be vulnerable to flooding. Of those that did, the MOVE framework was the most common, which identifies indicators for exposure, susceptibility, and lack of resilience (Birkmann et al 2013, Kablan et al 2017). Another study used the dimensions of socioeconomic status, households' composition and disability, minority status and language, and housing and transportation (Flanagan et al 2011).

Whether to develop an index

Many of the studies used indicator sets to develop an overall index – that is, a single value to represent social vulnerability in each small area. Well-known indices for social vulnerability include the Social Vulnerability Index (SoVI) (Cutter et al 2003) and the Social Flood Vulnerability Index (Tapsell et al 2002).

Indices are useful for comparing areas in a region, to identify those areas with overall high vulnerability and low vulnerability. These indices have value in summarising many social vulnerability indicators into one summary statistic.

However, a single value for an index does not show specific vulnerability factors that should be planned for in emergency management planning. Additionally, the selection of indicators into the index is important; including some urban-based variables (such as household density, access to vehicle) may lead to an urban bias in the index, while including mainly economic indicators will lead to a focus on financial deprivation (Khan 2012).

Whether to use a statistical approach for indicator selection

Many of the studies used a statistical approach to select indicators and/or create indices (Cutter et al 2003, Fekete 2009, Mavhura et al 2017). A statistical approach involves identifying a large number of indicators (often 30–80 indicators), then using principal component analysis or factor analysis to select the most statistically significant indicators, based on the data in the study. Indicators may be weighted or unweighted during the analysis.

The disadvantages of using a statistical approach to indicator selection include that indicators are only selected for their statistical significance rather than practical significance. Indicators are only relevant for the specific study area that the data came from; repeating the analysis in a different area may get a different set of indicators. Additionally, these types of analyses are complicated and can be difficult to explain to policy-makers.

Whether to develop individual indicators

Another approach is to simply identify a set of indicators, such as in Atyia Martin (2015). This approach can be useful for showing specific reasons for vulnerabilities, such as limited English language skills, and access to a vehicle. These vulnerabilities can then be addressed through emergency planning and preparedness activities.

However, the disadvantage in this approach is if there is an overwhelming number of indicators, as they become difficult to use and prioritise. Often, a large number of indicators may be reduced to a smaller set of core indicators, to aid interpretation.

The importance of considering the context of the place

Some of the indicators were quite place-specific, referring to a specific societal, political or cultural context. This suggests the importance of developing indicator sets specific to the country of interest. Examples of indicators that needed special consideration included race and ethnicity, women, and slums.

Race and ethnicity were separately included as social vulnerability indicators in a number of studies in the United States, including SoVI. This is partly due to the role that ethnicity (and in turn socioeconomic status, marginalisation, and/or racism) has played in the impact that natural hazards has on people in the United States.

Some indicator sets also identified women as a vulnerable population, as women are often left caring for children, and can find it difficult to find work after a disaster. However, women's vulnerability is strongly influenced by the social context (for example, a lack of rights for women, percentage of women in the workforce). This social context can vary markedly between countries, including between developed and developing countries.

Some indicator sets included indicators on the presence of informal settlements (such as slums, tenements - slum apartments, and mobile homes). However, these housing types may not exist or be particularly relevant in all countries, with other aspects of housing being more relevant to flood vulnerability.

Social vulnerability work in New Zealand

There are no current sets of social vulnerability indicators for flooding in New Zealand. Based on the work that has already been done, we have made the following observations.

- There are specific aspects about the New Zealand situation that need to be considered, including whether it is useful or relevant to include women and ethnic groups as social vulnerability indicators.
- To date, little work on development of social vulnerability indicators has considered Māori views and Mātauranga Māori on vulnerability and resilience, or what health and wellbeing means from a Māori perspective.
- Census data is a key data source for social vulnerability indicators in New Zealand.
- Socioeconomic deprivation (NZDep) is useful, but is not the whole picture about social vulnerability.

Key considerations for indicator development

In reviewing previous sets of social vulnerability indicators, the following points have emerged as important considerations during the indicator development process.

- Thinking about the end-users and the practical implications of the indicators is important and useful.

- Conceptual frameworks are a useful addition to the indicator development process, to ensure that all aspects of vulnerability are covered, not just one aspect such as socioeconomic status.
- Clarifying the relationship between social vulnerability and resilience is important, given the work currently being done on resilience in New Zealand; this is particularly important for end-users, who will have a variety of indicator sets to choose from.
- Most previous sets of social vulnerability indicators have focused on relative measures of vulnerability (ie creating indices to compare and/or benchmark areas); however, these types of indices do not provide information about the number of people affected or specific vulnerabilities, which would be needed for planning purposes.
- It is important to be clear about what impacts the indicators relate to, as considering a narrow set of impacts (such as only deaths) is likely to give different results to considering a wider range of impacts on health and wellbeing.
- Contextual factors (including the physical, political, economic and environmental contexts) are important for understanding and interpreting social vulnerability indicators.

6. Vision Mātauranga

Summary

- This research project contributes to the Mātauranga and Taiao themes of Vision Mātauranga, and explores the distinctive Māori approach to hazard vulnerability and the contribution it can make to policy, planning and community outcomes.
- Iwi/Māori have a special and well-recognised connection to the natural world. Values and Mātauranga Māori connect '*people and place'* in a way that enhances and adds value to natural hazard decision-making and planning.
- Aspects of Te Ao Māori that contribute to Māori resilience to natural hazards include existing social structures (such as networks of people across whānau, hapū and iwi), physical structures (such as marae), Māori cultural values and practices, and existing leadership structures.
- Marae provide an important source of resilience during previous emergencies, providing safety and shelter, social connectedness, and a place to sleep, eat, cook and share resources. One of the biggest challenges during an event is ensuring that marae are well resourced and prepared for an emergency.
- Marae hold special significance to all Māori, especially those with deep ancestral connections to them. Along with protecting whānau, protecting the local marae is a high priority for Māori during an emergency.
- Māori have experienced difficulties establishing good links with civil defence during previous emergencies, which has led to difficulties and a lack of resilience when trying to cope with, and assist during, disasters. Iwi have expressed a desire to be partners in emergency planning for events at all levels (central government, regional and local government).

This chapter describes how this research project contributes to the Mātauranga and Taiao themes of Vision Mātauranga, and explores the distinctive Māori approach to hazard vulnerability and the contribution it can make to policy, planning and community outcomes. This component of the project was carried out by Rawiri Faulkner (Tūtaiao Ltd) and Ngāti Toa Rangatira.

The mission of the Vision Mātauranga (VM) policy framework seeks to '*To unlock the innovation potential of Māori knowledge, resources and people to assist New Zealanders to create a better future'* (MORST 2007). It is an 'opportunities-based' framework that focuses on the distinctive contribution that Māori can make to benefit all New Zealanders.

He Mihi

The research team partnered with Ngāti Toa Rangatira to develop, implement and deliver this research project. We thank the people of Ngāti Toa Rangatira and particularly the community around Takapūwāhia Marae for their support and input into this project. Tenei te mihi nunui ki a koutou kātoa.

Mātauranga Māori (knowledge) and Māori values

Mātauranga Māori can be translated as meaning '*Māori knowledge'* or *'traditional knowledge'*. However, this single translation does not adequately capture the nuances and multi-faceted dimensions of this phrase. It is effectively captured by Bay of Plenty Regional Council in their document *He Korowai Mātauranga - Mātauranga Māori Framework* (Bay of Plenty Regional Council) when they state:

> ***Mātauranga Māori***
>
> *Mātauranga Māori not only refers to the knowledge that Māori have, but encompasses the Māori way of knowing and the connectedness that knowledge has with the environment out of which it was derived.*

In a recent report by Landcare Research (2019), Māori values were defined as:

> ***Māori Values***
>
> *Any natural resource, area, place, or thing (tangible or intangible) which is of physical, economic, social, cultural, historic, and/or spiritual significance to tangata whenua.*

Although this phrase accurately captures the meaning of Māori values in a 'policy context', the term 'Māori values', like 'Mātauranga Māori', has many nuances, local connotations and subtle variations. However, for the purpose of this report, this definition captures the sentiment of Māori values effectively.

The 'distinctive' Māori approach to natural hazards, floods, social vulnerability and resilience

The following section summarises some key findings about Mātauranga Māori on natural hazards and floods, from the literature, research studies, and our initial hui with Ngāti Toa Rangatira as part of this project.

Māori environmental perspectives

Iwi/Māori have a special and well-recognised connection to the natural world. This is evident in many traditional values and concepts such as whakapapa (genealogy) and mauri (the life force of everything around us and how everything is interconnected). This intimate and unbreakable bond between tangata whenua and their sites and areas of significance has been developed over many centuries of observation, interaction and mātauranga creation. These connections are as strong today as they have ever been. Values and Mātauranga Māori connect '*people and place'* in a way that enhances and adds value to natural hazards decision-making and planning. It also creates a reciprocal responsibility for iwi and hapū to nurture the natural environment for the benefit of future generations. An example of this is the role of iwi and hapū in supporting communities during a natural hazard event. This is covered further later in this chapter.

Because of this perspective, Māori have a particular interest in the management of hazards and associated risks, including risks that may be posed to wāhi tapu sites and other sites of significance (MCDEM 2008).

Mātauranga Māori contribution to government policy on the management of freshwater

Māori have, and continue to make, a distinctive and valuable contribution to Aotearoa. The most noticeable place where this contribution is evident is with recent changes to government policy. In particular, Mātauranga Māori is informing the way that Regional Councils now manage freshwater bodies, which plays an important role in reducing the risk of floods.

An example of this distinctive contribution is the way in which fresh and coastal water is valued 'in its own right' before it is seen as a resource, in the recent update of the National Policy Statement on Freshwater Management. This policy includes objective and policy provisions focused on Te Mana o te Wai. Te Mana o te Wai was introduced into the National Policy Statement (NPS) as part of the changes announced in August 2017. In their factsheet issued after the release of the changes, the Ministry for the Environment describes Te Mana o te Wai as (Ministry for the Environment 2017b):

> *Each community will decide what Te Mana o te Wai means to them at a freshwater management unit scale, based on their unique relationship with fresh water in their area or rohe. The Statement of National Significance in the Freshwater NPS describes the concept of Te Mana o te Wai as the integrated and holistic well-being of the water. It is up to communities and councils to consider and recognise Te Mana o te Wai in their regions*.

A working definition of Te Mana o te Wai is:

> '*Valuing freshwater and all that it represents and provides for, including its inherent right to exist in its own state, as well as the species and ecosystems within and surrounding it.*'

This objective and policy acknowledges and supports the protection of the mauri of the water and provides for the health of the environment, waterbodies and people. It requires regional councils and tangata whenua to work with their communities, to understand what values are held for each freshwater body in their region. Councils should then set freshwater objectives and limits guided by these values, recognising that all decisions made about freshwater management should be made by putting the health and well-being of the water at the forefront of their discussions.

Te Mana o te Wai provides Regional Councils with the opportunity to rethink the way they identify community values regarding freshwater management. This approach is consistent with Vision Mātauranga, as it explores the distinctive contribution that Mātauranga Māori can make to freshwater management.

Māori land tenure and the impacts of human modifications to the environment

Māori land tenure, resilience and vulnerability

Māori land tenure provides aspects of resilience to natural hazards, but also some unique challenges for Māori. Te Ture Whenua Māori Act 1993 classifies Māori land into two categories: Māori Customary Land and Māori Freehold Land.

Māori Customary Land:

- has not had its ownership investigated and determined by the Māori Land Court
- has not been acquired by the Crown
- does not have a Land Transfer Act title or Deed
- continues to be held in accordance with tikanga Māori (Māori customary values and practices).

Māori Freehold Land is held by individuals who have shares together as tenants in common (Māori Land Court 2019). Māori Freehold Land:

- has been investigated by the Māori Land Court and a freehold order has been issued, or
- was set aside by the Crown as Māori freehold land and awarded by Crown Grants to specific individuals, or
- has had the status determined as Māori Freehold Land by order of the Māori Land Court.

In both customary and freehold title, Māori have usually had a long association (sometimes hundreds of years) with the whenua and its environment. Many hapū and iwi have often occupied land for many generations and feel deep links to the environment. This is partly due to the nature of Māori land tenure, making it difficult to sell or dispose of their land. This presents both a distinctive opportunity and risk.

Māori land tenure encourages a long-term view, given the deep connections with the whenua and that hapū and iwi are unlikely to move. This encourages a long-term community-centred view of both vulnerability and development. However, other groups (like private investors) have the option to relocate should vulnerability and risk increase; Māori often do not have the same opportunities. Also planning tools like 'managed retreat' are difficult to implement with regards to Māori land, as the option to relocate is difficult given many marae communities do not have access to resources, even if they wanted to move.

In our case study of Porirua, the Ngāti Toa marae at Takapūwāhia is located in a vulnerable location given its proximity to sea level and therefore propensity to flooding. However, the options available to relocate are limited. This leads Ngāti Toa to be willing to explore innovative solutions and contribute to future planning processes.

Human modifications to the environment increasing flooding risk

Iwi and hapū have often identified that human modification of the environment has increased flooding risk. These human modifications include land modification for agriculture, the addition of stop banks, draining of wetlands, and water abstraction for irrigation (King et al 2012).

In Porirua, Ngāti Toa iwi considered that flooding in Takapūwāhia had increased since hard stormwater infrastructure was installed in the local stream several decades earlier. This meant that the marae and surrounding buildings are now more at risk of flooding than when they were built.

Resilience and vulnerability to natural hazards

Māori have a range of resilience factors for natural hazards. Aspects of Te Ao Māori that contribute to resilience to natural hazards include existing social structures (including networks of people across whānau, hapū and iwi), physical structures (such as marae), Māori cultural values and practices, and existing leadership structures.

Established networks and relationships, and collaborative leadership

Māori generally have wide support networks and strong social connectedness, often based around marae. In particular, Māori have a strong focus on whānau, hapū and iwi, and looking out for members of the whānau and community, particularly during an emergency. This increases their capacity to cope with and respond to hazard events, thereby decreasing their vulnerability. For example, Ngāti Toa report that when a flood threatens, they can call on whānau and the community to rally together to put sandbags around their marae, to protect it from flood waters.

Māori communities also often have important resources for response and recovery, including Māori welfare and support services, as well as marae for use as emergency shelters (MCDEM 2008).

Marae play an important role as evacuation shelter

Marae are the basis of traditional Māori community life. Māori see their marae as their turangawaewae (loose translations given in brackets: place to stand), and it is the centrepiece of modern and traditional Māori society. Marae hold special significance to all Māori, especially those with deep connections to them through whakapapa (ie for people whose ancestors stand within the whare). Along with protecting whānau, protecting the local marae is a high priority for Māori during an emergency.

Marae are the automatic place that iwi and whānau go to when a natural hazard occurs, for whanaungatanga (social connection), whakarurutanga (safety) and manaakitanga (hospitality). In previous emergencies, marae have played an important role as evacuation shelters for the local community. Marae, including the wharenui (meeting house) and the wharekai (dining hall) are well set up for accommodating large numbers of people for sleeping and eating. For example, participants in a Manawatu-Whanganui flood study highlighted the key role of marae as hubs for providing emergency support and hospitality (Hudson & Hughes 2007). After the February 2011 Christchurch earthquake, Ngāi Tahu opened the doors of all of its South Island marae to earthquake evacuees (Kenney & Phibbs 2015). In addition, papakainga housing developments (Māori housing villages) were used to help whānau left homeless after the 2017 Edgecumbe flood.

One of the biggest challenges during an event is ensuring that marae are well resourced and prepared for an emergency. There is significant opportunity for government to establish a process that recognises the role of marae in emergency planning, and explores ways in which these challenges can be addressed in an ongoing partnership with Māori.

Resilience and the importance of Māori cultural values and practices

Much of the capacity and resilience in Māori communities comes from Māori cultural values, such as tikanga (Māori customary practices or behaviours) and kawa (marae protocol) and actioned through principles such as whakapapa (genealogy or descent), whanaungatanga (kinship or close relationships), manaakitanga (hospitality or reciprocal care), tautokotanga (support) and kotahitanga (unity or togetherness) (King et al 2012). In this way, the concepts of mutual support and collective action, with “everyone joining in together to look after each other”, can be considered as important coping mechanisms, particularly when resources (such as power, food or water) are short (King et al 2012).

An example of the importance of Māori cultural values and practices was after the Christchurch earthquake, where the Māori Recovery Network, coordinated and led by Ngāi Tahu, was framed with the mission statement ‘aroha nui ki te tangata’ (extend love to all people), which included not only Māori but all local people, particularly those in minority groups (Kenney & Phibbs 2015). The Ngāi Tahu response was guided by kaitiakitanga (a sense of responsibility for the people in the area), as well as manaakitanga (hospitality).

However, these capacities are not uniform across the community. In some studies, Māori communities have suggested that a lack of resilience may be due to people having less resources and an increased reliance on technology, which can then lead to them being less self-sufficient and

flexible – which are important qualities to dealing with adverse environmental conditions (King et al 2012).

Effective leadership

Effective formal leadership within iwi has been identified as a key factor contributing to resilience, particularly in the response phase of a disaster (Kenney & Phibbs 2015). After the 2011 Christchurch earthquake, the Māori Earthquake Recovery Network was established within 24 hours of the earthquake, and was led by Ngāi Tahu, as the kaitiaki (guardians) of the region. The Māori Recovery Network coordinated emergency management and disaster relief efforts across the region, which included: opening all marae in the South Island (and several North Island marae) to earthquake evacuees; coordinating and distributing food packages; setting up telephone helplines; and door-knocking in isolated areas (Kenney & Phibbs 2015).

Additionally, leadership within a Māori worldview is collaborative, and acknowledges the collective authority of the Māori community (Kenney & Phibbs 2015). In these ways, existing relationships between agencies, the existing leadership structure within iwi/hapū, and a collective and collaborative leadership style, contribute to the resilience of Māori iwi and hapū to respond effectively to natural hazards.

Building up resilience

There are many examples of Māori iwi, hapū and communities actively working to build up resilience in their local community (Phibbs et al 2016).

One particular example is the development of emergency networks across Lower Hutt and Wellington region by the Wellington-based marae Ngā Hau e Whā o Paparārangi, after they had received evacuees from the February 2011 Canterbury earthquake (Phibbs et al 2016). Sponsored by Hutt City Council, this initiative involved 10 maraes, who were dedicated to improving their standards, and focussed on preparing their community to be able to take responsibility and look after people after an emergency. The initiative included developing emergency procedures, and included doctors, pharmacies, local community centre, ham radio operators, as well as linkages into the local school, retirement home and parole office. They developed programmes to strengthen community network and social cohesion, such as classes on weaving, cooking, gardening, rongoa (Māori medicine) and Māori language classes. People from their community were also trained in how to operate the facility in an emergency (Phibbs et al 2016). As a result, they went from having no Civil Defence emergency resilience programme, to being much more resilient in terms of emergency preparedness, having a refurbished and safe building, having money in the bank, restoring toxic land to a better standard, and having good community involvement.

Difficulties in getting communication and coordination links with Civil Defence

During previous emergencies, Māori have faced some challenges, in particular getting good links with civil defence (Hudson & Hughes 2007). In an earthquake context, Māori networks were ready to work with Civil Defence after the February 2011 Christchurch earthquake, but coordination with formal emergency management took several days, and had to be negotiated through an external person (Phibbs et al 2016). Similarly, after the 2016 Kaikōura earthquake, there was a breakdown in communication between agencies and marae, which resulted in Takahanga marae of Ngāti Kuri struggling to identify key contacts and to secure enough supplies for the 10,000 meals that were served to affected individuals in the community (Carter & Kenney 2018).

Given these types of issues, Māori have identified the need to be part of the civil defence system, and to obtain better access to services in the response and recovery stages. For floods, Māori have said they would like to get better information about how to prepare for floods, get updated weather reports during flood threats, and be provided with sandbags as part of preparedness if their marae is in a flood hazard zone. Ngāti Toa have also expressed a desire to be partners in planning for events at all levels (central government, regional and local government).

Additionally, isolated communities (including rural Māori) can find it hard to get access to key services, particularly if communication systems are affected (Hudson & Hughes 2007). Māori were also disproportionately impacted by the loss of access to basic public health infrastructure, including power and sanitation, poor access to frontline services, and loss of financial resources during the Christchurch earthquake (Phibbs et al 2016).

Differences between rural Māori and urban Māori

The vulnerability and resilience of Māori varies between Māori living in small rural settlements and those in regional centres and large urban areas, with each group likely to face different challenges and/or combination of pressures (King et al 2012). For example, Māori living in rural settlements are more likely to be isolated during an emergency, and are also more likely to be reliant on the land. In the 2004 Manawatu-Whanganui floods, there were claims that some small communities, including some marae, could not be located on maps, impeding relief effort (Hudson & Hughes 2007). However, small rural communities may also have strong connections with whānau, the local community and the land, and have a range of skills and knowledge that would help them during an emergency.

Māori and climate change

Many iwi and hapū groups live in coastal (often remote) areas. These areas are susceptible to sea level rise associated with climate change. There are many examples of how Māori have adapted to climate change over time; however, the resources available to Māori are different now and circumstances are much different. The capacity of Māori to adapt to climate change and the imminent rise in sea level (and associated hazards such as coastal flooding) is probably the biggest single challenge facing Māori communities today.

Mātauranga Māori and capacity, resilience, and social vulnerability

In summary, Mātauranga Māori, including topics discussed in this section, can be insightful when understanding capacity, resilience, and social vulnerability. Mātauranga Māori, and looking at the indicators through a holistic lens, helps to inform the aspects of what contributes to resilience. In Māori communities, the following aspects of Te Ao Māori have been shown to contribute to capacity and resilience:

- Māori cultural values and social connectedness
- Māori participation in disaster risk reduction (DRR) decision-making, before, during and after emergencies
- appropriately resourcing marae so that they can support communities in response, through providing shelter, food, water and support
- Māori knowledge and experience of natural hazards.

7. Policy context for the indicators

Summary

- The Treaty of Waitangi is a foundational policy context for risk reduction for natural hazards in New Zealand. In particular, the three Treaty principles of *protection, partnership* and *participation* are important to include in emergency management and preparedness, resilience building, and risk reduction activities.
- The recent New Zealand National Disaster Resilience Strategy, implemented in April 2019, signals a shift towards a greater focus on resilience and risk reduction, including a focus on vulnerability and meeting people's diverse needs.
- The New Zealand Government now has a strong focus on wellbeing, through the Living Standards Framework and four capitals (natural, human, social, financial/physical) approach.
- With recent changes to the Resource Management Act, local councils are starting to take a risk-based approach to land use planning for natural hazards, which should include consideration of vulnerable populations. However, very few councils are doing this in their District Plans, potentially due to a lack of guidance on how to identify vulnerability in a community, or how to include it into land use planning.
- Internationally, New Zealand is a signatory to the Sendai Framework for Disaster Risk Reduction 2015-2030. The Sendai Framework includes a shift in focus from managing disasters to managing risk, including to reduce the underlying drivers of risk (exposure and vulnerability).
- The National Disaster Resilience Strategy and the Sendai Framework both promote a whole-of-government and whole-of-society approach to risk reduction for natural hazards. Risk reduction is not just the responsibility of the emergency management sector, but all sectors, including the health sector.
- Social vulnerability indicators for flooding could be useful for supporting these policies and strategies. For example, the indicators could support the National Disaster Resilience Strategy and the Sendai framework, by helping end-users to understand and identify vulnerabilities and resilience, and providing nationally-consistent data for measuring social vulnerability.

This chapter summarises the key policy context for the social vulnerability indicators. Understanding the policy context is important for placing the indicators into the user context, and knowing how the indicators might be used and why they are needed. The policy context contributes to the rationale for developing the indicators, informs the scope of the indicators and what they should include, and helps to identify why the indicators are important.

Treaty of Waitangi

The Treaty of Waitangi is an important foundational policy context for risk reduction for natural hazards in New Zealand. The Treaty of Waitangi informs the whole of government approach,

including to emergency management and preparedness, resilience-building, and risk reduction activities.

In particular, the three principles of *protection, partnership* and *participation* are important to include in civil defence emergency management and risk reduction. The following explanation of the three principles of the Treaty of Waitangi, in the context of natural hazards, have been adapted from the SchoolNews website (Coxhead 2016).

- **Partnership** involves working together with iwi, hapū, whānau and Māori communities. This includes engaging with the Māori community, involving Māori as partners in planning at all levels (central government, regional and district government), and building and maintaining genuine and meaningful relationships with Māori communities.

- **Protection** involves actively protecting Māori knowledge, interests, values and other taonga. This includes valuing, validating and protecting local knowledge and taonga; and inclusion of Māori tikanga and a Māori perspective.

- **Participation** includes working to strengthen relationships between Māori and the Crown, Māori participation in civil defence and other sectors, sectors representing the biculturalism of Aotearoa, and aspirations of Māori whānau and iwi reflected in planning.

Equity is also a strong focus of the Treaty of Waitangi; policy, plans, and practices should be aimed at pursuing equitable outcomes.

National Disaster Resilience Strategy

The National Disaster Resilience Strategy sets the vision and long-term goals for civil defence emergency management (CDEM) in New Zealand (MCDEM 2019). CDEM in New Zealand is governed by the CDEM Act 2002, which, among other things, "promotes the sustainable management of hazards in a way that contributes to safety and wellbeing". To support this, the National Disaster Resilience Strategy has a strong focus on building community and societal disaster resilience to protect New Zealand's prosperity and wellbeing. The strategy has been strongly influenced by the Sendai Framework, and came into effect in April 2019, replacing the previous National Civil Defence Emergency Management Strategy (DIA 2008).

The Strategy has the following overall goal:

> To strengthen the resilience of the nation by managing risks, being ready to respond to and recover from emergencies, and by enabling, empowering and supporting individuals, organisations and communities to act for themselves and others, for the safety and wellbeing of all.

Some of the 18 objectives of the Strategy relate to vulnerability and data preparedness, in particular:

- Objective 1: Identify and understand risk scenarios (including the components of hazard, exposure, vulnerability, and capacity), and use this knowledge to inform decision-making.
- Objective 12: Improve the information and intelligence system that supports decision-making in emergencies to enable informed, timely, and consistent decisions by stakeholders and the public.

In terms of vulnerability, the Strategy identifies the importance of reducing vulnerability and pursuing equitable outcomes. In particular, the Strategy states:

> The impact of hazards and threats is likely to exacerbate existing inequities that exist across New Zealand. This means that some populations are disproportionately affected by many of the social and economic impacts of risks. This includes Māori, as well as Pasifika, and any people for whom English is not their first language, those living with high levels of social and economic deprivation, those who face challenges associated with disability, ill health, or social or geographic isolation.
>
> Obligations under the Treaty of Waitangi as well as commitments to improving wellbeing (including in existing strategies and action plans, such as the New Zealand Disability Strategy), mean we need to ensure any action toward reducing risk is cognisant of different types of vulnerability, and the disproportionate effect disasters can have. Policy, plans, and practices should be aimed at pursuing equitable outcomes, as well as planning for, and taking opportunities to build back better in recovery to reduce vulnerability and improve living standards. (page 15)

In this way, social vulnerability indicators could support the National Disaster Resilience Strategy, particularly through helping end-users to identify and understand vulnerability to flooding, and through providing a nationally-consistent approach to measuring vulnerability. The indicators could also be a useful tool for ensuring equitable support for vulnerable population groups.

Civil defence emergency management in New Zealand

The Civil Defence Emergency Management Act 2002 (CDEM Act) provides the framework under which natural hazards in New Zealand are to be managed. The Act sets out the duties, responsibilities and powers of central and local government, lifeline utilities and emergency services. It establishes an 'all-hazards' approach that seeks to achieve the sustainable management of hazard risk, through the 4 Rs:

- **Risk reduction:** reducing the risk of impacts from natural hazards
- **Readiness**: being prepared for a natural hazard, and developing operational systems and capabilities before an emergency occurs; this includes preparedness by individuals, households, businesses, services (such as schools, early childcare centres, rest homes), civil defence and the health sector
- **Response**: actions taken immediately before, during and directly after a civil defence emergency, to save lives and protect property, and to help communities recover
- **Recovery**: recovering from a natural hazard, getting people back on their feet.

Risk reduction includes land use planning and infrastructure (such as stormwater services). However, risk reduction may also be interpreted to include other sectors, particularly those who might be involved in reducing people's vulnerability (eg social housing providers). The risk reduction phase also includes preparing vulnerability assessments, including assessment of social vulnerability.

The CDEM Act requires the formation of a number of regional CDEM Groups, made up of representatives from territorial authorities, regional councils, emergency services and lifeline utilities.

Each CDEM Group must prepare a CDEM Group Plan that details how the risks that threaten their region will be managed.

Resource Management Act 1991

New provisions to the Resource Management Act (RMA) 1991 now require councils to assess significant natural hazards risks (Section 6 (h)) as a matter of National Significance. With the recent RMA changes, local councils are starting to take the risk-based approach to land use planning for natural hazards, which should include consideration of vulnerable populations (Beban & Saunders 2013).

However, a 2014 review of natural hazards provisions in district plan chapters found that only 2.9% of district plans mentioned vulnerable populations, and 11.6% mentioned vulnerable facilities (Saunders et al 2014). The authors suggest these low figures may reflect a current lack of guidance on how to identify vulnerability in a community, or what factors to consider when assessing vulnerability.

Local Government Act 2002

The Local Government Act 2002 (LGA) is a key piece of legislation relevant for promoting social resilience in local government processes. The LGA provides the obligations and powers of local government in New Zealand, and the general framework under which they must operate. The purpose of the LGA is to enable democratic local decision-making that meets the current and future needs of communities in terms of infrastructure, services and regulatory performance in a cost-effective manner. Section 11A(d) directs that in performing its role, local government shall have particular regard to the avoidance and mitigation of natural hazards.

Under the LGA, local authorities prepare a long-term plan (LTP), which must cover a period of at least 10 years, and provide for integrated and co-ordinated decision-making. The Long-Term Plan can include actions to manage the effects of natural hazards and climate change. Local authorities also have the powers to make bylaws for the purpose of protecting, promoting or maintaining public health and safety. Bylaws can be a useful tool to facilitate and support post-event recovery processes, for example by allowing public open spaces to be used for temporary accommodation after a major event has occurred. Under section 149, regional councils are given the power to make bylaws for flood protection and flood control works.

Living standards and wellbeing framework

The New Zealand Government now has a strong focus on wellbeing, through the Living Standards Framework developed by the New Zealand Treasury. Wellbeing is an important part of resilience. Given this, the National Disaster Resilience Strategy is partly driven by the Living Standards Framework.

The Living Standards framework puts wellbeing, and the four capitals (human, social, natural, and financial/physical capital) at the core of the state sector.

In the context of the National Disaster Resilience Strategy, wellbeing is defined as “our quality of life, including: civic and human rights, culture and identity, housing, knowledge and skills, leisure and recreation, material standard of living, employment status and job satisfaction, the physical and natural environment, safety and security, health, and social connectedness”.

Sendai Framework for Disaster Risk Reduction 2015-2030

From an international perspective, New Zealand is a signatory to the new Sendai Framework for Disaster Risk Reduction 2015-2030. The New Zealand implementation of this framework is being led by the Ministry for Civil Defence & Emergency Management.

The Sendai Framework focuses on reducing the impact of natural disasters for all people, with the following outcome: *The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.* In particular, a key priority is 'to understand disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment'.

The Sendai Framework takes a holistic approach to risk reduction for natural disasters, not simply a response-driven approach. It includes a shift in focus from managing disasters to managing risk, including to reduce the underlying drivers of risk (exposure and vulnerability). It promotes a whole-of-government, and a whole-of-society approach, with populations at risk and communities at the centre of emergency and disaster risk management measures. Risk reduction is not just the responsibility of the emergency management sector, but all sectors, including the health sector.

The Sendai Framework highlights the following key points that are relevant to health.

- The Framework has a strong focus on health. Four of the seven Sendai Framework global targets have direct links to health, focusing on (1) reducing mortality, (2) population wellbeing, (3) early warning, and (4) promoting the safety of health facilities and hospitals.

- The Framework states "There has to be a broader and a more people-centred preventive approach to disaster risk. Disaster risk reduction practices need to be multi-hazard and multisectoral, inclusive and accessible in order to be efficient and effective. While recognizing their leading, regulatory and coordination role, Governments should engage with relevant stakeholders, including women, children and youth, persons with disabilities, poor people, migrants, indigenous peoples, volunteers, the community of practitioners and older persons in the design and implementation of policies, plans and standards" (para 7).

- The Framework supports strengthening the "design and implementation of inclusive policies and social safety net mechanisms, including through community involvement, integrated with livelihood enhancement programmes, and access to basic health care services, including maternal, newborn and child health, sexual and reproductive health, food security and nutrition, housing and education, towards the eradication of poverty, to find durable solutions in the post disaster phase and to empower and assist people disproportionally affected by disasters" (para 30j).

- The Framework states that "People with life threatening and chronic diseases should be included in the design of policies and plans to manage their risk before, during and after disasters, including having access to lifesaving services" (para 30k).

- The Framework supports "[ensuring] the use of traditional, indigenous and local knowledge and practices, as appropriate, to complement scientific knowledge in disaster risk assessment and the development and implementation of policies, strategies, plans and programmes of specific

sectors, with a cross-sectoral approach, which should be tailored to localities and to the context" (para 24i).

- The Framework recommends making "non-sensitive hazard-exposure, vulnerability, risk, disaster and loss-disaggregated information freely available and accessible, as appropriate" (para 24e).

The Sendai Framework is supported by the Bangkok Principles for the implementation of the health aspects of the Sendai Framework.

8. Key end-users and their needs

Summary

We identified a range of key end-users for the social vulnerability indicators, including:

- CDEM groups and local council CDEM staff
- Ministry for Civil Defence & Emergency Management (MCDEM)
- local and regional councils, including policy planners, and decision-makers
- emergency planners in the health sector (including district health boards, primary health organisations and ambulance services)
- public health units and district health boards
- the housing sector (particularly social housing providers)
- the education sector
- Māori iwi and hapū
- RiskScape users and disaster risk reduction scientists
- local community groups (including ethnic and cultural communities).

We identified that end-users required high-quality and robust indicators. Indicators need to be based on solid evidence and rationale, relevant to the New Zealand context, as up-to-date as possible, accurate, meaningful and useful.

We identified three types of information required by end-users from this project:

- information and evidence about social vulnerability to flooding – identifying vulnerable population groups and reasons for this vulnerability
- social vulnerability indicator information/data for local areas, which might include data tables, maps, shapefiles and metadata
- guidance and ideas about how to implement social vulnerability indicators into different sectors, including civil defence emergency management and land use planning, to reduce the impact of floods on health and wellbeing.

This chapter identifies the key end-users of indicators, and their information needs, based on the policy context, structure of emergency management activities in NZ, and their responsibilities. This work was carried out based on a literature review, as well as discussions with key stakeholders.

New Zealand emergency management context

Readiness, response and recovery activities in New Zealand are led by the civil defence and emergency management (CDEM) sector. The CDEM sector includes the Ministry for Civil Defence & Emergency Management (MCDEM), CDEM Groups (which operate at the regional council level), local council civil defence groups, and related groups (including welfare NGOs). Because Civil Defence tend to take an all-hazards approach to this work, we have included examples of CDEM activities for other recent hazards in New Zealand (particularly the Christchurch and Kaikōura earthquakes). The CDEM sector is guided by a series of director's guidelines, strategies, plans, guidance and resources, published by the Ministry of Civil Defence & Emergency Management.

CDEM Groups are each required to prepare a CDEM Group Welfare Plan. In this context,

> ‘welfare aims to alleviate the impacts on people, including loss of employment and income, experiencing loss or separation of those close to them, physical injury or trauma, psychosocial impacts, pandemic illness, or loss of property and possessions’ (Williams 2016).

The group welfare plans help coordinate the range of organisations, agencies and individuals that provide vital welfare services before, during and after an emergency (Williams 2016). Welfare services coordinated by CDEM during an emergency include:

- shelter and accommodation
- food, water and clothing
- assistance with contacting family/whānau and significant others
- psychosocial support
- financial assistance
- medication, medical assistance, assistance with other health needs
- veterinary assistance, food, and/or shelter for their pets.

A key part of the CDEM Group Welfare Plan is to identify and understand risks and vulnerabilities, and identify strategies to reduce the impacts of these. As well as Welfare, other functions coordinated through CIMS (Coordinated Incident Management System) include Operations, Logistics, Intelligence, and Planning.

Key end-users

Given the range of potential uses of social vulnerability indicators, there are a range of key end-users. Key end-users and end-benefiters for the social vulnerability indicators include:

- CDEM groups and local council CDEM staff
- Ministry for Civil Defence & Emergency Management (MCDEM)
- local and regional councils, including policy planners, and decision-makers
- emergency planners in the health sector (including district health boards, primary health organisations and ambulance services)
- public health units and district health boards
- the housing sector (particularly social housing providers)
- the education sector
- Māori iwi and hapū
- RiskScape users (disaster risk reduction practitioners, consultants and researchers in CDEM, insurance, reinsurance infrastructure, planning and policy sectors)
- Disaster risk reduction (DRR) practitioners
- researchers
- local community groups (including ethnic and cultural communities).

Other potential end-users may include:

- people with diverse needs (eg medical needs, disability)
- local tourism groups, such as moteliers
- emergency services (for example, NZ Police have a statutory obligation to respond to Civil Defence emergencies).

The Ministry of Civil Defence & Emergency Management (MCDEM) is responsible for setting the overall policy and strategic direction of civil defence emergency management in New Zealand, to support and enable communities to manage emergencies. In this context, civil defence emergency

management includes local government, emergency services, national agencies, lifeline providers, and others that sit across multiple stakeholders belonging to various sectors of society. MCDEM are responsible for administering the CDEM Act 2002, and for leading New Zealand's implementation of the Sendai Framework 2015-2030. MCDEM will become the new National Emergency Management Agency (NEMA) in 2019/2020.

CDEM groups are semi-autonomous organisations who coordinate CDEM services on behalf of the local councils in each regional council. They are each required to prepare a CDEM Group Welfare Plan, which identifies risks and vulnerabilities, and strategies to reduce the impacts of these, as well as coordinating the range of organisations, agencies and individuals that provide welfare services before, during and after an emergency.

Local council CDEM welfare managers and other CDEM staff are responsible for implementing civil defence emergency management in their local areas.

Land use planners in local councils are responsible for reviewing and updating the District Plan in their district (policy planners), and for making land use planning decisions about proposed developments.

Decision-makers (including councillors at local councils) are responsible for making decisions such as deciding whether to upgrade key infrastructure such as stormwater services in their local area.

Emergency planners in the health sector (including district health boards, primary health organisations and ambulance services) are responsible for emergency planning and preparedness in the local health sector. This includes primary health care, mental health care, dialysis services, hospital-level services, prescription medication (pharmaceuticals) and long-term care for people with higher needs.

Public health units and district health boards are responsible for improving and protecting the health of the population in their region, including a focus on reducing inequalities. Public health units have a focus on promoting wellness, and have a statutory role in protecting the health of the community.

The housing sector (including social housing providers in central government, local government and iwi) are involved in developing new housing, including social housing which will house potentially vulnerable people.

The education sector (schools and early childhood education centres) provide schooling and care for children, who are a vulnerable population group. In many places around New Zealand, schools are also used as civil defence centres for the local community.

RiskScape users include disaster risk reduction (DRR) practitioners and researchers who want to assess potential impacts of natural hazards on our communities to inform risk-based DRR decision-making. Users include central government, MCDEM, CDEM, local government and private sector planning or policy, infrastructure personnel in local government and private sector companies, researchers (at universities, Crown Research Institutes, local government and in private sector), private sector/risk consulting, insurance/reinsurance, non-governmental organisations and non-New Zealand governments (such as in the Pacific).

Māori are tangata whenua and have a strong connection to the environment, expressed through the Māori value of kaitiakitanga (guardianship and protection). Given this, Māori have a particular interest in the management of hazards and associated risks. Māori communities also have important resilience factors for natural hazards, and have played important roles in emergency responses in previous emergencies.

Local community groups include ethnic and cultural communities, among others.

Information needs of key users

Table 5 identifies the main information needs of these key end-users, including the range of ways that end-users might use the indicators. Overall, there were three main types of information users needed.

- Information and evidence about social vulnerability to flooding – identifying vulnerable population groups and reasons for this vulnerability
- Social vulnerability indicators for local areas, which may include data tables, maps, shapefiles and metadata
- Guidance and ideas about how to implement social vulnerability indicators into different sectors, including civil defence and land use planning, to reduce the impact of floods on health and wellbeing.

End-users need the indicators to be robust and of high quality. We identified the following requirements of indicators and data source:

- Based on solid evidence – the indicators are likely to inform decision-making, so they need to be robust
- Data sources and indicators need to be reliable and accurate
- Applicable and relevant to the New Zealand context
- Up-to-date – so that emergency management plans reflect reality as close as possible
- Ability to keep the indicators up-to-date on an on-going basis
- Meaningful – so that users can easily understand and interpret the information
- Relevant to CDEM activities in the 4 Rs – so that people can see the clear link between an indicator and the types of activities that could be done to reduce the vulnerability.
- Indicator data available as both counts (to show the actual number of people affected and to inform planning), and percentage of the population (to show the relative impact of the vulnerability).

In terms of the data and indicators themselves, these were some important considerations:

- Availability of data at least at the territorial authority (TA) level – to align with CDEM work carried out at the local council level
- Ability to disaggregate data to smaller areas (such as area units (AU) and meshblocks, or similar geographies) – to see the spatial variation of vulnerability across an area, which can inform local response and planning work

- Availability of data for Māori – ideally for each separate indicator, to allow 'equal explanatory power' for Māori and to allow Māori to see the level of vulnerability and/or resilience in their own population
- Social vulnerability indicators translated into point locations (where more vulnerable population are likely to cluster, such as early childhood centres), for use in District Plans and policy work, as well as RiskScape.

Technical users (such as data analysts and spatial GIS experts) were likely to need the following from the indicators:

- Data tables available to download (eg in csv or Excel format)
- Map shapefiles available to download and use in their own GIS systems
- Metadata for indicators, outlining the details such as data sources, definitions, and analytical techniques used, as well as any issues or uncertainties in the data quality.

Table 5: Key end-users of the indicators, their potential uses of the indicators, and their likely information needs

End-user	**Potential uses for social vulnerability work**	**Information needs**		
		Information about social vulnerability	**Indicators**	**Guidance on implementation**
MCDEM	To provide guidance for CDEM stakeholders on how to assess social vulnerability to floods in their local area, and what measures can be done to reduce social vulnerability, through the 4 Rs	Information about the types of people who might be more vulnerable during a flood event Information about how social vulnerability differs from resilience	Indicators available across the whole of New Zealand	Input from CDEM stakeholders on how they might use social vulnerability indicators
CDEM Groups and local council CDEM staff	To identify vulnerable population groups for targeting and prioritizing efforts, such as resource allocation during emergencies (including emergency shelters etc) To provide clear effective communication to the public around disasters and their risk To inform emergency preparedness and planning, including for key community groups and local iwi/hapū	Information about the types of people who might be more vulnerable during a flood event	A range of indicators to choose from, to be relevant to their local population Quantitative data, to understand about their local population who are at risk and the number of people with diverse needs Spatial data to use in their own GIS (geographical information systems), to show the spatial distribution of vulnerable population groups in the local area Data on other important factors, such as people working out of the local area (commuters)	Guidance in deciding which indicators to choose for their local area Guidance on how social vulnerability indicators might be applied across the 4 Rs.
Land use planners at local councils	Reducing risk to the population by limiting future development in flood hazard zones Understanding the importance of having high-quality flood hazard data Incorporating a consideration of the vulnerability of people using buildings (for example, childcare centres, rest homes) when developing the District Plan objectives and rules for new developments, and change in use of existing buildings	Robust evidence linking each social vulnerability indicator to harm from flooding, in order to stand up to scrutiny as part of the district plan review process	Application of the social vulnerability indicators to the types of buildings and building uses, which might lead to a clustering of vulnerable people inside.	Guidance on how social vulnerability indicators might be applied in a district plan policy writing process.

End-user	Potential uses for social vulnerability work	Information needs		
		Information about social vulnerability	**Indicators**	**Guidance on implementation**
Decision-makers (eg local councillors)	To consider the social and health impacts of flooding on the local people, to help inform the decision-making process around expensive infrastructure upgrades, to complement economic cost-benefit analyses.	Evidence on the likely social and health impacts of flooding on the local population. Evidence on the social vulnerability of the local population	Data on which geographic areas have the highest levels of social vulnerability, particularly if they are located in flood hazard zones	
Local councils	To be proactive about building community resilience and welfare response to the most vulnerable	Evidence on the likely social and health impacts of flooding on the local population. Evidence on the social vulnerability of the local population	Data on which geographic areas have the highest levels of social vulnerability, particularly if they are located in flood hazard zones	
Housing sector	To inform new housing developments, to make housing more resilient to floods and natural hazards	Evidence about how housing can increase vulnerability after a natural hazard Evidence about health impacts from flooding, and ways that these health impacts can be mitigated through housing.	Information about the vulnerability of population groups likely to be living in housing developments	Guidance on how housing (particularly social housing) can be made more resilient to flooding, particularly if the houses are being built in flood hazard zones
Health sector (including public health units)	To identify the health needs of the population, and identify where healthcare services are likely to be affected by flooding To inform emergency preparedness planning and business continuity planning for health services To inform public health communications during and after a flood, including languages and types of information To support work towards equity in the response and recovery stages, as well as in risk reduction, in the local area		Identification of areas with socially vulnerable populations Data on the health needs in the community – eg elderly people, people with chronic health conditions Likely impact due to flood waters affecting pharmacies, hospitals, medical supply depots Thinking about the impact if health services are flooded and out of action Areas where need for psychosocial support may be higher in the longer-term	
Education sector	To inform emergency preparedness and planning To inform understanding of the vulnerability of the local community		Identification of areas with socially vulnerable people in the local neighborhood Information about the flooding vulnerability of the school/ECE, and the neighborhoods where the local children come from	
Māori and local iwi	Inform Māori-led social development projects, including housing developments, employment prospects, building resilience. Acknowledge important role of marae in the community. Get direct communication between local council civil defence and local iwi – particularly when information is needed to protect marae, taonga etc	Information on what types of factors increases social vulnerability to floods	Data specifically about the Māori population	Information on how to address vulnerabilities in their local community, and build resilience
Local communities	Getting vulnerable people and communities (eg people with life	Information on what types of factors increases social vulnerability to floods	Data on which geographic areas have the highest levels	Information on how to address vulnerabilities in their local

End-user	Potential uses for social vulnerability work	Information needs		
		Information about social vulnerability	**Indicators**	**Guidance on implementation**
	threatening or chronic health conditions) involved in developing emergency plans Thinking about likely impact of climate change on flooding, and how to start mitigating and adapting to this		of social vulnerability in their local area	community, and build resilience
RiskScape users	Using RiskScape social vulnerability resource layer, to give information about the location and characteristics of socially vulnerable populations	Information on what types of factors increase social vulnerability to floods	As small an area as possible for indicator data (eg meshblock or area unit). Metadata	Tutorial document on how to use the social vulnerability resource layer within RiskScape

9. Conceptual framework for understanding social vulnerability

Summary

We developed a conceptual framework to help understand social vulnerability to flooding, and to guide the indicator selection process. Flooding has both a natural hazards and a climate change perspective, so we needed a unifying model that brought these different viewpoints together in a cohesive way.

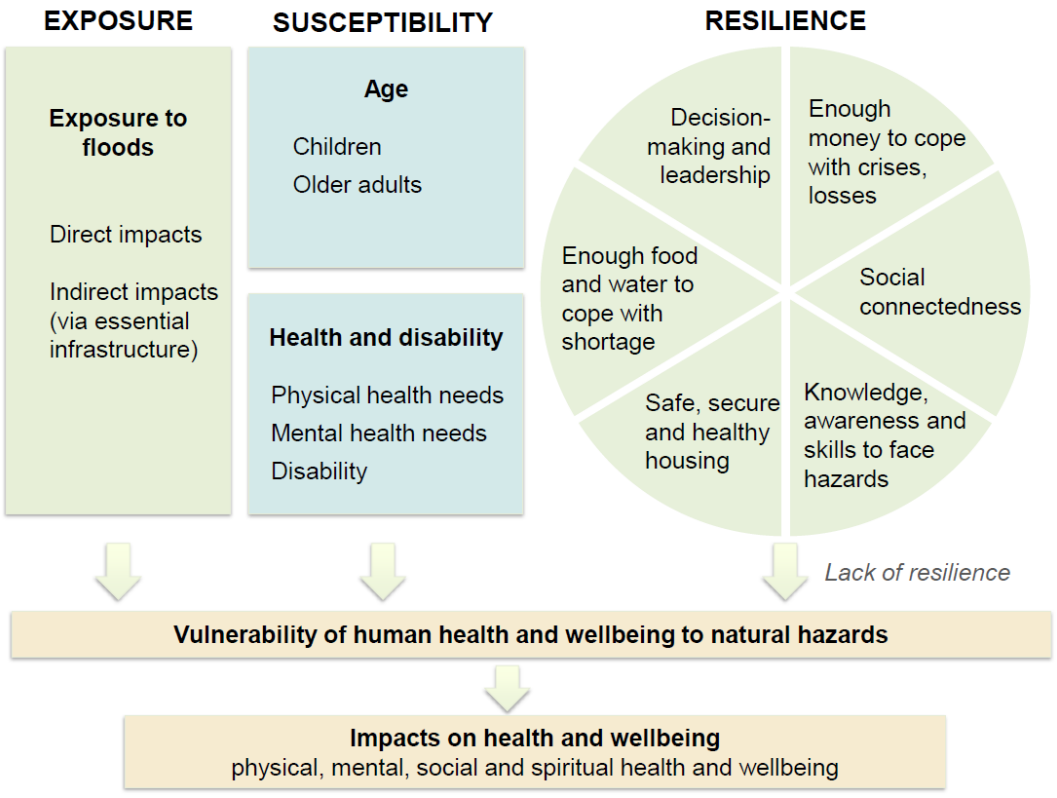
We used the following frameworks and models:

- MOVE (Methods for the Improvement of Vulnerability Assessment in Europe) framework (Birkmann et al 2013), for both natural hazards and climate change
- circle of resilience (Wisner et al 2012)
- climate change and health framework (USGCRP 2016)
- the Māori model of health, Te whare tapa whā (Durie 1985).

By bringing these frameworks and models together, we developed a conceptual framework for social vulnerability that defines the three main components of vulnerability as:

- Exposure (being exposed to flooding)
- Susceptibility (being more susceptible or sensitive to the impacts of flooding)
- Lack of resilience (determined by the capacity to anticipate, cope and recover).

Each component has one or more dimensions (see diagram below).



This chapter describes the conceptual frameworks and models that influenced our work, and how these were used to inform our conceptual framework for social vulnerability indicator for flooding.

Conceptual frameworks help to bring together a range of concepts and relationships, and show the way ideas are organised and relate to each other. They are generally based on a literature review, and bring together ideas into a cohesive whole.

Developing a conceptual framework is an important part of the indicator development process, as it informs indicator selection, and helps to identify and align indicators.

For this work, the conceptual frameworks needed to draw on several different disciplines, including:

- Disaster risk management vulnerability assessments
- Climate change vulnerability assessments
- Public health concepts of health and wellbeing
- Māori world-views and concepts of health and wellbeing.

Conceptual frameworks for social vulnerability

A variety of approaches exist for understanding social vulnerability to natural hazards, coming from a range of disciplines, including political and social sciences.

Across these approaches, risk is generally conceptualised as the potential for loss. Risk is generally given as a function of hazard and vulnerability:

Risk = function of (Hazard, Vulnerability)

where hazard refers to a hazardous event, and vulnerability refers to the propensity of exposed people to experience harm and suffer loss (Birkmann et al 2013). Disaster risk has also been defined by UNISDR as “the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity”.[1]

Over the past 30 years, a range of models have been used to understand social vulnerability to natural hazards to better understand risk. Some of the key models include:

- Hazards-of-place model of vulnerability (Cutter 1996)
- Pressure and release model of vulnerability (Wisner et al 2004)
- Access model (Wisner et al 2004)
- Vulnerability framework (Turner et al 2003)
- Climate change impacts model (IPCC).

These models are not generally conflicting; rather, they describe vulnerability from different perspectives, and have different focuses (Birkmann et al 2013). The hazards-of-place model focuses on how the geographic context interacts with the social characteristics of society to produce the overall place vulnerability. The pressure and release model focuses on vulnerability arising from inequalities in society, which create pressure in society. The access model focuses on the access that people have to capacities, assets and opportunities. The vulnerability framework frames vulnerability as having components of exposure, sensitivity and resilience, and being influenced by a range of contextual factors at the societal and environmental levels. The IPCC climate change

[1] See: https://www.unisdr.org/we/inform/terminology

impacts model focuses on how vulnerability and risk are influenced by the hazard, exposure, sensitivity, and people's capacity to cope and adapt.

However, given that flooding can be considered from both a disaster risk management and climate change adaptation perspective (Birkmann et al 2013), we needed a unifying model that brought these different viewpoints together in a cohesive way.

The MOVE framework – bringing together disaster risk management and climate change models for understanding vulnerability

The MOVE framework (Methods for the Improvement of Vulnerability Assessment in Europe) brings together the two approaches of disaster risk management and climate change for understanding vulnerability to natural hazards (Birkmann et al 2013).

The aim of the MOVE framework was to develop a cohesive framework for assessing vulnerability, which can be used for both natural hazards, and climate change impacts. In particular, the framework brings together risk reduction, resilience (coping) and adaptation. The authors describe it as 'a multi-dimensional and holistic framework for assessing vulnerability' (Birkmann et al 2013).

The MOVE framework incorporates, into one holistic framework, four distinct approaches to understanding vulnerability and risk: (i) the political economy approach, (ii) the social-ecology approach, (iii) vulnerability and disaster risk assessment from a holistic view, and (iv) climate change systems science. The framework was developed for Western Europe, but has been used in other countries, including in Africa (Kablan et al 2017, Sané et al 2015).

The MOVE framework has the following key features.

- *Vulnerability* includes exposure, susceptibility/fragility, and lack of resilience.
    - *Exposure* refers to exposure to natural hazards or climate change, and it has a spatial and temporal dimension.
    - *Susceptibility (or fragility or sensitivity)* refers to the susceptibility or sensitivity of people (or assets etc) to the impacts of the hazard. It can include physical, ecological, social, economic, cultural and institutional factors.
    - *Lack of resilience* is determined by the capacity to anticipate, cope and recover.
- *Risk* is a result of hazard and vulnerability interacting. Risk is described as the potential impact on economic, social and environmental domains.
- *Adaptation* is about both hazard intervention and vulnerability intervention.
    - *Vulnerability intervention* can include exposure reduction, susceptibility reduction and resilience improvement. In this case, resilience improvement can also mean adaption to climate change impacts, such as through learning from previous disasters.
- *Risk governance* includes the activities of organisation, planning and implementation, plays a crucial role in adaptation, hazard intervention and vulnerability intervention.

Figure 3: The MOVE framework for vulnerability assessment (Birkmann et al 2013)

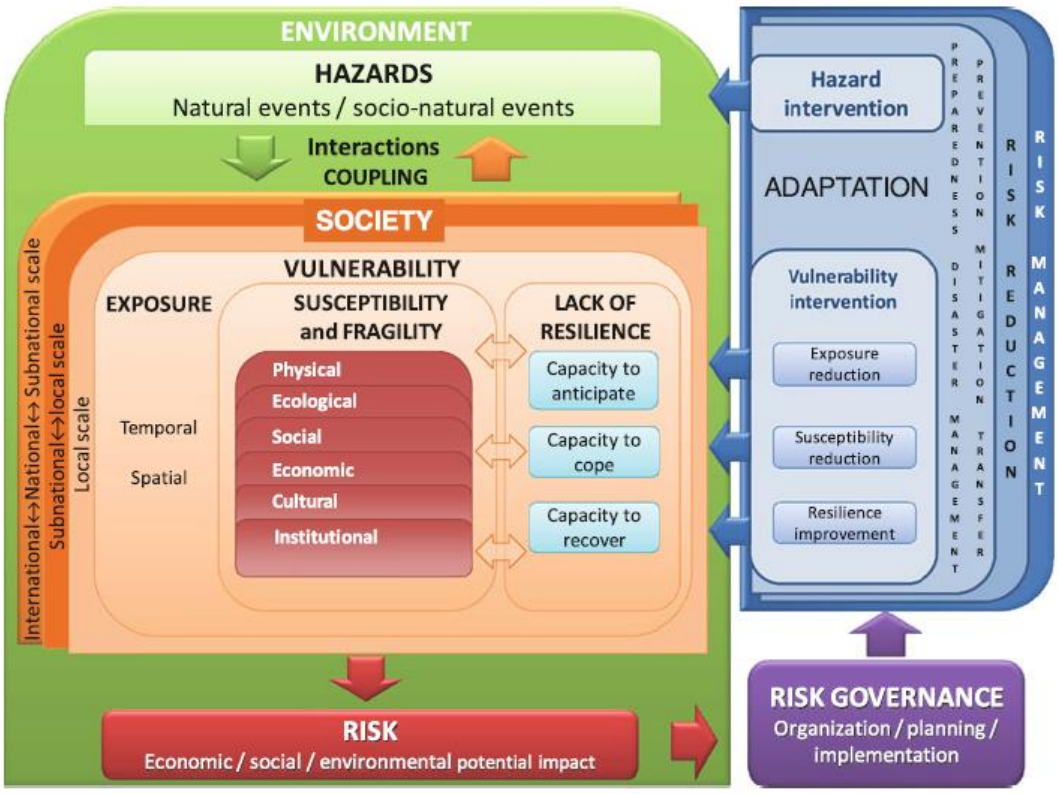


Fig. 1 The MOVE framework (own figure, based particularly on concepts of Cardona 1999a, p. 65; Cardona 2001; Turner et al. 2003; Bogardi and Birkmann 2004; IDEA 2005; Birkmann 2006a, b; Carreño et al. 2007a)

The MOVE framework gives us the overall framework through which we can understand vulnerability. However, to use this framework to develop social vulnerability indicators, we need to understand some components of the framework better. This includes having a better understanding of the following parts:

- social impacts, in terms of health and wellbeing
- vulnerability, in terms of impacts on human health and wellbeing
- resilience (and capacities)
- vulnerability intervention
- environmental and social contextual factors that influence social vulnerability.

From these more detailed understandings, we then can bring all the components together into a comprehensive conceptual framework for understanding social vulnerability to natural hazards.

Understanding social impacts, in terms of health and wellbeing

In the MOVE framework, the 'Risk' box refers to 'Economic / social / environmental potential impact'. In this framework, 'social impacts' refers to impacts on people (as compared with impacts on the economy or on the environment).

For the purposes of this project, we have interpreted social impacts as impacts on health and wellbeing. In particular, we have used conceptualisations of health and wellbeing from the World Health Organization, Sendai Framework, and a Māori conceptual model of health and wellbeing.

World Health Organization

Health is defined by the World Health Organization as 'a complete state of physical, mental and social wellbeing, not merely the absence of disease or infirmity'.

From a flood perspective, this means that health can be thought of as more than simply physical health (avoiding injuries and death), to also include mental wellbeing and social wellbeing.

Sendai Framework

The Sendai Framework refers to 'lives, livelihoods and health'. This definition acknowledges that livelihoods are an important aspect of social wellbeing, particularly in terms of being able to financially provide for families and households, which then determines health and wellbeing (including mental health) in the longer term.

Māori conceptual model of health and wellbeing - Te whare tapa whā

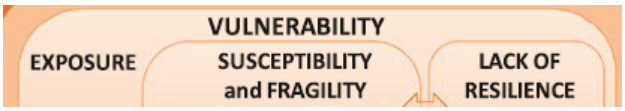
Māori have a holistic approach to understanding health and wellbeing. Mason Durie proposed the conceptual model of 'te whare tapa whā' (the house with four walls), as a way of understanding Māori health, and the four dimensions of Māori wellbeing (Durie 1985) (Figure 4). If any one of the four dimensions is missing or in some way damaged, a person or a collective may become 'unbalanced' and subsequently unwell. These four walls are:

- *Taha tinana* - physical wellbeing – capacity for physical growth and development
- *Taha hinengaro* - mental and emotional wellbeing - the capacity to communicate, think and feel; mind and body are inseparable
- *Taha whānau* - family and social wellbeing – the capacity to belong, to care, and to share, where individuals are part of wider social systems; the importance of whānau
- *Taha wairua* - spiritual wellbeing – faith and wider communication; spiritual awareness and a mauri (spirit and vitality); the spiritual essence of a person is their life force; belief in god; connection and relationships with the environment; access to tribal lands or territories (Harmsworth & Awatere 2013).

This Māori model of health and wellbeing highlights the importance of incorporating not only physical health, but mental health, the health of family and whānau, and spiritual health.

Figure 4: Te whare tapa whā – Māori model of health and wellbeing (Durie 1985)

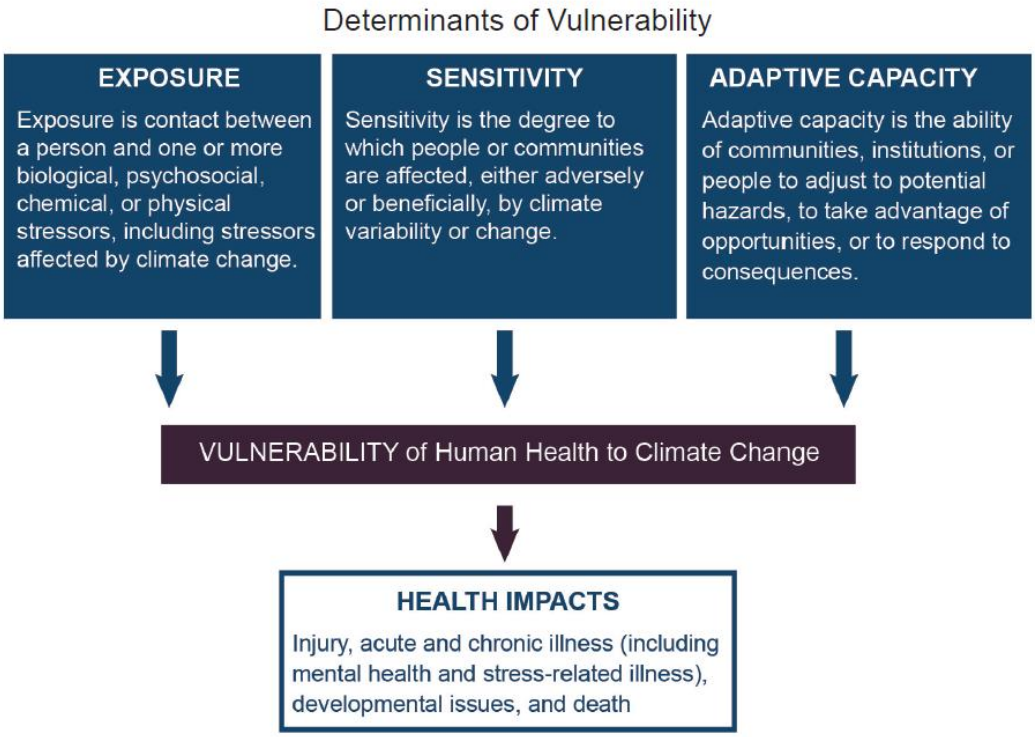
Understanding vulnerability, in terms of impacts on human health and wellbeing



To help further apply the MOVE framework's box on vulnerability as it relates to impacts on human health and wellbeing, we draw on the work of the U.S. Global Change Research Program (USGCRP 2016). This research group have used a similar approach to the MOVE framework to describe vulnerability to climate change, but with a focus on human health impacts.

In the framework developed by this group, vulnerability incorporates three main components of *exposure*, *sensitivity*, and *adaptive capacity*. Figure 5 shows this conceptualisation of vulnerability from a health and climate change perspective. From a climate change perspective, susceptibility/fragility are referred to as sensitivity, and lack of resilience has become adaptive capacity.

Figure 5: Determinants of vulnerability of human health to climate change (USGCRP 2016)



Understanding susceptibility/sensitivity

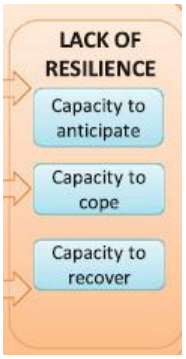
From an environmental health perspective, the term *susceptibility* can be understood as the degree to which individuals or groups may be affected by a given exposure to a hazard. People who are susceptible have a higher likelihood (or severity) of health impacts due to exposure to a hazard, compared with other people who are exposed to the same hazard (Faustini et al 2010).

Susceptibility can be divided into two types:

- innate susceptibility: largely due to genetic predisposition or to incomplete development of normal adult physiological functions (for example, newborn babies not yet having an immune system)
- acquired susceptibility: may be due to disease or age (for example, people with pre-existing heart disease).

In the context of natural hazards and flooding, susceptibility can be simplified to include the young, the old, and people with pre-existing health conditions and disabilities.

Understanding resilience (and capacities)

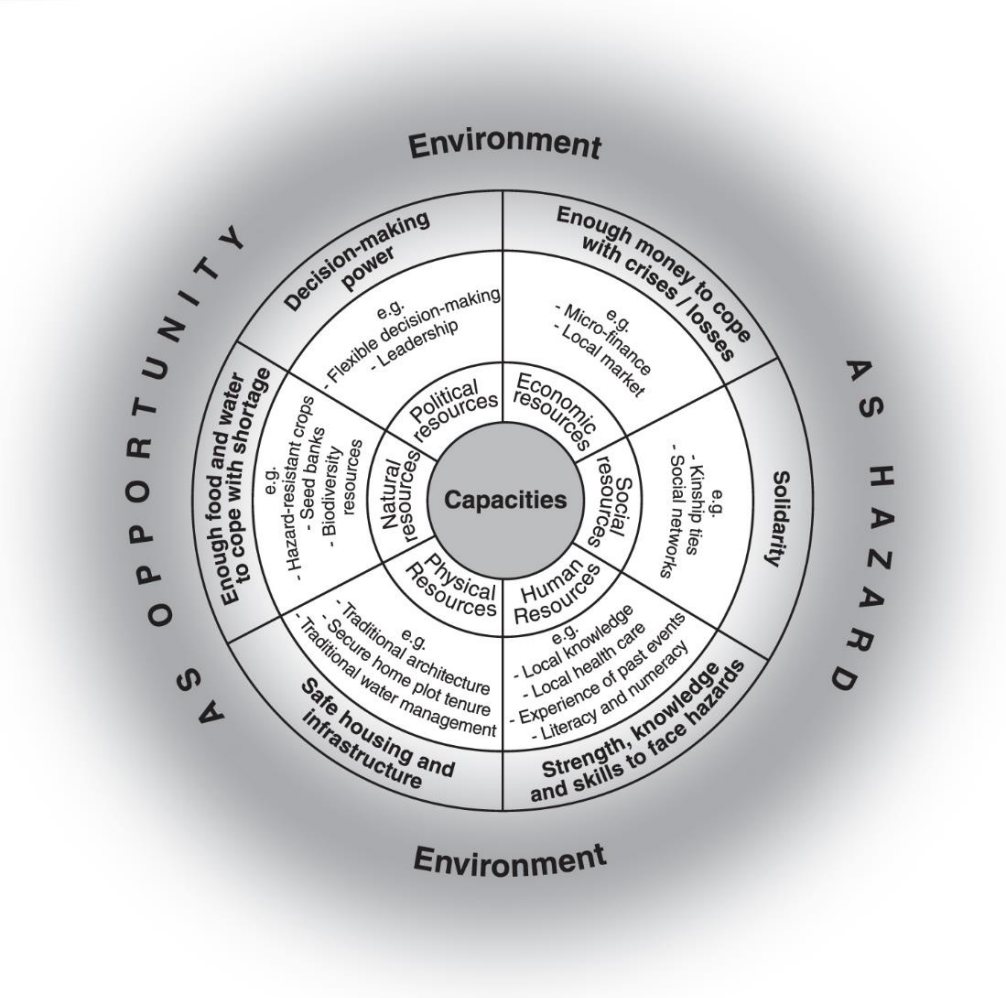


The MOVE framework refers to 'lack of resilience' as a key component of vulnerability. In this context, resilience refers to capacities: the capacity to anticipate, the capacity to cope, and the capacity to recover from natural hazards. However, it is helpful to consider the underlying factors that play a role in capacity and resilience.

To better understand the factors underlying a lack of resilience, we have used idea of the circle of resilience, adapted from the circle of capacities (Wisner et al 2012). Figure 6 shows the circle of resilience, which outlines six components that make people more resilient to the impacts of natural hazards. The components of resilience are:

- Enough money to cope with crises / losses (economic resources)
- Solidarity (social resources)
- Strength, knowledge and skills to face hazards (human resources)
- Safe housing and infrastructure (physical resources)
- Enough food and water to cope with shortage (natural resources)
- Decision-making power (political resources)

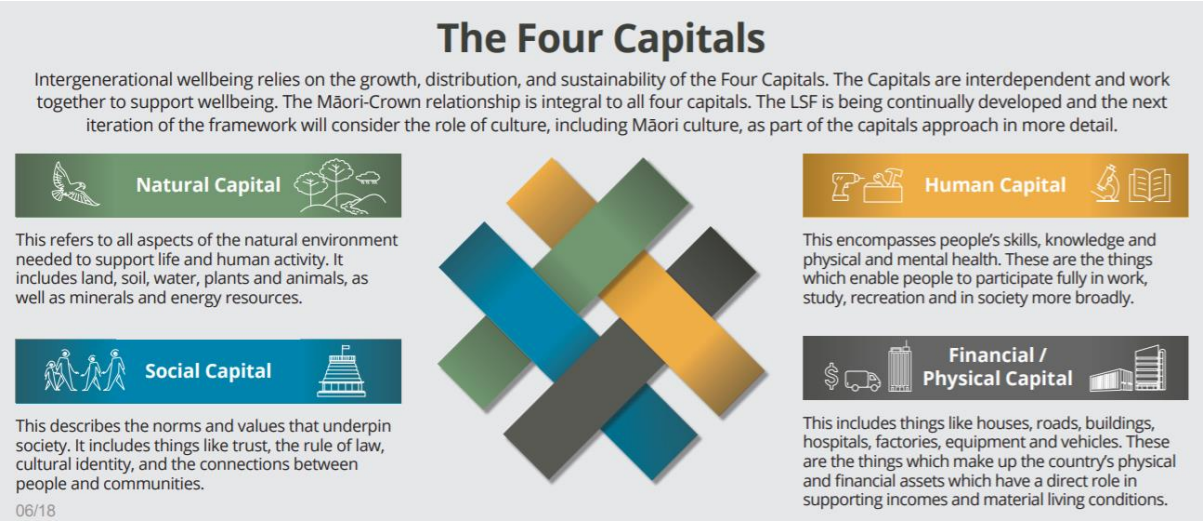
Figure 6: The circle of resilience (adapted from the circle of capacities from Wisner et al (2012))



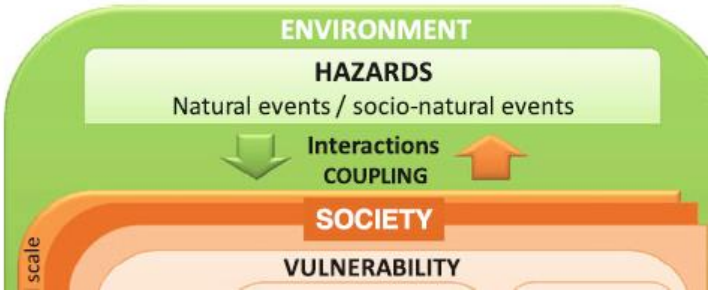
In terms of capacities, the New Zealand Treasury has also recently developed the Living Standards Framework (Figure 7). This framework helps to explain wellbeing in terms of Four Capitals: natural capital, social capital, human capital and financial/physical capital, and is based on the OECD definition. The capacities in the circle of resilience, and susceptibility, align with the four capitals, as follows:

- Natural capital: Enough food and water to cope with shortage
- Human capital: Strength knowledge and skills to face hazards; physical and mental health
- Social capital: Social connectedness; decision-making and leadership
- Financial/physical capital: Safe, secure and healthy housing; enough money to cope with crises/losses.

Figure 7: The Living Standards Framework, developed by the New Zealand Treasury (MCDEM 2019)



Understanding environmental and social contextual factors influencing social vulnerability



The environmental and societal context in which vulnerability to natural hazards occurs is important for understanding social vulnerability. This is shown in the MOVE framework, and is also a common theme in other vulnerability models. Contextual information is likely to be important when assessing social vulnerability in a local area, and in many ways forms the baseline information against which to interpret social vulnerability indicators.

Recently, there has been greater understanding and acknowledgement that climate change is likely to have a large influence on social and environmental context factors, as well as climate-related hazards. This suggests that when considering contextual factors, it is helpful to also include climate change impacts.

Figure 8 shows a conceptual model for understanding the contextual factors that influence flooding and related health impacts, in the context of climate change. In this model, contextual factors are separated into environmental and institutional context (such as land use planning, flood control, critical infrastructure, and emergency preparedness), as well as social and behavioural contexts

(such as social determinants of health and emergency preparedness). This model also demonstrates how climate change can influence the health impacts of flooding:

- directly through climate drivers, such as increased frequency and severity of flooding
- indirectly, through affecting both the wider (environmental and institutional) context, and the individual (social and behavioural) context.

Figure 8: Conceptual model of exposure pathways and contextual factors for flood impacts on human health (USGCRP 2016)

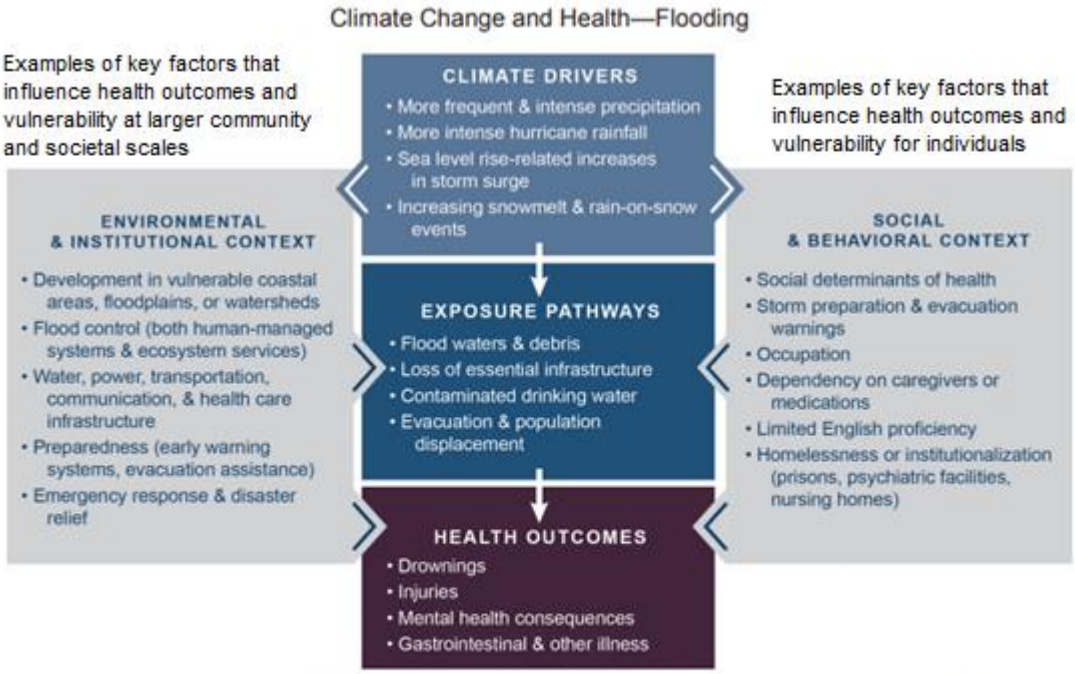


Figure 2: This conceptual diagram for a flooding event illustrates the key pathways by which humans are exposed to health threats from climate drivers, and potential resulting health outcomes (center boxes). These exposure pathways exist within the context of other factors that positively or negatively influence health outcomes (gray side boxes). Key factors that influence health outcomes and vulnerability for individuals are shown in the right box, and include social determinants of health and behavioral choices. Key factors that influence health outcomes and vulnerability at larger community or societal scales, such as natural and built environments, governance and management, and institutions, are shown in the left box. All of these influencing factors may also be affected by climate change. See Chapter 1: Introduction for more information.

Adapted from USGCRP (2016), p102

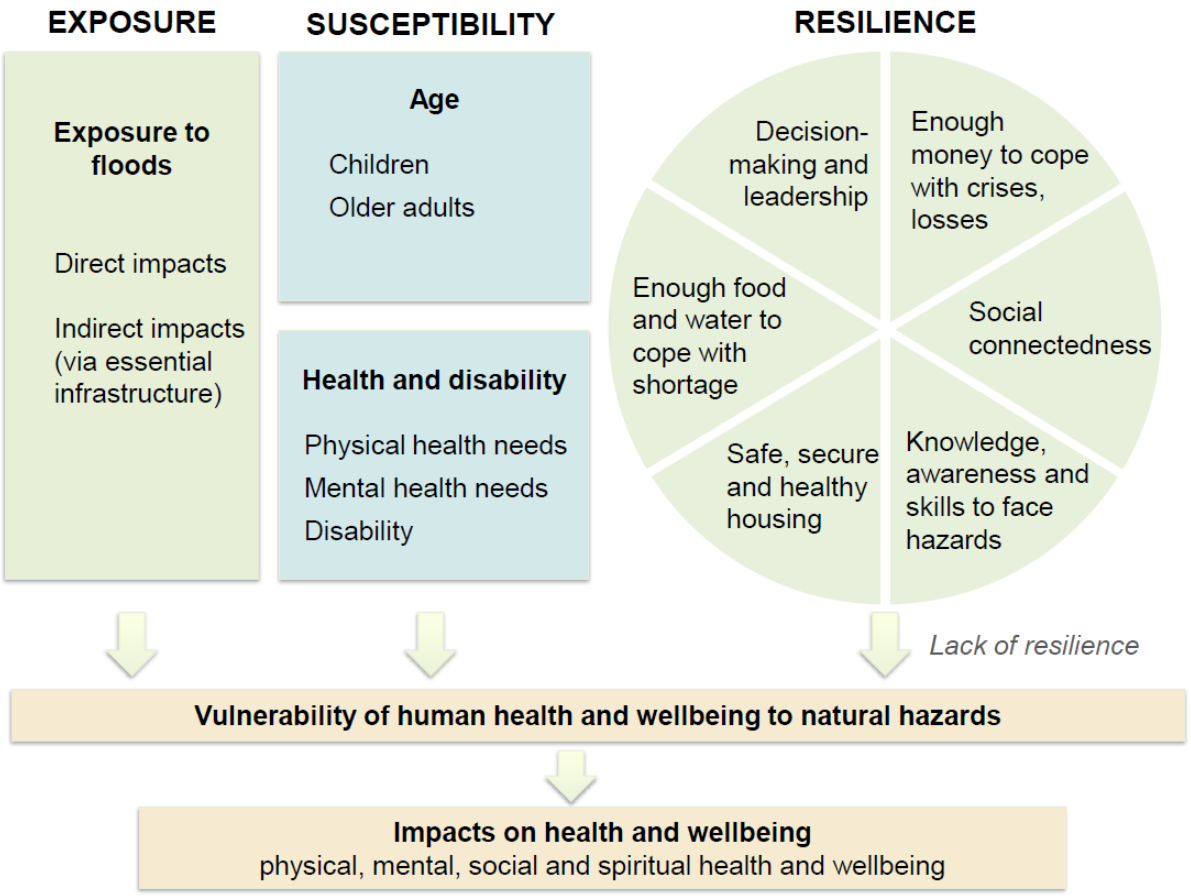
Bringing it all together - our conceptual framework for social vulnerability to flooding

Figure 9 presents our conceptual framework for social vulnerability to flooding. This framework brings together the different elements from the MOVE framework (Birkmann et al 2013), the circle of resilience (Wisner et al 2012), the climate change and health framework (USGCRP 2016) and the Māori model of health, Te whare tapa whā (Durie 1985). The framework incorporates our understanding of health and wellbeing, vulnerability, resilience, and contextual factors.

In our conceptual framework, social vulnerability is separated into three main components: exposure, susceptibility, and lack of resilience. These three components of vulnerability were based on the MOVE framework, and are defined in a similar way to that used in the climate change and health framework. Susceptibility was divided into age (the young and old) and health status (physical health, mental health, and disabilities), according to environmental health understandings of susceptibility. Resilience was conceptualised using the circle of resilience, into six dimensions of

resilience. We adapted the dimensions to the New Zealand context. These aspects of resilience are supported by Mātauranga Māori, as identified in chapter 6. The link between social vulnerability, to increased vulnerability to natural hazards, to impacts on health and wellbeing, was adapted from the climate change and health framework.

Figure 9: Conceptual framework for social vulnerability to flooding in New Zealand



In particular, Mātauranga Māori helped to inform the aspects of resilience included in the conceptual framework. The capacity and resilience in Māori communities that comes from Māori cultural values is represented in the framework as *Social connectedness*. Māori participation in disaster risk reduction decision-making, before, during and after emergencies, is represented as *Decision-making and leadership*. Appropriately resourcing marae so that they can support communities in response is represented in *Safe, secure and healthy housing* and *Enough food and water to cope.* Knowledge and experience of natural hazards and responding to disasters is represented under *Knowledge, awareness and skills to face hazards*. For understanding health and wellbeing, we used the Māori model of health, Te Whare Tapa Whā, to include physical, mental, social and spiritual wellbeing. This enabled a broad definition of health and wellbeing to be considered as part of understanding social vulnerability.

10. Understanding the dimensions of social vulnerability in our framework

Summary

For each dimension of social vulnerability in the conceptual framework, we identified the reasons (causal pathways) for vulnerability to flooding. These pathways focus generally on people's ability to prepare for emergencies, cope during a flood (eg evacuating, having access to healthcare), and recover after a flood. The rationale were based on a literature review and previous sets of social vulnerability indicators.

We identified rationale for vulnerability for the following dimensions of social vulnerability:

- Exposure dimensions:
  - Exposure (direct impacts of flooding)
  - Exposure (indirect impacts via infrastructure impacts)
- Susceptibility dimensions included:
  - Children
  - Older adults
  - People with physical health needs
  - People with mental health needs
  - People with a disability
- Resilience dimensions included:
  - Having enough money to cope with shortage
  - Social connectedness
  - Knowledge, skills and awareness of natural hazards
  - Safe, secure and healthy housing
  - Enough food and water to cope with shortage
  - Decision-making and leadership
- Other individual-level factors

This chapter identifies and discusses the proposed dimensions of social vulnerability relating to flooding, building on the conceptual framework presented in Figure 9.

This chapter draws on a wide range of literature and research to provide evidence and rationale for these different dimensions (Atyia Martin 2015, Birkmann et al 2013, Coninx & Bachus , Du et al 2010, Houghton 2010, March 2002, Phibbs et al 2016, Rufat et al 2015, Shultz et al 2013, Tapsell et al 2002, USGCRP 2016).

1. Exposure

Understanding who is exposed is an important part of assessing risk to natural hazards. Exposure refers to people's exposure to natural hazards, both geographically and in time. Exposure impacts can occur directly because of floodwaters, and indirectly, through impacts on infrastructure.

1a. Exposure to flooding (direct impacts)

People who live in flood hazard zones are exposed to direct impacts from flood waters. Floodwaters may damage their home and/or belongings, put their lives in danger, and/or increase the risk of injury or health impacts.

Additionally, people working, studying at educational facilities, or spending time in flood hazard zones are also exposed to direct impacts from flood waters, if the flood occurs at a time when they are in these locations. Exposure to direct impacts from flood water varies depending on the day of the week, and the time of the day.

1b. Exposure to flooding (indirect impacts via essential lifelines infrastructure and services

People can also be exposed to indirect flooding impacts through lifelines infrastructure damage and disruptions. For example, a flood may directly impact an infrastructure component, which causes a cascading failure within the system, leading to service outage in areas that may not be directly flooded. This can occur when infrastructure hotspots (places where a number of infrastructure assets from different networks are co-located and interdependent) and pinchpoints (single points of failure within an infrastructure network) are flooded.

Floods can case disruption to:

- the transportation system (road, bridges, rail)
- communication lines (mainly underground cables such as landline and internet if there is an electricity outage)
- electricity (also affecting communications, water and fuel)
- three waters (potable, waste and storm water) supply, disposal and contamination
- fuel and reticulated gas supply.

Impacts on the transportation network (road, bridges and public transportation such as rail) may lead to people being cut off or isolated due to floodwaters, even if their property is not in a flood hazard zone. Commuters may be particularly impacted, as well as people travelling to schools and early childhood education facilities to pick up their children. Road blockages, damaged bridges and slips may affect whether emergency services can reach some properties, and whether people can access health services. Additionally, people living in remote communities may be vulnerable if the infrastructure that connects these communities (such as roads and communications) are affected.

Infrastructure issues with electricity, water and gas services can lead to multiple hazards.

- Damaged live power lines increase the risk of electrocution.
- Power outages can lead to issues with food safety and keeping medications such as insulin chilled (fridges and freezers), cooking food, heating, disruptions to medical needs (such as home oxygen therapy), sanitation (hot water for showers), and communications (with no internet, and possibly no phone).
- Gas outages may have similar consequences if people rely on gas for cooking and heating.
- Contaminated drinking water would need to be boiled or disinfected (eg with bleach) before being consumed, otherwise it may pose risks of gastrointestinal illnesses.
- Outages to telecommunications systems (particularly the cellphone network) can cause major difficulties for people in contacting friends and family, and getting access to up-to-date information.
- Disruptions to fuel supplies can also impact transportation.

Floodwaters can also lead to contamination from hazardous substances facilities/industries and/or contaminated sites.

2. Susceptibility

Susceptibility refers to the susceptibility or sensitivity of people to the impacts of the hazards, due to biological traits. For a given exposure, these individuals are more likely to be affected by the hazard. The susceptibility component includes children, older adults, people with physical health needs, people with mental health needs, and people with a disability.

2a. Children

Children, particularly young children (0-4 years), are dependent on adult carers, as they cannot protect themselves during a flood. They may be unable to react themselves to warnings of an impending flood, and they rely on others to move them out of harm's way.

Children are also more susceptible to the impacts of floods, including drowning, infections and diarrhoea. Diarrhoea (and gastrointestinal illness) from contact with contaminated water can increase the risk of dehydration for children. Safe drinking water is particularly important for newborns and young children.

Parents are likely to want to pick up kids from childcare centres and schools in the event of an emergency, which may put them in the path of direct flooding impacts. Additionally, families with children can also find it difficult in the clean-up and recovery stage after a flood, if they do not have childcare available. This may particularly be a risk for single-parent households. Closure of institutions after a flood (temporarily and/or permanently) can make recovery more difficult for parents (through lack of childcare) and children (through changes to their routine), and have an impact on long-term recovery.

Children and youth are also vulnerable to the psychosocial impacts from floods. The main factors that influence this are parental distress, distress in another family member, and marital and family conflict.

However, children can also play a key role in recovery, bringing together community networks through schooling, leisure and friendship networks.

2b. Older adults

Older adults are particularly susceptible to impacts from floods. They often have disabilities and mobility issues, and/or reduced hearing and vision. As a result, they are likely to require the help of others to evacuate, move their belongings to safety, and during the clean-up. They may be unable or unwilling to leave their home before, during and after the flood, which may result in poor living environment. Recovery can often take a long time, because older adults may depend on others to clean the dirt and to negotiate with insurer and builders.

Older adults can also be more susceptible to the health impacts of floods, if they have existing chronic health conditions putting them at increased risk, or poorer physical health condition, which means they may not recover as quickly from physical injuries.

Older adults may also have lost their partners and be living alone or in a rest home. They often have limited social network and few resources, and may become isolated from their usual networks and supports, making recovery difficult.

2c. People with physical health needs

During and after a flood, people with pre-existing health conditions are more susceptible to health impacts and death, as well as problems related to preparedness, protection and evacuation.

People who are vulnerable due to pre-existing health conditions include the following.

- People with existing coronary heart disease are at risk of experiencing a heart attack after a flood, due to stress and excess activity from evacuation and clean-up activities.
- People with diabetes are at risk of developing diabetic foot (such as an infection or diabetic foot ulcer) after contact with floodwaters.
- People with chronic lung diseases (including asthma and chronic obstructive pulmonary disease) are at increased risk of health impacts due to exposure to mould, particularly during the clean-up phase after a flood.
- People who have compromised immune systems are at higher risk of getting an infectious disease.
- People with other particular chronic health conditions (such as tuberculosis, sickle cell disease, HIV/AIDS) may require certain medication, services or electricity to manage their condition during and after a flood.

Some types of medications and health services are essential for people's health, and any disruptions to this care could lead to major health impacts for these people. Disruptions to medication may occur due to people not having access to their homes, power outages, and lack of access to healthcare services

The following people may be vulnerable to the impacts of a flood:

- People on angina medication (for heart disease)
- People with insulin-dependent diabetes
- People needing inhalers (and/or other medications) for chronic lung conditions such as asthma and COPD
- People taking medication for epilepsy
- People taking immunosuppressant drugs
- People on anti-HIV medication
- People taking medication for mental health conditions, such as anti-depressants and anti-psychotics
- People on opioid substitution treatment (OST) (methadone or buprenorphine).
- People needing dialysis for renal failure
- People needing home oxygen therapy.

Pregnant women will also have special needs during a flood, and face risks such as premature delivery, underweight infants and infant mortality. Some women may have to deliver babies without the benefit of hospital care. Some may also run the risk of being evacuated without access to medical records, or may lose access to prenatal vitamins or essential medication. They have a poorer immune response than non-pregnant women (Menne & Murray 2013).

2d. People with mental health needs

People with pre-existing mental health issues are more susceptible to the impacts of flooding, as they may have more difficulties in coping with the stress of flooding. In particular, people with mental

health issues and one or more other vulnerabilities (such as financial stress, or a lack of internet for accessing information and resources) may be particularly vulnerable.

People taking medication for mental health conditions are more susceptible to adverse effects, if they do not have access to this medication. Many of these medications are required daily, and disruptions can lead to mental health impacts. People on opioid substitution treatment rely on being able to collect medication daily from pharmacies, so are a particularly vulnerable group.

People with existing substance abuse disorders (alcohol and/or drugs) are at higher risk of more substance abuse due to stress. For example, studies have shown that people with pre-existing alcohol use disorders tend to be the most vulnerable to increased alcohol use following extreme weather events (USGCRP 2016).

2e. People with a disability

People who are restricted in daily activities by a physical, learning or mental disability are more vulnerable to impacts from floods. They may have difficulty in evacuating, moving themselves, understanding instructions, and taking care of themselves.

People with disabilities living alone or in supported accommodation are more vulnerable to the impacts of floods, because they are likely to be more dependent on care-givers to help them. They may also find it difficult to know or understand what is going on (due to hearing or vision disability, or due to learning difficulties). They may also be hampered in protecting properties, evacuation and recovery. The presence of disabled family member can put pressure on the household organisation, and the recovery of properties may take longer.

3. Resilience

Resilience is determined by the capacity to anticipate, cope, and recover from hazards. Resilience includes the following dimensions: having enough money to cope with crises and recover; social connectedness; knowledge, skills and awareness of natural hazards; safe, secure and healthy housing; enough food and water to cope with shortage; decision-making and leadership. A lack of resilience contributes to vulnerability.

3a. Having enough money to prepare, to cope with crises and to recover and adapt

People need to have enough money to prepare for floods, to cope with floods, and to recover and adapt after floods occur. People with low-to-no income often do not have the money to protect themselves from flooding, through insurance, flood protection materials or works, and having sufficient emergency food and supplies. Financial deprivation can also lead to difficulties in providing the basic needs, such as food, housing, car and fuel, telecommunications (such as phone and internet access), and insurance, which can all impact on health and wellbeing. A lack of employment can make it difficult to recover after a flood, due to lack of income.

After the flood, recovery can take a long time for low-income households, as they often do not have insurance, and find it difficult to cope with the loss of material goods, as well as damage to the property. After floods, people may find it difficult to move, and end up staying in flood-damaged houses, and/or houses that are damp and mouldy due to water on the ground. Temporary relocation is often no option for those people.

Low-income families can also experience more mental health impacts due to financial stress. This can lead to other social and health impacts, including mental health issues, anxiety, family relationships and conflicts, substance use, and domestic abuse.

Single-parent families are among the more vulnerable population groups, as they have to bear all the financial costs on their own, as well as coping with the stress without emotional support. Single parent families can also be more hampered in meeting basic needs, like food, housing and emotional support to their children. Additionally, childcare may be difficult to arrange during the clean-up stage after a flood, if schools and early childcare centres have closed, which impacts on their ability to recover quickly.

There is also a neighbourhood effect; if many households in an affected area are suffering from financial hardship, this leads to less resilience in the neighbourhood. Additionally, if many people are unable to afford to leave their damaged housing, living in areas that are (or feel) contaminated or affected by flood waters can be bad for morale and community resilience, as well as for health.

After a flood, recovery can take a long time for people with financial stress, and they often end up staying in damp and mouldy houses through an inability to repair damages or leave. Financial stress can also lead to mental health impacts.

Having enough money to cope may mean different things for different people, depending on their level of community support, access to other resources (such as home-grown food), and where they live (urban vs rural).

People in primary industries may be vulnerable after a flood, if they depend on the land for their livelihood.

3b. Social connectedness

Having strong social connections, networks and kinship ties can be very helpful for coping during and after a natural hazard. Knowing other people in the community, and being able to help and support each other during and after a flood, is very important for resilience. Schools, early childhood centres, marae and places of worship are important for social networks and social connectedness in a community.

By contrast, social isolation is an important aspect of vulnerability for people, as it means that people may not have people to help them if needed, including to evacuate (if they have mobility issues), and coping after an event.

Some population groups may be more likely to suffer from social isolation. Older adults living alone may experience social isolation, if they do not have other strong social networks. Single parents can be vulnerable, as they may have a lack of emotional support, and have to bear all the financial costs on one income. They may find it more difficult to meet basic needs, like food, housing and emotional support to their children. A lack of transport can also contribute to social isolation and loneliness.

People who are new to an area, and particularly people who have recently arrived in New Zealand, may struggle more after a flood, if they do not know other people in their neighbourhood, or how to access official support. If the neighbourhood is full of people who have not lived there for a long time (for example, if there are many rental properties in the area), then the social networks may not have had time to establish themselves.

There are also strong factors that can lead to strong social connectedness and therefore resilience, including:

- rural communities, who are used to helping each other out
- local iwi, who have strong kinship ties and provide support (whanaungatanga and manaakitanga) to people at their marae during a disaster
- communities with schools and kindergartens, which can provide a good source of community cohesion
- community engagement, networks and resilience.

In New Zealand rural areas, as farms get larger, the distances between farms also gets larger, which can lead to increasing social and geographic isolation.

3c. Knowledge, skills, and awareness of natural hazards

An important aspect of coping with natural hazards and floods is having an awareness of the risks, and the knowledge and skills to cope.

A lack of awareness is an important cause of vulnerability in flooding. A lack of awareness can be due to a lack of knowledge of flood hazards in the area, for example, due to being new immigrants or tourists. People living in an area for a longer time have a better knowledge and experience of flood risk (particularly for regular flood events), than people who have lived in the area for a shorter time. Newcomers often do not know the flood history of the area. People who do not have previous experience of hazard impact or indigenous knowledge of hazard impacts will be more vulnerable. People who are new to the area, seasonal or transitory workers, or tourists, are particularly vulnerable.

Understanding information is also important for being able to prepare adequately for floods, understand early warnings, know where to evacuate to if needed, and how to cope and recover after the event. People who have limited proficiency in English may not be able to understand local warnings. Language difficulties can hamper access to appropriate information on flood warnings, evacuation plans and recovery mechanisms, including support services during the recovery phase. Therefore, it is possible that these people are surprised by the flood, do not know how to prepare, or to evacuate and have no idea about the existence of disaster insurances or funds. Recent migrants may also struggle, even if they have good English skills, as they may not be as aware of the hazard, or aware of the New Zealand system for accessing help and support services during and after the event.

People without access to telecommunications or internet may also be particularly at risk, if the internet is the main way that information is shared during the readiness phase (eg how to get prepared for a flood), response phase (eg updated weather information) and recovery phase (eg boil water notices, how to access help).

3d. Safe, secure and healthy housing

Having safe housing after a flood is very important, as shelter, warmth and security are some of the basic needs for human survival.

At the basic level, houses that are not well constructed are more at risk of being washed away during flood events. Building construction standards, and the location of buildings in relation to flood hazard zones, are important factors that influence the vulnerability of houses and the people who live in them.

People living in houses with low floor heights (relative to flood depths) and in single-storey properties (with nowhere high to go) can also be more vulnerable. They are more at risk of

experiencing damage to personal belongings, and may not have anywhere to go to escape flood waters. If houses are damaged after a flood, people can be displaced or have to endure living in a broken home. Additionally, floodwaters may pond under low-lying houses after a flood, leading to damp and mould issues. People in these households are likely to suffer more household disruption, longer periods of evacuation, and a greater loss of sentimental items.

People's living situation can also make them vulnerable. Overcrowded houses can increase the number of people in a hazard zone, put pressure on emergency resources in a household, and increase the risk of infectious diseases. They are also particularly susceptible to housing issues if they are displaced due to the flood. People living in rental housing are at risk of having a lack of housing after a flood, for example if the owners need to do repairs. People in rental properties are also likely to live in poorer quality housing (including damp, mouldy housing, which can affect health).

People experiencing homelessness / severe housing deprivation (which includes people living in emergency housing, camping grounds, boarding houses, marae and those in severely overcrowded households) are also particularly vulnerable. They do not have permanent safe shelter (which is a basic need), or many belongings or emergency provisions. They may also lack social networks, and may not have good access or established relationships with health and support services. They may find it difficult to get good information and early warnings about an event, or to access help. They are also more likely to have existing health and/or mental health conditions, which make them more susceptible to the impacts of natural hazards.

Houses on Māori land cannot be sold, so people living in these houses cannot move if the property is damaged in a flood. This means these people may have difficulties in recovering after a flood, and may remain living in flood-damaged houses if they do not have the resources to repair the house or have alternative accommodation.

Additionally, people also need to have an emergency shelter they can go to in their local area. This emergency shelter needs to be out of the hazard zone, accessible to all, and provide shelter from the weather. In previous emergencies, marae have played an important role as evacuation shelters for the local community. If emergency shelters such as marae and schools are located in a flood hazard zone, this increases the vulnerability of the community.

3e. Enough food and water (and other essentials) to cope with crises

Having enough safe food and water, as well as ways of cooking food and ensuring that drinking water is safe, is essential for survival in the immediate days after a flood, as well as longer term. A lack of emergency water, emergency food supplies, electricity supplies (to cook food, boil water, and keep fridges and freezers going) and/or shelter can severely impact on people's health and wellbeing.

Other essential items for meeting basic needs after a flood may include essential medication, torches, batteries, emergency cooking facilities (and/or ability to boil water), a way of disinfecting water (eg bleach, if boiling water is not an option), and emergency food that is safe to eat. People with good emergency preparedness, including emergency plans in place, are more likely to have sufficient supplies to get through a disaster.

Food insecurity (a lack of access to safe, nutritious and affordable food) pre-disaster can increase the risk of a household not having sufficient food after a disaster. Floods can also affect the ability to produce and gather food from the land, particularly in rural areas and/or isolated communities, which can impact on food security.

In New Zealand, some population groups are less likely to meet emergency preparedness requirements or have food security. These groups include people with low household incomes, people living in rental housing, and sole parents[2]. These factors could be used as proxy indicators to help understand the areas where people might be less likely to have enough food and water to survive after a flood (if neighbourhood-level data were not available for indicators of emergency preparedness and food security).

For countries that produce most of the food for their population, large-scale disasters can have a large impact on the country's ability to feed their population. In New Zealand, floods are unlikely to affect such a large region that the food supply chain is disrupted and there is not enough food. However, floods might affect some regions that have a concentration of one crop, or isolate communities that rely heavily on the land for their food.

Having access to safe drinking water is also important for protecting health and wellbeing. Flood waters can often lead to contaminated drinking water, which can lead to diarrhoea and gastrointestinal illnesses.

3f. Decision-making and leadership

People's ability to participate in, and influence, decision-making and leadership (which includes flexible decision-making, access to decision-makers, and self-efficacy) plays an important role in resilience. People without involvement in decision-making are likely to feel left out of the process, and not have their needs listed to or fully met. Being inclusive in decision-making, particularly for iwi/hapū and more vulnerable population groups, helps to build resilience. At the individual level, self-efficacy and autonomy are important for making people feel like they have a sense of control over their situation.

Decision-making can occur at many levels, including individual and household, iwi/hapū, CDEM groups, local government (council staff and Councillors), central government (MPs and Ministers), and everything in between. For example:

- individual /household/whānau level – being autonomous, able to make decisions for yourself, and within your household and family/whānau
- community level – able to participate in decision-making about things happening in the local community
- iwi/hapū – ensuring Māori and local iwi/hapū have sufficient knowledge and information to be able to make autonomous decisions and build resilience
- local government – participating in local council processes through submissions etc, such as infrastructure upgrade decisions, and through local body elections
- CDEM response
- central government

Decision-making impacts can occur at all stages of the disaster management cycle, including:

- risk reduction activities, such as deciding where infrastructure should be upgraded

[2] In 2010, household emergency preparedness was less common in New Zealanders for people living in rental accommodation, single parents, and people with low household income Statistics New Zealand. 2012. *How prepared are New Zealanders for a natural disaster?* Wellington: Statistics New Zealand. . Similarly, in 2015/16, rates of food insecurity were highest for New Zealand children living in houses rented from a public landlord (52.9% of children were food insecure) or private landlord (27.7%), living in a household with an income below $30,000 (about 52%), living in more deprived areas (NZDep2013 quintile 5) (34.8%), living in single parent households (38%), and having a caregiver receiving a means-tested benefit (55.8%) Ministry of Health. 2019. *Household Food Insecurity Among Children in New Zealand*. Wellington: Ministry of Health.

- readiness, such as being involved in preparing emergency plans that meet the needs of these people, and ensuring emergency shelters will be accessible to those with mobility issues
- response, such as having members of vulnerable population groups as part of the CDEM welfare network
- recovery, such as decisions around red-zoning areas.

There is strong support in the policy context for recognising the importance of being involved in decision-making for building resilience.

- The Sendai Framework for Disaster Risk Reduction calls for people with specific needs or vulnerabilities to be engaged in the design and implementation of policies, plans and standards. These population groups included women, children and youth, persons with disabilities, poor people, migrants, indigenous peoples, volunteers, the community of practitioners, older people, and people with life-threatening and chronic diseases.
- The Ottawa Charter of Health Promotion has the concept of 'enabling' as a key strategy, which refers to empowering people to control the determinants that affect their health and wellbeing.
- Te Pae Māhutonga (a Māori conceptual framework for health promotion developed by Sir Mason Durie) includes a central star of *te oranga* (participation in society), and two pointers of *ngā manukura* (community leadership) and *te mana whakahaere* (autonomy).
- The Treaty of Waitangi calls for participation, protection and partnership – in particular, working in partnership with Māori.

4. Other individual-level factors of social vulnerability

A few other factors can also contribute to social vulnerability to flooding at the individual level.

Healthcare workers and first responders are at higher risk of exposure to floodwaters and hazardous situations, and therefore higher risk of psychosocial impacts. People who have a family member involved in the response may also be indirectly affected. However, healthcare workers and first responders can be an asset during a flood, particularly in isolated / cut-off areas.

People who have previously experienced domestic violence are at greater risk of experiencing domestic violence again after a natural hazard. Studies have found that reports of domestic violence increase following natural hazards and civil defence emergencies (Clemens et al 1999), including in New Zealand (Houghton 2010). The main contributing factors tend to be prior abuse, and financial strain, for example through loss of jobs, property damage or loss, damage or destruction of homes, displacement, and absence of childcare when schools and early childcare centres temporarily closed down.

People in institutions (such as prisons) are more vulnerable, as they rely on others to look after them. People serving community-based sentences or who are on parole may also be at increased vulnerability, if they are not aware of provisions that allow them to leave their home to avoid or minimise a serious risk of death. However, people serving sentences such as community work can also be an asset after a flood, through helping with flood clean-ups.

People living in other types of group quarters may also be more vulnerable to the impacts of a flood. These can include university dorms, military quarters, and rest homes.

People who own animals (including pets and livestock), as these people may put their life in danger in order to rescue animals, and may be less likely to evacuate. They may also have more difficulties in evacuating, for example if they have multiple pets, an outdoor dog, or no cat carrier.

5. Contextual factors that can influence social vulnerability

A range of contextual factors can influence social vulnerability to flooding. These include the population and social context, and the environmental and institutional context.

Having some contextual information about the population in an area is important for understanding the underlying drivers of vulnerability and population characteristics. The following information may be useful at a regional level, but also at the neighbourhood level if available. The population and social context includes the following:

- population characteristics and distribution
- population density and growth
- local economy characteristics.

The environmental and institutional context influences health impacts and vulnerability to floods at larger community or societal scale, such as natural and built environments, governance and management, and institutions. For flooding, the environmental and institutional context includes the following:

- development and land use planning
- flood control
- key infrastructure (transport, power, water supply, sanitation, healthcare, communications)
- emergency preparedness
- emergency response and relief.

6. Factors not been included in our conceptual framework

Previous social vulnerability indicators have included indicators for women and for race and/or ethnic group. We consider that sex and ethnicity are proxies for other underlying vulnerability factors, rather than being causally related to vulnerability.

Women have often been identified in social vulnerability indicators as being more vulnerable. Studies suggest that women can have a more difficult time during recovery than men due to family care responsibilities and lower wages. Women are also at higher risk of psychosocial impacts after a flood. However, these studies may come from societies where women are more vulnerable, are less likely to be in employment and have less political power. It is unclear to what extent this is a reasonable indicator for the current New Zealand context.

Ethnic groups and race have also been previously identified in social vulnerability indicator sets. Again, these studies are based in other countries, including the United States, where some minority groups have experienced marginalisation.

11. Indicator selection process

Summary

- After the scoping stage and development of the conceptual framework, we followed a robust indicator selection process to develop a set of indicators that reflected the framework.
- The indicator selection process involved selecting indicators based on causal associations/rationale and availability of data, evaluating the indicators, testing the indicators with a case study, and seeking stakeholder feedback.
- We included stakeholder feedback throughout the process, to ensure that the indicators were robust, that they reflected the New Zealand situation, and that they would be useful to meet the needs of end-users.

This chapter gives a brief overview of the indicator selection process we used. We have provided a flow diagram (Figure 10) to show the process used to select and finalise the indicators. In particular, the process involved stakeholder feedback, trialling indicators, and refining the indicator dataset. This process is briefly described below.

Firstly, we used the inputs from the scoping stage to identify the types of indicators we wanted. For example, we identified from the end-user needs that we needed specific indicators, not simply an overall index, as end-users needed to be able to use indicators for specific purposes. We also needed data at the small geographic level, and we needed point locations relating to social vulnerability and/or resilience (such as schools, health services and aged residential care facilities) to inform emergency preparedness and land use planning work.

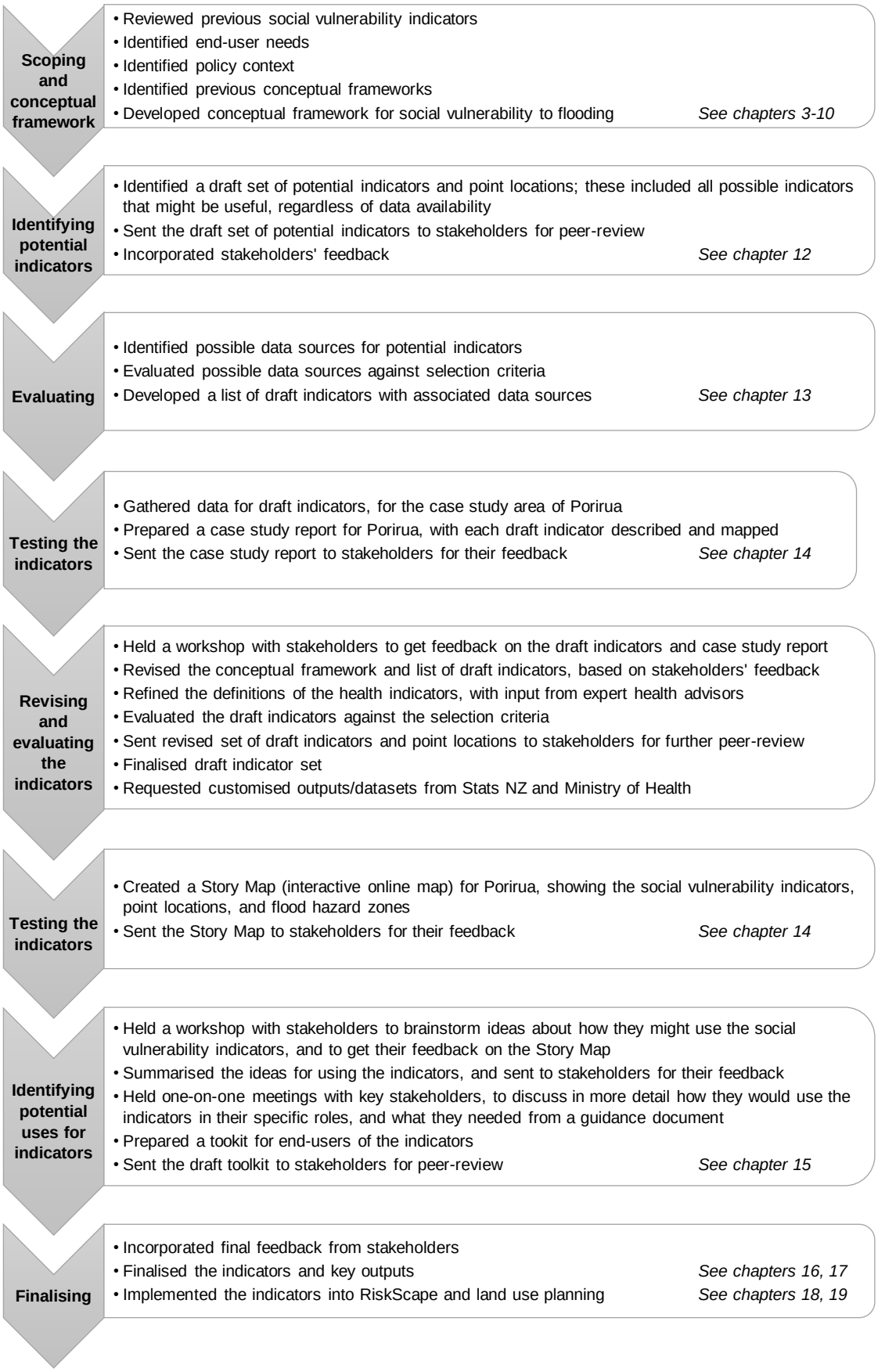
We used the conceptual framework for guiding indicator selection; that is, we tried to find indicators that helped measure each dimension of social vulnerability. For this, we used the rationale identified in the previous chapter as guidance. To identify potential indicators, we looked at other indicator datasets in New Zealand, to see what was already available. However, in the list of potential indicators, we also included vulnerable population groups that we did not have national-level data for (such as refugees). This was important, as we did not want to exclude potential indicators at this initial stage simply because we were not aware of a dataset for them.

The indicator selection process that followed included refinements to the indicator list, evaluation of the indicators, testing the indicators, and getting stakeholder feedback. This was a somewhat iterative process. We evaluated the potential data sources, and then the indicators themselves, against indicator selection criteria. Additionally, we tested the indicators using a case study for Porirua. For this, we developed a case study report for Porirua, with maps of available indicators at the area unit level. We also developed an online interactive map (Story Map), to help the stakeholders engage with and assess the indicators. We used the identification of potential uses of the indicators to inform the final indicator selection.

We included stakeholder feedback and participation throughout the indicator selection process, through seeking feedback on draft indicator sets and outputs, and through stakeholder workshops and meetings. Our stakeholder group included representatives from Porirua City Council, Wellington Region Emergency Management Office (WREMO), Regional Public Health, emergency planners from Tū Ora Compass PHO and Capital & Coast District Health Board, Ministry of Civil Defence &

Emergency Management, NIWA, and GNS Science. We also incorporated views of Ngāti Toa Rangatira, and held hui at Takapūwāhia Marae to discuss the project.

Figure 10: Indicator selection process for developing the social vulnerability indicators for flooding



12. Identifying a full list of potential social vulnerability indicators

Summary

- For each of the 14 dimensions of social vulnerability, we identified a number of potential indicators, based on the literature and previous indicator datasets.
- We identified these indicators based on a concept-driven approach (that is, reflecting a conceptual framework), rather than a data-driven approach (that is, based purely on available data). For this reason, the list of potential indicators includes indicators both with and without possible data sources.
- We also identified potential point locations for each dimension. Point locations are sites, buildings or locations where clusters of vulnerable people might gather, such as schools, rest homes and health care centres. These point locations were considered important for our end-users, particularly in emergency management and land use planning.

This chapter provides the full set of potential social vulnerability indicators that we identified as part of this project. These indicators were used as input into the next stage of the project, evaluating indicators against selection criteria.

Process for identifying potential social vulnerability indicators

The first step of turning the conceptual framework into a final set of indicators was to identify a set of potential indicators to reflect the conceptual framework.

We used the scoping work (including potential uses for the indicators), our conceptual framework, the dimensions of social vulnerability identified previously, and previous sets of social vulnerability indicators to inform the selection of potential indicators. We included all possible indicators that could be potentially useful, regardless of whether there was a data source available. We sent a draft version of the potential indicators to key stakeholders, and included their feedback and additions into the final set of potential indicators, to ensure that the potential indicators met their information needs.

Potential social vulnerability indicators and point locations

Table 6 presents our set of potential social vulnerability indicators for flooding, and potential point locations.

Point locations included important facilities and buildings in terms of socially vulnerable populations. These locations are important to consider alongside the indicators, as they are where higher numbers of more vulnerable people are likely to be, and/or are important places for the local community. They are also important locations to consider in the context of flooding, particularly with regard to emergency management and planning, and land use planning.

The indicators and point locations in Table 6 have been identified using a concept-driven approach. It does not necessarily mean that a suitable data source is available for every indicator or point location in the list.

Table 6: Potential social vulnerability indicators, and associated point locations, by social vulnerability dimension

Social vulnerability dimensions	**Potential indicators**	**Point locations**
Exposure (direct impacts)	Land area in flood hazard zone Estimated number of people living in flood hazard zone Estimated number of buildings / dwellings in flood hazard zone Estimated number of people working (or studying at educational facilities) in flood hazard zone Estimated number of children and youth attending ECEs / schools in flood hazard zone	Emergency shelters, including: • Civil Defence Centres • marae Important community assets in flood hazard zone (and number of people), such as: • schools • early childhood education services • rest homes • marae • hospitals • health care centres • pharmacies
Exposure (indirect impacts via lifelines infrastructure and services)	People who regularly commute outside of the area People who use public transport to get to and from work People living in an area likely to be isolated during a flood due to impacts on the transportation network (eg isolated from emergency services, health services, central business district, food stores) People living in an area likely to experience water and/or electricity loss during a flood People living in an area likely to experience telecommunications outages during a flood People living in an area likely to be contaminated during a flood (eg by fuel or sewerage pipe leakage, or due to floodwaters affecting hazardous substances facilities or contaminated sites) People living in rural and/or remote communities Households reliant on electricity for heating	Important transport routes likely to be affected during a flood • Main/arterial roads • Bus routes • Trains tracks and train stations (including underpasses) Emergency service facilities • Fire station • Police station • Ambulance station • Hospital / Emergency Department Important utilities in flood hazard zones • Power substations • Water pumping stations • Stormwater pumps • Sewerage pumping stations • Telecommunications infrastructure (including cellphone towers) • Petrol stations Exposed infrastructure hotspots and pinchpoints, including: • Bridges that also carry communications, water, electricity and/or fuel lines • Pumping stations Hazardous substances facilities / contaminated sites in flood hazard zones
Children	Children aged 0–4 years Children aged 0–14 years Households with children aged 0–4 years Households with children aged 0–14 years Households with school-aged children	Early childhood education centres • Daycares • Kindergartens • Kohanga reo • Playcentres and playgroups Schools • Primary schools • Secondary schools • Kura Kaupapa schools • Specialist schools (eg schools for high needs childrens) Other facilities for children, such as: • Care and protection residences for children

Social vulnerability dimensions	Potential indicators	Point locations
		• Youth justice facilities
Older adults	Older adults aged 65+ years Older adults aged 75+ years Older adults aged 85+ years Older adults (65+ years) living alone	Residential facilities for older adults • Residential care facilities, for people who need a higher level of daily assistance (which include rest homes, long-stay hospitals, and dementia/psychogeriatric units) • Retirement villages (independent living) Social housing for older people
Physical health needs	People with a pre-existing health condition, who are at risk of worsening health due to a flood, such as: • People with coronary heart disease • People with diabetes • People with chronic respiratory diseases (such as asthma, COPD) • People with compromised immune systems (such as those on immunosuppressant drugs, having cancer treatment, or with HIV/AIDS) • People with other chronic health conditions (such as tuberculosis, cystic fibrosis, sickle cell disease) People requiring essential medication (within 1–3 days of the flood), such as: • People on angina medication • People with insulin-dependent diabetes • People needing inhalers (and/or other medications) for chronic lung conditions • People taking medication for epilepsy • People taking immunosuppressant drugs • People on anti-HIV drugs People requiring electricity and/or health services for medical purposes (within 1–3 days of the flood), such as: • People on dialysis (haemodialysis or peritoneal; at home or at a dialysis unit) • People using home oxygen therapy for lung conditions • People receiving cancer treatment Pregnant women	Primary health care facilities (GP medical centres, A&M emergency clinics) Pharmacies Medical supply depots Hospitals Other health facilities (note: these may be already included as part of hospitals): • Dialysis units • Birthing units • Long-stay hospitals (including at aged care facilities)
Mental health needs	People with pre-existing mental health issues, who are at risk of worsening of mental health status due to a flood, such as: • People with a diagnosed serious and persistent mental illness • People with a psychological or psychiatric impairment People requiring essential medications (within 1–3 days of flood), such as: • People on antidepressants and/or anti-anxiety medication • People on anti-psychotic medication • People on opioid substitution treatment (OST) People with substance abuse issues	Mental health facilities (mental health services, in-patient mental health units) Primary health care facilities (GP medical centres) Pharmacies Hospitals
Disability	People with a disability (mobility, hearing, vision, learning/language, limited intellectual skills) • People with a physical disability • People with a hearing disability • People with a vision disability	Facilities for people with disabilities • Community residential homes • Respite care facilities

Social vulnerability dimensions	Potential indicators	Point locations
	• People with a psychological or psychiatric impairment • People with an intellectual disability People with a service dog	Specialist schools for children with disabilities and high needs
Having enough money to cope with crises / losses	Socioeconomic deprivation People living in low income households (eg people with low equivalised household income) Single-parent households Unemployed Not in labour force People with minimal education Households with no home or contents insurance No access to car People working in the primary industries that depend on the land (eg agriculture and related sectors)	Social housing • Housing NZ homes • Council social housing • Social housing provided by other providers and NGOs (eg Salvation Army) Hazard areas where properties are uninsurable and/or prohibitively expensive to insure
Social connectedness	Neighbourhoods where most people are new to the neighbourhood (eg within previous year) Older adults living alone Single-parent households Single person households Neighbourhoods with higher levels of people living in rental properties Neighbourhoods with fewer households with children Recent immigrants Refugees	Marae Schools Early childhood centres Churches Other places of cultural/spiritual significance (such as urupā)
Knowledge, skills, and awareness of natural hazards	People who are new to the neighbourhood (eg within previous year) People with no access to telecommunications or internet People with limited English proficiency Recent immigrants Refugees Seasonal or transitory workers (such as fruit pickers, truck drivers) Tourists People with minimal education	Visitor accommodation • Hotels • Motels • Holiday inns • Backpacker accommodation • Camping grounds • Freedom camping sites • Holiday houses Flood hazard zones that have not experienced a flood in recent times (eg last 10 years) Refugee settlement centres and locations
Safe, secure and healthy housing	People living in low-lying properties in flood hazard zones People in single-storey properties (or on the bottom floor of multi-storey buildings) in flood hazard zones People living in damp and mouldy housing People living in rental housing People living in crowded households People in severe housing deprivation (homelessness) People living in houses on Māori land People who do not have house insurance	Houses in flood hazard zones (by hazard classification zone: stream corridors, overland flow paths, inundation areas; deep floodwater depths) Houses on low-lying land Houses with a floor height below flood depth (particularly houses built 1980s–2000s, slab on ground, with no minimum floor height taking into account flood depths) Houses likely to be aggraded during a flood (ie where the river deposits mud, rocks, boulders, and/or erodes land under or around the house) Emergency housing, such as • Night shelter • Women's refuge Temporary accommodation • Camping grounds and motor camps

Social vulnerability dimensions	Potential indicators	Point locations
		• Boarding houses, hotels, motels Houses on Māori land in flood hazard zones Safe place for community to shelter out of flood hazard zone • Civil Defence Centres • Marae
Enough food and water (and other essentials) to survive	Households without emergency water supplies for 3-7 days Households without emergency food supplies for 3-7 days Households without an emergency plan Households without better levels of emergency preparedness (torch, portable radio, spare batteries, essential first aid, medication) Households experiencing food insecurity (ie adequate and nutritious food is often not readily available in the household) Use of local food banks *Possible proxy indicators:* People living in low income households People living in rental housing Single parent households Receiving a means-tested benefit Socioeconomic deprivation	Food stores • Supermarkets • Dairies • Other food stores Food banks Local emergency water supplies (such as water storage tanks, boreholes) *Possible proxy indicators:* Rental housing owned by a public landlord (Housing New Zealand Corporation, local authority or city councils, other state landlords)
Decision-making ability and participation	Inclusion of Māori, iwi, and hapū in civil defence emergency management planning and decision-making Inclusion of vulnerable population groups (such as those with health needs and/or disabilities) in civil defence emergency management and decision-making Inclusion of marae committees, and committees of other important assets (such as schools) in flood hazard zones, in CDEM response communications Level of voting participation in the community	Marae Civil Defence Centres
Other individual-level factors of social vulnerability	Healthcare workers and first responders Households with a healthcare worker and/or first responder People who have previously experienced domestic violence People who are serving community sentences (such as home detention, community work) or who are on parole Households with one or more pets People who own or manage livestock	Prisons Youth justice facilities Police stations Community corrections centres University dorms Military quarters Rest homes

[1] In 2010, household emergency preparedness was less common in New Zealanders for people living in rental accommodation, single parents, and people with low household income (Statistics New Zealand 2012). Similarly, in 2015/16, rates of food insecurity were highest for New Zealand children living in houses rented from a public landlord (52.9% of children were food insecure) or private landlord (27.7%), living in a household with an income below $30,000 (about 52%), living in more deprived areas (NZDep2013 quintile 5) (34.8%), living in single parent households (38%), and having a caregiver receiving a means-tested benefit (55.8%) (Ministry of Health 2019).

13. Evaluating potential indicators and data sources

Summary

- We identified and evaluated potential data sources and indicators to ensure they were fit for purpose, met the end-users needs, and met our indicator selection criteria.
- Given that most indicators were likely to come from only a few data sources, we firstly evaluated potential data sources against four key criteria: data availability, methodologically sound measurement of data source, able to be disaggregated, and timely.
- The Census was identified as an important data source for the social vulnerability indicators. Due to delays and quality issues with the 2018 Census, the 2013 Census has been used for this project.
- National health collections datasets and other datasets were also considered for the health indicators. Potential health indicators have been identified; however, analysis of the health datasets was not possible within the project timeframes.
- The final set of indicators were evaluated against ten indicator selection criteria: data availability, methodologically sound measurement, able to be disaggregated, timely, intelligible and easily interpreted, consistent with other indicator programmes, comparable over time, sensitive to change, scientific validity, and public health impact.

This chapter describes the process we used to evaluate the potential indicators and data sources, based on those that we identified in chapter 12.

Process for evaluating the potential indicators and data sources

Once we had identified a set of potential social vulnerability indicators, the next step was to identify and evaluate potential data sources and indicators. We had two main considerations when identifying and evaluating potential indicators: (i) end-user needs for the data, and (ii) indicator selection criteria.

For this project, our evaluation work mostly focussed on potential data sources, for a few key reasons. Firstly, our end-users needed data at the fine geographic scale (ideally meshblock) for the whole of New Zealand, which ruled out many potential datasets (such as sample surveys and local datasets). This meant that most potential indicators were likely to come from the Census. Having a large number of indicators come from one or two datasets meant that the datasets themselves could be evaluated against the indicator selection criteria, for efficiency.

Secondly, during the course of this project (November 2017–October 2019), the 2018 Census was carried out, and then later determined to have a number of problems relating to non-response, which delayed publication of the first high-level Census outputs until September 2019. These quality concerns compelled us to assess both the 2013 Census dataset and 2018 Census datasets against indicator selection criteria, to ensure that we used a robust dataset.

In the following sections, we describe the specific needs of end-users, the indicator selection criteria we used to evaluate potential data sources and indicators, and the results of this evaluation.

Needs of end-users

End-user needs can affect all parts of the indicator selection and evaluation process, as well as the final selection of indicators. Given this, we used the needs of end-users to inform what datasets we considered using for the indicators.

In particular, end-users need the indicators to be robust and of high quality. In the user needs chapter, we identified the following requirements of indicators and data sources:

- based on solid evidence – the indicators are likely to inform decision-making, so they need to be robust
- data sources and indicators need to be reliable and accurate
- applicable and relevant to the New Zealand context
- up-to-date – so that emergency management plans reflect reality as close as possible
- ability to keep the indicators up-to-date on an on-going basis
- meaningful – so that users can easily understand and interpret the information
- relevant to activities across the 4 Rs of emergency management (risk reduction, readiness, response, and recovery).

In terms of the data and indicators themselves, the following are important considerations:

- ability to disaggregate data to small areas (preferably meshblocks or area units) – to see the spatial variation of vulnerability across an area, which can inform local response and planning work
- availability of data for Māori – ideally for each separate indicator, to allow 'equal explanatory power' for Māori and to allow Māori to see the level of vulnerability in their own population.

Indicator selection criteria

As part of assessing the quality of indicators, we evaluated our potential indicators before finalising them. For our work on the Environmental Health Indicators programme, we use a set of ten selection criteria, based on Statistics New Zealand's Good Practice Guidelines (Advisory Committee on Official Statistics 2009).

We used the same ten selection criteria to assess the potential social vulnerability indicators:

- data availability
- scientifically valid
- sensitive to change
- consistent with other indicator programmes
- comparable over time
- methodologically sound measurement
- intelligible and easily interpreted
- able to be disaggregated
- timely
- public health impact – relating to an issue of significant public health impact, through affecting a large number of people, Māori, a vulnerable population, and/or having substantial policy relevance.

Indicators would ideally be based on available (secondary) data that has already been collected by another agency. For this project, we primarily used publicly-available summary tables, and we requested customised data tables from other agencies (such as Stats NZ). We also had the means to analyse anonymised unit record health data, such as the Ministry of Health's hospitalisation dataset.

However, it was not within the scope of this study to carry out primary data collections (eg surveys). Nonetheless, other organisations (such as local councils and CDEM groups) may want to do some data collection at a later stage to fill gaps in the indicators. These organisations may also have some relevant datasets available at the local level.

Table 7 summarises the above ten indicator selection criteria, with comments relating to the social vulnerability indicators and the end-user needs. These selection criteria have been grouped according to what they most relate to: (i) indicator appropriateness, (ii) data source selection, and (iii) measurement of indicators.

This table helped guide the indicator selection process and the focus of the indicator evaluation process. In particular, consideration of the data sources emerged as the most important issue.

Evaluation of potential data sources for indicators

This section provides our evaluation of potential data sources for the social vulnerability indicators. In Table 7, we identified the key selection criteria relating to data sources as (i) data availability, (ii) methodologically sound measurement (of the dataset), (iii) ability to be disaggregated to small areas, and (iv) timely. As a result, we have focussed mainly on datasets that are available at least at the area unit (and preferably meshblock) level, in preference to sample surveys at the national level.

Given this, the main datasets to be used for the indicators include:

- Census data (2013 and 2018)
- National health collections data.

Census data (2013 and 2018)

The Census is a good data source for many of the social vulnerability indicators, as it collects relevant data from every person in New Zealand, and is available at small areas. The 2013 Census data is a useful dataset that was readily available, and has a wide range of information about the population. The data is available at small area level, including meshblock (representing about 100 people) and area unit (representing about 2000 people or a neighbourhood). Customised data tables are available upon request from Stats NZ.

The 2018 Census data may also be a useful dataset in the future. Stats NZ has noted that the data will be output by different boundaries: Statistical Areas 1 (SA1s) (similar to meshblocks, but combining smaller meshblocks together), and Statistical Areas 2 (SA2s) (similar to area units). However, the 2018 Census had some problems with completion rates, with 83.3% of the population completing an individual form, and a much lower rate (68.2%) for Māori. Low response rates were also likely among more vulnerable population groups (eg elderly, disabled people, people living in poverty). Given the potential for bias and undercounting of these people, the outputs from the 2018 Census have been very delayed, while Stats NZ use imputation and other statistical approaches to improve the data quality. The first outputs from the 2018 Census data (of population counts) were released on 23 September 2019, with remaining outputs due for release by mid-2020. For this reason, 2018 Census data could not be considered for this project.

For the Census data, we requested some customised data tables from Stats NZ, to ensure that the indicators had useful information for end-users. For example, for the indicator about single-parent families, we requested the data to be presented for households, rather than families.

Table 7: Indicator selection criteria and general considerations for social vulnerability indicators for flooding for New Zealand

Selection criteria	Description	Comments for social vulnerability indicators
Data sources		
Data availability	Indicator must have data that can be easily and reliably extracted	- Data needs to be currently available - Not too much work needed to extract the data - Ideally data is available for the Māori population as well
Methodologically sound measurement	Indicator measurement needs to be methodologically sound (in terms of both the quality of the data collection, and the measurement of the indicator).	- Data source needs to be reliable and accurate - Minimal bias and/or undercounting in the data collection; needs to be representative of the population
Able to be disaggregated	Indicator needs to be able to be broken down into population subgroups or areas of particular interest, such as ethnic groups or regional areas.	- Data needs to be available for territorial authorities (TAs), and ideally small areas (such as area unit (AU) or meshblock) - National survey data is unlikely to be helpful at the TA, AU or meshblock level
Timely	Data needs to be collected and reported regularly and frequently, to ensure it is reflecting current and not historical trends.	- One-off data collections are not particularly helpful - Out-of-date data may not be helpful, as will not show accurate population numbers
Measurement of indicators		
Intelligible and easily interpreted	Indicator should be sufficiently simple to be interpreted in practice, and be intuitive in the sense that it is obvious what the indicator is measuring.	- Indicators should not be too complex to understand - Indicators need to be able to be understood and implemented by a wide range of end-users, including CDEM planners
Methodologically sound measurement	Indicator measurement needs to be methodologically sound (in terms of the quality of the data collection, and the measurement of the indicator).	- Indicator definition and measurement needs to be robust, to ensure indicators are reliable and accurate - Indicators should measure some aspect of the social vulnerability dimension that we are trying to measure.
Consistent with other indicator programmes	Indicator should be consistent with those used in other indicator programmes (including internationally), so comparisons can be made.	- Indicators would ideally be similar to what is currently being used, in CDEM planning and/or other relevant indicator programmes
Sensitive to change	Indicator should respond relatively quickly and noticeably to changes, but not show false movements.	- Sensitivity to change is important, so that indicators are measuring the current situation
Comparable over time	Indicator should be consistent to allow comparisons over time.	- Comparisons over time are not a high priority, as comparisons are not the focus of these indicators - But ideally indicators can be interpreted in the same way when updated
Indicator relevance and appropriateness		
Scientifically valid	Indicator must have an established, scientifically sound link to the environmental health/natural hazard issue.	- Robust evidence needed for why the indicator is important (eg from the conceptual framework)
Public health impact	Indicator needs to relate to an issue of significant public health impact to New Zealand. This health impact may include affecting a large number of people, a vulnerable population, or Māori health; or having substantial policy relevance.	- Public health impact is useful to consider before or during the creation of an indicator - If numbers are very low nationally for an indicator, the indicator may not be so helpful - This criteria ensures indicators are relevant for New Zealand

National health collections datasets

The Ministry of Health has a number of administrative datasets that could be used for the health indicators. These datasets include:

- National Minimum Dataset (NMDS) – publicly-funded hospitalisations
- Pharmaceutical (Pharms) – dispensed prescription drugs
- Mental health dataset (PRIMHD) – mental health service use
- Mortality dataset
- Cancer registrations
- National non-admitted patient collection (emergency department and outpatient visits)
- National Maternity Collection (mothers and babies).

The datasets have the following attributes:

- Data availability: Confidentialised unit record data is available for each of the above datasets upon request to the Ministry of Health.
- Methodologically sound measurement: There are robust processes for data collection in each dataset, as these datasets are often used for funding purposes; the data quality will be considered separately for each health dataset that is used.
- Able to be disaggregated: Administrative health datasets record a domicile code (domcode) for each patient; these are equivalent to area units (AU) and can be used to get AU-level data.
- Timely: This depends on the dataset. There is often some time lag with these datasets (often 2–4 years).

Additionally, the Ministry of Health has some datasets with derived variables, available for specific time periods, which could be used in future. These health datasets include:

- Chronic conditions dataset
- Virtual Diabetes Register.

All the above datasets were considered when developing the health-related indicators. A data request was submitted to the Ministry of Health, but due to delays in accessing the datasets, we were unable to complete the analysis and implementation of the health indicators as part of this project.

Other national datasets

Other national datasets that we considered for the social vulnerability indicators include (but are not limited to):

- 2013 Disability small-area estimates: TA-level estimates of the prevalence of disability, based on the 2013 Census and 2013 Disability Survey
- 2013 New Zealand Index of Deprivation (NZDep2013): small-area levels of socioeconomic deprivation (Atkinson et al 2014), which is widely used in the health sector
- Homelessness datasets, developed by Amore et al (2016)
- Voting participation data from Department of Internal Affairs.

For the health indicators, prevalence data for health conditions are available from the New Zealand Health Survey, which covers long-term health conditions, mental health, lifestyle behaviours, alcohol and other drug use, and other topics. However, regional data is currently only available at the District Health Board (DHB), Public Health Unit (PHU) and Regional Council levels. This level of data was insufficient for the purposes of this project.

We considered other possible survey datasets, such as surveys on emergency preparedness. However, the survey results were generally not available at the small area level. Some of the surveys

also have a low response rate, which means that the results may not be representative of the total population.

An additional dataset is the Integrated Data Infrastructure (IDI) is a government-wide set of linked datasets. The IDI would provide a valuable source of data for these social vulnerability indicators, and would allow some updates. However, it was out of the scope of this project to develop indicators in the IDI, given the time it would take to gain access to the data and do the analysis. This is something that could be considered for future work and/or projects.

Local data sources

Local councils and other organisations may have other relevant datasets for some indicators in their areas (for example, level of household emergency preparedness, emergency food and water supplies). These could be used to supplement the national indicators being produced in this project. However, they were not considered for the main set of indicators, due to difficulties in accessing the data, and the lack of nation-wide availability.

Evaluation of indicators against the full set of indicator selection criteria

In addition to the above work on evaluating the potential data sources, we also carried out a full evaluation of potential indicators against the indicator selection criteria in Table 7. This assessment was carried out before we finalised the indicator set. For more details about the evaluation of the indicators against selection criteria, see Appendix 2.

As a result of the evaluation, we decided to mainly use 2013 Census data, although the data needs to be interpreted with some caution given the age of the data. We also identified the national health collections datasets as potentially being useful as indicators. However, there was not enough time during the project to access the datasets and properly assess them. Nonetheless, these data sources could be considered in future.

In terms of the indicators themselves, the majority met the indicator selection criteria. However, due to the impacts of the 2018 Census, the 2018 Census cannot be assumed to provide an updated valid set of indicators in future, without a robust evaluation of the indicators against indicator selection criteria.

14. Testing the indicators with the case study of Porirua

Summary

- We tested the draft indicators using a case study of the area covered by Porirua City Council. We used stakeholder participation and feedback on the case study to refine the indicators and outputs throughout the project.
- We held workshops and one-on-one meetings with stakeholders, and got their feedback on draft sets of indicators and outputs, as well as potential uses for the indicators. Our stakeholder group included those with relevant responsibilities in Porirua, including Porirua City Council, Wellington Region Emergency Management Office, Regional Public Health, Tū Ora Compass Health PHO, Capital & Coast DHB, and Ngāti Toa Rangatira.
- First, we created a case study document for Porirua, showing the first set of draft indicators on static maps, at the area unit (suburb) level.
- Based on stakeholder feedback, we then created an interactive online map (Story Map) for Porirua, that allowed users to see and explore local flood hazard zones, detailed indicator data, and point locations.
- To address the issue of needing to see a summary of indicators, we also created a 'heat map', showing the indicators at a glance for area units in a local council area.
- The case study was particularly helpful in refining the selection of indicators, indicator datasets, outputs, and the potential end uses of the indicators.

This chapter describes the case study area of Porirua, which was used during the development of the social vulnerability indicators, from selection to design and presenting the indicators in useful ways.

This case study demonstrated how the social vulnerability indicators could work in practice, so that stakeholders could assess the usefulness and meaningfulness of the proposed indicators. Draft indicators were used in an interactive flood map and subsequently shared with stakeholders for feedback, to help inform final outputs.

About Porirua

Porirua City is a territorial authority in the lower North Island of New Zealand. It encompasses a land area of about 180 square kilometres, and it surrounds Porirua Harbour. Porirua is situated about 25 kilometres north of Wellington CBD, and the main road of State Highway 1 runs through the middle of Porirua. Much of the infrastructure for Porirua (including roads, train lines, services) are low-lying.

Over the last 150 years, there have been many human modifications to Porirua land and harbour. This includes changes to land use, Porirua Harbour and Porirua Stream. During early European settlement (1820s), Europeans progressively cleared the forest surrounding the harbour for farm land. During this time, soil run-off into the harbour increased. In the late 1940s, large-scale state housing development led to higher levels of soil run-off into the harbour.

Today, much of Porirua's retail area is built on reclaimed land, and Porirua Stream has been straightened. State Highway 1 and rail infrastructure are now located along the inner harbour coastline.

Porirua flood risk

Flooding is the most frequent natural hazard affecting Porirua City. Flooding mainly occurs due to the various streams overflowing their banks during heavy rainfall, and stormwater pipes becoming blocked.

Porirua has experienced several flood events in recent years, including in May 2015, May 2016 and November 2016. These floods closed schools, interrupted transport (roads and public transport), and flooded houses. Some parts of Porirua are more affected by flooding hazard, including Porirua CBD, Takapūwāhia and Titahi Bay, Porirua East (including Cannons Creek), and Pauatahanui. Takapūwāhia marae, a marae of Ngāti Toa, has come close to flooding on multiple occasions.

Flood hazard data for Porirua

Flood hazard zone mapping has recently been carried out by Wellington Water for Porirua City Council, to inform its district plan review process. The flood mapping covers populated areas of Porirua.

As part of the case study, we gained access to these flood hazard zones from Wellington Water. These flood hazard zones were for 1-in-100 year floods (1% AEP), taking into account climate change impacts. As per standard practice, these hazard zones account for 100-year climate change impacts, in terms of sea level risk and increased rainfall. The models have used 1 metre sea-level rise, and a 20% increased rainfall. The flood modelling accounts for blockages and variations in flood inundation, by incorporating 200mmm freeboard in the model, as per best practice.

Stakeholders

Our stakeholder group included CDEM staff from Porirua City Council and Wellington Region Emergency Management Office (WREMO), as well as Regional Public Health (the local public health unit), and the emergency planners from Tū Ora Compass PHO and Capital & Coast District Health Board. We also included staff from the Ministry of Civil Defence & Emergency Management, NIWA and GNS Science.

During the scoping phase, we had a hui with Ngāti Toa Rangatira at Takapūwāhia Marae, to hear about local iwi experiences with flooding in the area, and their experiences relating to vulnerability and resilience. These conversations influenced the selection of conceptual framework, indicators, and potential uses for indicators.

Case study document

With the first set of draft social vulnerability indicators, we produced a case study document of Porirua. This document included static maps of all the draft indicators, at area unit (AU) level. Feedback on this document suggested that a finer resolution of geographic region, such as meshblock, would be more useful to inform emergency management. Additionally, being able to overlay flood information was identified as one way to make it easier to interpret the indicators.

Online interactive flood maps (Story Maps)

Based on this feedback, we then created an online interactive map of flood hazard zones and social vulnerability indicators for Porirua. We also included point locations relating to social vulnerability and resilience, including schools, ECEs, marae, rest homes, and health care facilities. This map was created using ESRI's ArcGIS Story Map software.

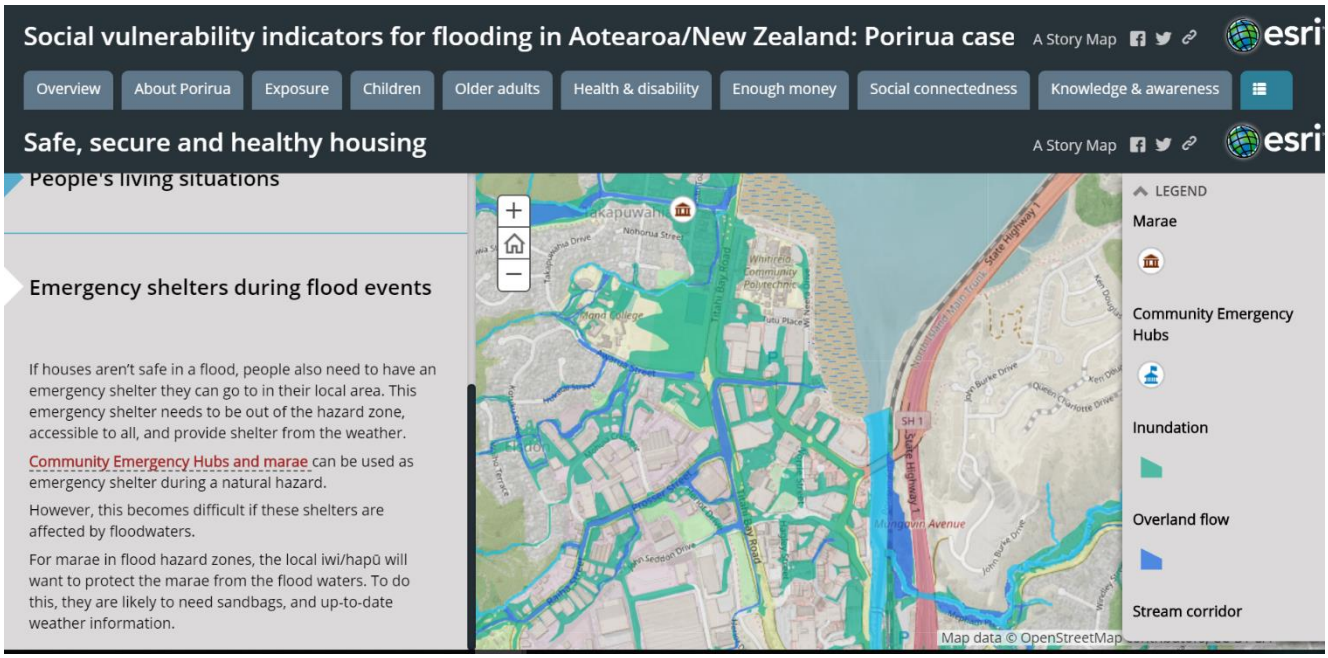
The Story Map was intended as a way of sharing the indicators for the purpose of the indicator development process, to get people engaged and so that they could see how the indicators might look in real life. We shared this Porirua Story Map with our key stakeholders. Stakeholders were very supportive of the approach, and suggested a range of ways that they could use the Story Maps to inform their work.

Identifying areas of social vulnerability in Porirua

Using the case study document and Story Map, we identified that some flood hazard zones in Porirua also had vulnerable population groups.

For example, many of the point locations were in flood hazard zones, including schools, ECEs, and health care centres. Additionally, Takapūwāhia marae is located in a flood zone (Figure 11). This was noted to be an issue, as marae are important sites for emergency resilience, safety during a disaster, social connectedness, and a place for whānau and community to gather to connect and share kai (food and water).

Figure 11: Screenshot of the Porirua Story Map for social vulnerability indicators for flooding



We developed a 'heat map' of the social vulnerability indicators for Porirua, to give an overview of the vulnerabilities experienced in each area unit (Figure 12). This heat map was a simple way to combine and synthesise indicators, in response to stakeholder feedback. For example, the heat map showed that some areas in Porirua had high levels of poverty, populations who did not speak English and/or had little access to the internet.

Figure 12: Example of a heat map of social vulnerability indicators for Porirua, by area unit (2013 data)

Porirua City Council		Percent of population (%) (2013 data)																											
		Children		Older adults			Pregnant women	Having enough money to cope with crises/losses						Social connectedness				Knowledge, skills and awareness to face hazards					Housing	Enough food and water to cope with shortage			Healthcare workers	
AU Name	AU	0-4 years	0-14 years	65+ years	75+ years	85+ years	0 years	NZDep2013 deciles	Unemployed	Not in the labour force	Single parent families	Minimal education	No access to a car	New to the neighbourhood	Single parent families	Single person households	Living in rental accommodation	New to the neighbourhood	Don't speak English	No access to the internet	No telephone	No mobile	rented_percent	NZDep2013 deciles	Living in rental accommodation	Single parent families	Healthcare workers and first responders	Workplace of healthcare workers
Pauatahanui	565601	4.2	22.2	9.2	1.9	0.0	0.8	1	3.1	19.8	8.2	10.7	0.0	10.7	8.2	11.0	12.4	10.7	0.6	5.6	4.7	11.2	12.4	1	12.4	8.2	6.9	2.3
Endeavour	565602	6.4	22.3	9.6	3.1	1.1	1.0	1	2.3	23.5	8.3	10.3	1.0	15.5	8.3	8.8	12.1	15.5	1.6	3.0	2.8	7.1	12.1	1	12.1	8.3	8.4	20.6
Resolution	565603	6.7	20.0	4.4	0.0	0.0		1	2.9	21.2	7.1	6.1	0.0	28.6	7.1	0.0	0.0	28.6	0.0	0.0	6.7	13.3	0.0	1	0.0	7.1	3.7	
Adventure	565604	7.3	23.2	13.5	6.6	2.2	1.8	2	3.9	27.7	15.3	14.3	2.5	17.7	15.3	19.0	20.3	17.7	3.4	11.5	7.6	10.8	20.3	2	20.3	15.3	12.4	16.8
Paekakariki Hill	565700	4.1	22.4	0.0	0.0	0.0		2	2.8	14.3	13.3	8.6	0.0	8.3	13.3	11.8	18.8	8.3	0.0	25.0	0.0	56.3	18.8	2	18.8	13.3	3.6	0.0
Titahi Bay North	570400	9.4	24.1	10.4	3.7	1.0	2.0	9	8.0	32.1	26.9	22.1	13.6	19.3	26.9	28.0	45.9	19.3	2.6	27.8	18.3	15.9	45.9	9	45.9	26.9	11.5	15.7
Onepoto	570500	9.3	25.3	9.2	2.8	0.3	1.7	7	5.9	28.9	27.0	22.9	6.3	15.4	27.0	15.4	24.2	15.4	2.5	20.4	11.5	13.6	24.2	7	24.2	27.0	10.5	2.9
Titahi Bay South	570600	10.0	26.5	12.4	5.9	1.6	1.8	9	6.5	37.2	31.7	23.8	16.8	20.0	31.7	25.9	50.5	20.0	3.4	29.2	17.4	15.9	50.5	9	50.5	31.7	13.1	26.5
Elsdon-Takapuwahia	570700	9.0	24.0	9.8	3.3	0.4	1.9	9	9.9	37.0	33.5	29.0	18.6	19.8	33.5	23.6	49.8	19.8	4.4	36.0	21.3	16.9	49.8	9	49.8	33.5	15.9	13.0
Porirua Central	570800	4.7	11.8	6.3	2.4	1.6	0.8	10	10.9	56.5	12.5	33.7	16.7	34.2	12.5	30.8	75.0	34.2	5.3	50.0	33.3	8.3	75.0	10	75.0	12.5	13.5	20.1
Porirua East	570900	7.8	22.6	7.9	2.5	0.4	1.8	10	10.1	39.8	34.3	31.8	19.9	19.7	34.3	21.3	62.2	19.7	6.6	35.4	21.2	20.1	62.2	10	62.2	34.3	12.9	18.6
Ranui Heights	571000	8.6	20.3	11.0	3.5	0.4	2.0	7	5.6	32.6	24.8	24.8	5.8	17.1	24.8	25.3	27.9	17.1	3.8	21.0	10.9	11.6	27.9	7	27.9	24.8	12.1	65.7
Cannons Creek North	571100	10.6	29.7	6.3	2.1	0.4	2.4	10	12.6	49.9	40.0	37.4	29.0	21.8	40.0	16.8	76.8	21.8	9.9	49.0	30.0	21.7	76.8	10	76.8	40.0	13.5	41.3
Cannons Creek South	571200	9.6	29.8	7.3	2.9	0.0	2.0	10	10.7	46.0	41.9	33.0	18.1	21.0	41.9	14.8	66.1	21.0	7.7	43.2	25.6	16.8	66.1	10	66.1	41.9	18.2	7.7
Cannons Creek East	571300	10.1	28.9	8.9	2.6	0.3	1.9	10	11.6	50.5	38.8	36.5	24.3	17.6	38.8	15.2	64.3	17.6	10.0	46.5	22.0	24.1	64.3	10	64.3	38.8	15.6	13.5
Waitangirua	571400	10.6	31.0	7.2	1.9	0.1	1.8	10	12.9	47.4	41.4	38.0	19.9	17.8	41.4	12.9	72.7	17.8	9.8	48.5	26.1	22.4	72.7	10	72.7	41.4	14.9	13.2
Papakowhai North	571501	6.2	19.1	15.9	6.6	2.5	1.2	1	2.8	30.1	11.5	14.1	2.4	15.4	11.5	16.4	17.7	15.4	3.3	7.9	4.3	7.9	17.7	1	17.7	11.5	9.2	8.3
Papakowhai South	571502	11.6	24.7	12.8	7.1	2.2	2.1	1	2.5	28.6	8.4	10.6	6.0	26.1	8.4	19.1	14.8	26.1	3.8	11.3	5.6	11.3	14.8	1	14.8	8.4	7.3	10.5
Ascot Park	571600	9.2	25.5	8.1	2.1	0.1	1.6	8	8.3	31.4	30.0	27.7	9.1	15.5	30.0	13.1	41.0	15.5	4.7	22.8	14.2	13.0	41.0	8	41.0	30.0	11.3	9.5
Pukerua Bay	571800	8.9	24.1	10.3	2.5	0.3	2.2	1	3.2	25.0	11.1	10.7	2.3	16.2	11.1	14.4	18.2	16.2	2.3	9.5	7.2	9.5	18.2	1	18.2	11.1	9.6	6.9
Plimmerton	571900	7.0	19.9	13.9	4.0	1.0	1.3	2	3.2	24.8	12.4	9.8	3.4	18.9	12.4	23.5	25.4	18.9	2.3	11.8	9.1	10.3	25.4	2	25.4	12.4	10.5	4.5
Mana-Camborne	572000	6.9	19.8	13.8	4.8	1.1	1.3	1	2.9	24.8	12.9	10.4	3.8	15.2	12.9	22.0	18.6	15.2	2.2	10.2	5.7	9.2	18.6	1	18.6	12.9	9.4	13.5
Paremata-Postgate	572100	6.2	20.3	11.8	2.7	0.5	1.3	1	2.8	24.4	13.6	11.3	2.3	17.0	13.6	16.3	21.9	17.0	2.4	8.3	7.6	8.6	21.9	1	21.9	13.6	9.2	2.4
Discovery	572200	7.6	23.8	11.2	3.2	0.9	1.4	1	3.4	23.8	11.6	11.2	1.3	14.7	11.6	10.5	16.1	14.7	2.7	5.0	3.0	6.6	16.1	1	16.1	11.6	10.4	8.8

Lessons from the case study

We found that the online Story Map was very well received by our stakeholders, who appreciated all the information (including vulnerability and hazard information) being available in one place. The Story Map allowed users to zoom into particular areas, and see the local flood hazard zones and vulnerable point locations. In this respect, having point locations on the maps allowed people to understand and assess the risk of flooding to specific sites, to inform emergency preparedness and planning. In our stakeholder meeting, people also commented on the importance of local knowledge in interpreting the indicators.

15. Identifying how the indicators could be used

Summary

We worked with key stakeholders to identify ways that social vulnerability indicators could be used in emergency planning and preparedness.

We identified that the social vulnerability framework, indicators, and maps may help to:

- provide a structured way of thinking about and understanding social vulnerability to flooding
- spark discussion and initiate further data-gathering at the local level
- contribute to the development of shared situational awareness during a response, by contributing in a way that crosses the whole response (Welfare, Operations, Logistics, Intelligence and others)
- target and prioritise emergency management efforts, to ensure the best use of resources and provide the best available support to the community
- provide an objective measure of social vulnerability, to inform forward planning for response work, and to counteract the 'squeaky wheel' effect during a response
- stimulate preparedness planning for individuals, businesses, health services, welfare networks, marae, government agencies
- provide evidence to support important risk reduction strategies, particularly in other sectors.

We also identified specific end uses for the indicators for people in the following sectors:

- CDEM sector
- health sector (including emergency planners and public health units)
- local councils (including land use planners)
- education sector
- housing sector
- wider social sector
- Māori iwi and hapū.

This chapter identifies general themes of how the indicators (and associated interactive maps of flood hazard zones and social vulnerability data) can be used to help reduce vulnerability to flooding.

The indicator outputs can help identify geographic areas with people more likely to experience adverse impacts on their health and wellbeing due to a flood. This information can help to inform policies and interventions, across the emergency management 4 Rs of risk reduction, readiness, response and recovery. Additionally, identifying potential uses helped to inform the final indicator selection.

In collaboration with key stakeholders, we identified seven key overall uses for social vulnerability indicators. This section explains these key uses for the indicators in more detail.

1. Provide a structured way of thinking about and understanding social vulnerability to flooding

The social vulnerability dimensions and indicators provide a structured way of thinking about and understanding social vulnerability and resilience to flooding (and potentially other natural hazards).

Having a framework can help as a type of checklist or reminder, to help agencies think in a structured way about social vulnerability to flooding. It gives a starting point for better understanding social vulnerability in a local area. The framework and indicators can also help identify strengths and resilience factors in local communities and iwi/hapū.

2. Spark discussion and initiate further data-gathering at the local level

The social vulnerability indicators we produced can be considered as a starting point for a social vulnerability assessment in a local area. For each dimension, we have aimed to provide one or more indicators to give an 'indication' of what the local vulnerability/resilience might be. At this stage, most indicators use relatively old data from the 2013 Census.

These indicators can be used as a basis for overlaying additional local data. Local areas are likely to have more detailed, relevant and up-to-date information for some indicators. We have provided some suggestions of additional point locations, data sources and indicators that users could consider for each dimension. These data and/or data sources may include:

- local data sources (such as council datasets like dog registrations)
- health sector datasets (eg from the Primary Health Organisation (PHO), eg about who is currently on what medication)
- location of environmental hazard sites (such as hazardous substances facilities)
- Mātauranga Māori (Māori knowledge)
- local/community knowledge
- talking to local people in the community
- qualitative data.

Importantly, these indicators can be used to spark discussion and further investigation at the local level. Interpretation can only come at a local level, using local knowledge and local judgement. The value comes in merging information from both the formal indicators, as well as local knowledge.

In this way, the indicators and local information can be useful for emergency management efforts, community engagement, and actions at various levels within agencies (such as business continuity planning).

3. Contribute to the development of shared situational awareness during a response

Social vulnerability indicators could contribute to the development of a shared situational awareness during a response, by contributing in a way that translates beyond the Welfare Function (supporting individuals and communities) to cross the whole CDEM response (Operations, Logistics, Intelligence and others).

4. Target and prioritise emergency management efforts, to ensure the best use of resources and providing the best available support to the community

Social vulnerability indicators can help target and prioritise CDEM activities that are going on all the time. This is particularly useful when resources are scarce; it helps get the biggest 'bang for your buck'.

The indicators can be used to inform different activities across the different stages of a disaster. In terms of a flood, activities happen across five key stages:

Readiness → imminent flood → response → short-term recovery → long-term recovery

Some examples of activities that the indicators could inform include:

- Targeting and tailoring community engagement and public education in communities with specific vulnerabilities, to improve emergency preparedness and resilience.
- Working with relevant sites in flood hazard zones (such as schools, health services, rest homes) to ensure they have up-to-date and relevant emergency preparedness and business continuity plans.
- Providing early warning to relevant institutions and organisations (including local schools, rest homes and marae committee), as well as to vulnerable population groups.
- Considering where the greatest needs for evacuation assistance and welfare help will be during and after a flood, in the response and recovery stages.
- Prioritising distribution of resources and support during the recovery phase (e.g. physical location of support services so accessible by most vulnerable).

5. Providing an objective measure of social vulnerability, to support an equitable response to emergency preparedness, planning, response and recovery

Social vulnerability indicators provide an objective measure to help understand where the greatest need is likely to be during a flood event. This can help inform response work – both forward planning, during an event (such as in an Emergency Operations Centre (EOC)), and during the recovery stage.

For example, without data about local communities before an emergency, the emergency response may simply respond first to people who request help and services. However, areas that are silent are just as (or more) significant, and may represent areas where people are really struggling. This can represent the 'squeaky wheels' effect, where areas with people who request help and services get more assistance than areas that do not, or who are unable to, ask for help. By contrast, having social vulnerability data before an emergency gives a better understanding of local communities and their vulnerabilities, and the types of problems to be expected during and after the event. When an emergency occurs, first responders can go visit the community, find out what is happening, and improve the intelligence. This may help switch where responders focus their attention, effort and resource during a response.

6. Stimulate preparedness planning for individuals, businesses, health services, welfare networks, marae, government agencies

The social vulnerability dimensions and indicators, along with maps of flood hazard zones and vulnerable locations, can be useful for engaging with people and stimulating emergency preparedness planning.

Individuals and businesses

Being able to see a map with flood hazard information, as well as locations of schools, health care centres, marae etc, is likely to spark discussion and thinking about emergency preparedness for a range of people. This may be relevant and helpful for engaging with:

- individuals and households
- health services, pharmacies
- marae
- schools, early childhood education (ECE) centres
- rest homes and aged care facilities
- visitor accommodation sites.

Community engagement

The indicators and interactive flood maps will help in community engagement, through:

- identifying priority audiences and geographic areas for engagement and resilience-building
- being able to use and promote the tools during community engagement and public education sessions
- understanding the vulnerabilities in the local area, so that the material provided in the sessions can be relevant and useful to the target audience.

Working with the local welfare network

The social vulnerability indicators work can help inform the types of people and organisations who could be included in the CDEM welfare network for a local area. Ideally, the CDEM welfare network would include representatives from all types of socially vulnerable population groups, as well as ethnic communities in the local area, given their strong social connectedness.

An example of this is Porirua City Council, which has recently widened the scope of their CDEM welfare network group to include 'all people who will be helping people in an emergency'.

The social vulnerability indicators and interactive flood maps can be shared in CDEM welfare network meetings, to prompt further discussion, and sharing of local knowledge so that it becomes shared knowledge across the network.

Coordinating services and building relationships with agencies working in flood-prone areas

The social vulnerability indicators work can prompt thinking about the types of agencies who are likely to be providing support and services to people in flood-prone areas. These services may include:

- Ministry of Education: schools and ECEs in flood hazard zones
- WINZ: WINZ clients receiving benefits
- Oranga Tamariki: homes with vulnerable children
- Housing NZ, local council, other NGOs: Social housing
- Ministry of Health: People receiving disability support services; aged care facilities in flood hazard zones; mental health services in flood hazard zones
- District Health Board: People relying on DHB services/care packages; services located in flood hazard zones
- PHO: Medically dependent individuals; health care services in flood hazard zones
- Pharmacies: People dependent on medication (eg opioid substitution treatment)
- Department of Corrections: people on parole, home detention or community sentence

This would provide an opportunity to start building relationships with these agencies before an event (if this has not already occurred), so that they can make plans at an agency level, and be aware of the potential impacts of floods.

Agencies could then also work with individuals who are living in these areas, to plan for potential disruption, in a feasible way for that person. Agencies could also work together and coordinate the services that they provide to affected communities after a flood.

7. Provide evidence to support important risk reduction strategies by other sectors

For many of the social vulnerability dimensions identified, there are underlying upstream factors that impact on (or exacerbate) vulnerability. Social vulnerability indicators can provide evidence about vulnerabilities in the local community, to support important risk reduction strategies.

Social vulnerability indicator data may provide evidence to support the following types of initiatives:

- prioritising and targeting stormwater infrastructure upgrades and hazard mitigation in areas with high numbers of socially vulnerable people
- providing more housing stock, and making housing stock more resilient to flooding
- providing more social housing that is resilient to flooding and addresses the needs of the local people (eg housing for large families, accessible housing for people with disabilities)
- land use planning, to reduce the risk of harm from flooding, particularly for vulnerable population groups
- employment initiatives to reduce unemployment, if this is a notable vulnerability in the local community
- providing a health-promoting environment, to help reduce the levels of chronic diseases (such as heart disease and diabetes) in the community
- identifying and addressing issues contributing to poverty in a local community, such as large numbers of pokie machines
- ensuring that community champions are identified in the most vulnerable areas.

For example, a resilience / emergency management perspective could inform and influence the national housing debate, such as through making housing more resilient to natural hazards, accessible to all, and able to support residents during and after a disaster (for example through emergency rainwater tanks).

Land use planning has a vital role to play in the reduction of social vulnerability and the strengthened resilience of communities. A number of mechanisms are available to land use planners to include social vulnerability thinking and information into land use planning, including: restricting development and the location of critical buildings and vulnerable land uses in areas subject to natural hazards, protecting natural flood buffers during the planning process, requiring urban design that promotes resilience, recovery planning to promote resilience, and ensuring policies facilitate emergency/temporary housing solutions.

As part of this project, we have produced some documents for end-users with examples of how the social vulnerability indicators could be used to improve resilience. For more information, see the resources described in chapter 20, which are available on the EHI website (www.ehinz.ac.nz/our-projects/social-vulnerability-indicators).

16. Final set of recommended indicators and data sources

Summary

- We finalised the set of indicators after the indicator selection process, evaluation of indicators, testing the indicators with the Porirua case study, and identifying potential uses for the indicators.
- The final set of indicators mainly come from the 2013 Census, and included customised data tables from the Census that are not available elsewhere.
- We also identified a set of potential point locations that could be included in a social vulnerability assessment.

Final set of social vulnerability indicators and data sources

This section provides information about the data sources identified for the social vulnerability indicators (Table 8). This table notes the geographic levels that each indicator is available for: meshblock (MB), area unit (AU) and territorial authority (TA). These indicators are available in a dataset in Excel, and in a heatmap (in Excel).

Table 8: Final set of social vulnerability indicators available in the indicator dataset

Social vulnerability dimensions	Indicator	Data source	Geography
Exposure (direct impacts	Usually resident population	2013 Census	MB, AU, TA
	Number of households	2013 Census	MB, AU, TA
Exposure (indirect impacts, via lifelines infrastructure outages)	People who commute outside of the area (ie they work outside of the territorial authority that they live in)	2013 Census	AU
	People who use public transport to get to work	2013 Census	AU, TA
	People living in rural or remote communities	2013 Census	MB, AU
Children	Children aged 0–4 years	2013 Census	MB, AU, TA
	Children aged 0–14 years	2013 Census	MB, AU, TA
	Households with one or more children aged 0-4 years	2013 Census	MB, AU, TA
	Households with one or more children aged 0-14 years	2013 Census	MB, AU, TA
	Households with one or more children aged 5-16 years	2013 Census	MB, AU, TA
	Households with one or more children aged 0-16 years	2013 Census	MB, AU, TA
Older adults	Older adults aged 65+ years	2013 Census	MB, AU, TA
	Older adults aged 75+ years	2013 Census	MB, AU, TA
	Older adults aged 85+ years	2013 Census	MB, AU, TA
	Households with an older adult aged 65+ years living alone	2013 Census	MB, AU, TA
Physical health needs	Pregnant women (estimated by a proxy of children born in last year)	2013 Census	AU, TA
Mental health needs	People with a psychological or psychiatric impairment	Disability small-area estimates online tool (Stats NZ)	TA
Disability	People with a disability People with a physical disability People with a vision disability People with a hearing disability People with a psychological or psychiatric impairment	Disability small-area estimates online tool (Stats NZ)	TA
Having enough money to cope	Socioeconomic deprivation	NZDep2013 deciles (Atkinson et al 2014)	MB, AU
	People who are unemployed	2013 Census	MB, AU, TA

Social vulnerability dimensions	Indicator	Data source	Geography
	People who are not in the labour force	2013 Census	MB, AU, TA
	People with minimal education	2013 Census	MB, AU, TA
	Single-parent households	2013 Census	MB, AU, TA
	Households with no access to a car	2013 Census	MB, AU, TA
	People working in the primary industries	2013 Census	MB, AU, TA
Social connectedness	Households with an older adult aged 65+ years living alone	2013 Census	MB, AU, TA
	People living in a neighbourhood for less than a year	2013 Census	MB, AU, TA
	Single-parent households	2013 Census	MB, AU, TA
	Single-person households	2013 Census	MB, AU, TA
	Households living in rental housing	2013 Census	MB, AU, TA
	Households with at least one young child (0-4 years)	2013 Census	MB, AU, TA
	Households with at least one child (0-14 years)	2013 Census	MB, AU, TA
	Households with at least one child (0-16 years)	2013 Census	MB, AU, TA
	Households with at least one school-aged child (5-16 years)	2013 Census	MB, AU, TA
	Recent immigrants	2013 Census	MB, AU, TA
Knowledge, skills and awareness of natural hazards	People living in a neighbourhood for less than a year	2013 Census	MB, AU, TA
	People who do not speak English	2013 Census	MB, AU, TA
	Recent immigrants	2013 Census	MB, AU, TA
	Households with no access to the Internet	2013 Census	MB, AU, TA
	Households with no access to a mobile phone	2013 Census	MB, AU, TA
	Households with no access to a telephone	2013 Census	MB, AU, TA
Safe, secure and healthy housing	Households living in rental housing	2013 Census	MB, AU, TA
	Crowded households	2013 Census	AU, TA
	People living in crowded households	2013 Census	AU, TA
	People who are homeless or severely housing deprived	Amore (2016) (based on Census data and other data)	TA
Enough food and water (and other essentials) to survive	Households living in rental housing	2013 Census	MB, AU, TA
	Single-parent households	2013 Census	MB, AU, TA
	Socioeconomic deprivation	NZDep2013 deciles (Atkinson et al 2014)	MB, AU
Decision-making and leadership	Level of voting participation	2016 Local Body elections voting participation data	TA
Other individual-level factors of social vulnerability	Health-care workers and emergency services workers (ambulance, police and fire)	2013 Census	MB, AU, TA
	Households with at least one health-care worker and/or emergency services worker	2013 Census	MB, AU, TA
	Currently registered dog owners	National Dog Database, DIA (FY ending June 2019)	TA
	Currently registered dogs	National Dog Database, DIA (FY ending June 2019)	TA

For all the indicators (where possible), we have provided both the counts and percentages. Counts allow end-users to see the actual number of people affected, while percentages show the relative impacts in different areas.

Indicators for Māori

To demonstrate how indicators could be presented for the Māori population, we have also included Māori data for a few of the indicators, across exposure, susceptibility and resilience (Table 9). Additionally, important point locations such as marae and houses on Māori land were included in the list of point locations. Further work could be done to implement all the social vulnerability indicators for the Māori population.

Table 9: Example social vulnerability indicators for the Māori population

Indicator group	Indicator	Data source	Geography
Exposure	Māori usually resident population		MB, AU, TA
Children	Māori children aged 0-14 years		MB, AU, TA
Older people	Māori older adults aged 65+ years		MB, AU, TA
Safe, secure and healthy housing	Māori living in crowded households		AU, TA

Demographic (contextual) information

We have also included some contextual demographic data in the national indicator dataset. Table 10 presents the additional indicators that we have included in the Excel spreadsheet.

Table 10: Indicators of population demographics and population projection

Indicator group	Indicator	Data source	Geography
Urban/rural	Urban/rural code (5-category: main urban, secondary urban, minor urban, rural centre, rural)	2013 Census	MB, AU, TA
Population	Number of families	2013 Census	MB, AU, TA
Sex	Males	2013 Census	MB, AU, TA
	Females	2013 Census	MB, AU, TA
Ethnic group (total response)	European	2013 Census	MB, AU, TA
	Māori	2013 Census	MB, AU, TA
	Pacific peoples	2013 Census	MB, AU, TA
	Asian	2013 Census	MB, AU, TA
	MELAA (Middle Eastern, Latin American, Aftrican)	2013 Census	MB, AU, TA
	Other ethnic group	2013 Census	MB, AU, TA
Languages spoken	English, Māori, NZ Sign Language, Samoan, Tongan, Northern Chinese, Yue, Sinitic (not further defined), Korean, Hindi, Tagalog, French, German, Spanish, Afrikaans, Other, None (eg too young to talk)	2013 Census	AU, TA
Population estimates and projections	Population estimates for 2018 (total, 0-14 years, 65+ years)	Stats NZ	AU, TA
	Population projections for 2023 (total, 0-14 years, 65+ years)	Stats NZ	AU, TA
	Population projections for 2033 (total, 0-14 years, 65+ years)	Stats NZ	AU, TA
	Population projections for 2043 (total, 0-14 years, 65+ years)	Stats NZ	AU, TA

The social vulnerability indicators for which we have provided data can be considered as a starting point for a social vulnerability assessment in a local area. Additional local data and information may be helpful for supplementing these indicators.

For more details about the final set of indicators, and the metadata for the indicators, see Appendix 3.

Limitations of the current indicator dataset

From the indicator selection criteria, we identified that the age of the Census data (2013) is a key limitation of the indicators. However, at this current stage, there are no other readily-available datasets. This means that users need to be aware of the age of the data. These indicators will give an indication only – they can allow some assumptions to be made, that may need to be tested or checked in the field before being used to make decisions during a response.

Additionally, we did not have time to fully implement the some identified indicators (including health indicators) (Table 11). In some cases, we have provided proxy indicators that could be used instead. However, these indicators could be implemented in future.

Table 11: Potential future indicators

Social vulnerability dimensions	Indicator	Potential data source
Exposure (indirect impacts, via lifelines infrastructure outages)	People living in rural and/or remote communities	2013 Census (7-category classification based on urban influence)
	Households reliant on electricity for heating	2013 Census
People with physical health needs	People with a pre-existing health condition (including heart disease, diabetes, respiratory conditions, immunosuppression)	National health collections datasets
	People requiring essential medications or health services (such as angina medication, insulin, inhalers, epilepsy medication, immunosuppressant drugs, anti-HIV drugs, dialysis, home oxygen therapy)	National health collections datasets
People with mental health needs	People accessing mental health services in the past year	National health collections datasets
	People requiring essential medication for mental illness (anti-depressants, anti-anxiety medication, anti-psychotics, opioid substitution treatment)	National health collections datasets
Having enough money to cope with crises/losses; Enough food and water to cope with shortage	People living in low-income households	2013 Census

Potential point locations relating to vulnerability and/or resilience

For each social vulnerability dimension, we have also identified potential point locations that would be useful for emergency planning and preparedness, and land use planning (Table 12). These point locations could be considered in a social vulnerability assessment at the local level, alongside the indicators above.

Table 12: Point locations to consider in a social vulnerability assessment

Social vulnerability dimensions	Point locations
Exposure (direct)	Emergency shelters, including Civil Defence Centres and marae Important community assets in flood hazard zone (and number of people), including: • schools • early childhood education services • rest homes • marae • hospitals • health care centres • pharmacies
Exposure (indirect)	Important transport routes likely to be affected during a flood • main/ arterial roads; bus routes; trains tracks, stations and underpasses Emergency service facilities • fire stations, police stations, ambulance stations, hospitals / Emergency Departments Important utilities in flood hazard zones • power substations, water pumping stations, stormwater pumps, sewerage pumping stations, telecommunications infrastructure (including cellphone towers), petrol stations Infrastructure vulnerable locations (such as bridges), including hotspots and pinchpoints Hazardous substances facilities / contaminated sites in flood hazard zones
Children	Early childhood education (ECE) centres Schools Other facilities for children, including care and protection residences, youth justice facilities
Older adults	Residential care facilities for older adults Retirement villages (independent living) Social housing for older people
Physical health needs	Primary health care facilities (GP medical centres, A&M emergency clinics) Pharmacies Medical supply depots Hospitals Other health facilities (note: these may be already included as part of hospitals): • Dialysis units

Social vulnerability dimensions	Point locations
	• Birthing units • Long-stay hospitals (including at aged care facilities)
Mental health needs	Mental health facilities (mental health services, in-patient mental health units) Primary health care facilities (GP medical centres) Pharmacies Hospitals
Disability	Facilities for people with disabilities • Community residential homes • Respite care facilities Specialist schools for children with disabilities and high needs
Having enough money to cope with crises / losses	Social housing • Housing NZ homes • Council social housing • Social housing provided by other providers and NGOs (eg Salvation Army) Hazard areas where properties are uninsurable and/or prohibitively expensive to insure
Social connectedness	Marae Schools Early childhood centres Churches Other places of cultural/spiritual significance (such as urupā)
Knowledge, skills, and awareness of natural hazards	Visitor accommodation • Hotels • Motels • Holiday inns • Backpacker accommodation • Camping grounds • Freedom camping sites • Holiday houses Flood hazard zones that have not experienced a flood in recent times (eg last 10 years) Refugee settlement centres and locations
Safe, secure and healthy housing	Houses in flood hazard zones Houses on low-lying land Houses with a floor height below flood depth Houses likely to be aggraded during a flood (ie where the river deposits mud, rocks, boulders, and/or erodes land under or around the house) Emergency housing (such as night shelters, women's refuge) Temporary accommodation • Camping grounds and motor camps • Boarding houses, hotels, motels Māori land Houses on Māori land in flood hazard zones
Enough food and water (and other essentials) to survive	Food stores • Supermarkets • Dairies • Other food stores Food banks Local emergency water supplies (such as water storage tanks, boreholes)
Decision-making and leadership	Marae Civil Defence Centres
Other individual-level factors of social vulnerability	Prisons Youth justice facilities Police stations Community corrections centres University dorms Military quarters Rest homes

Data sources for point locations

Data are not necessarily available nationally for all the above point locations. However, we have identified some potential data sources and/or places to access spatial data.

- Critchlow's NationalMap Emergency Management Basemap contains locations of schools, health services – freely available either to download to use in a GIS system, or to use online http://www.critchlow.co.nz/data/nationalmap-em-basemap
- Local councils may have information on the location of a range of infrastructure and other key locations.
- Other agencies may also have relevant spatial datasets, including the Ministry of Education, Ministry of Health, Department of Corrections, and CDEM groups.
- Māori land shapefiles can be found on the Māori Land Online website: https://www.maorilandcourt.govt.nz/your-maori-land/maori-land-data-service/#spatial-data

17. Additional information to include in a social vulnerability assessment

Summary

- The indicators in the national dataset are just a starting point for understanding social vulnerability in a local area. The indicators work best when they are combined with local knowledge and expertise.
- We identified a range of additional information that could be included in a local social vulnerability assessment. This additional information includes:
  - flood hazard information
  - additional potential indicators using local data sources
  - information about the population and societal context
  - information about the environmental and institutional context
  - potential future vulnerability relating to climate change.

This chapter identifies additional information that could be included to examine social vulnerability in a local area.

The national social vulnerability indicators work best when combined with local knowledge. Local areas are likely to have more detailed, relevant and up-to-date information to supplement the national indicator data. In this way, the national indicator dataset can be used as a starting point for a social vulnerability assessment in a local area, with additional information and local knowledge overlaid over top.

This chapter provides some suggestions of additional information that could be considered in relation to the social vulnerability of an area. This information includes flood hazard information, additional potential indicator datasets, the population and societal context, the environmental and institutional context, and consideration of climate change.

Flood hazard information

It is helpful to have up-to-date information about flood hazard zones when carrying out an analysis of social vulnerability in a local area. This enables end-users to see the at-risk areas in flood hazard zones, then combine that knowledge with social vulnerability information, to inform emergency planning and preparedness.

Some important considerations include the following.

- For flood hazard zones, it is useful to include information about flood depth, stream corridors, overland flow paths and inundation zones, as these are all important factors that influence people's risk of harm.
- The expected impacts of climate change can be taken into account in the flood modelling, through sea level rise and increased rainfall.
- One consideration is what size flood (ie Annual Exceedance Probability, AEP) to use; a 1-in-100 year flood event is generally used.

Having up-to-date hazard information can help people's interpretation of the vulnerability data. Datasets may be available through lifelines infrastructure utilities and local councils (particularly policy

planning teams and/or GIS teams), but they may have not been fully shared with CDEM groups and other interested parties.

Additional potential indicators using local data sources

The indicators can be used as a basis for overlaying additional local data. Local areas are likely to have more detailed, relevant and up-to-date information.

Additional data may include:

- local data sources (such as council datasets like dog registrations)
- health sector datasets (eg from the Primary Health Organisation (PHO), eg about who is currently on what medication)
- Mātauranga Māori (Māori knowledge)
- local/community knowledge
- talking to local people in the community
- qualitative data.

We have identified potential additional point locations, data sources and indicators that users could consider for each dimension (Table 13).

Table 13: Examples of potential other indicators that could be included at the local level

Social vulnerability dimensions	**Other potential indicators**	**Potential data sources**
Exposure (direct impacts	Flood hazard zones	Flood hazard maps
	Land area in flood hazard zones	Flood hazard maps; GIS analysis
	Estimated number of people living in flood hazard zones	Flood hazard maps; Census data; GIS analysis
	Estimated number of buildings/dwellings in flood hazard zone	Flood hazard maps; building data; GIS analysis
	Estimated number of people working (or studying at education facilities) in flood hazard zones	Flood hazard maps; Census/population data; GIS analysis
	Estimated number of children attending ECEs/schools in flood hazard zones	Flood hazard maps; Ministry of Education data; GIS analysis
Exposure (indirect impacts, via lifelines infrastructure outages)	People living in an area likely to be isolated during a flood due to impacts on the transportation network	Census data; GIS analysis
	People living in an area likely to experience outages in safe drinking water during a flood	Census data; GIS analysis
	People living in an area likely to experience power outages during a flood	Census data; GIS analysis
	People living in an area likely to experience telecommunications outages during a flood	Census data; GIS analysis
	People living in an area likely to be contaminated during a flood	Census data; flood hazard maps; contaminated sites data and GIS analysis
Older people	Older adults with a disability or chronic health condition	InterRAI database (eg held by DHB)
Physical health needs	People with chronic health conditions	Local PHO database
	Pregnant women	Local PHO database; midwife database (if possible)
	People on dialysis	Local clinicians/register
Mental health needs	People on anti-depressants, anti-anxiety medication or anti-psychotic medication	PHO database
	People on OSTs	PHO database; pharmacies
Disability	People receiving disability support services	Disability support services
	People with a service dog	Mobility Dogs Trust
Having enough money to cope with losses/crises	Households with no home or contents insurance	Local data

Social vulnerability dimensions	Other potential indicators	Potential data sources
Social connectedness	Refugees	Local data
Knowledge, skills and awareness of natural hazards	Refugees	Local data
	Seasonal or transitory workers	Local data
	Tourists	Local data
Safe, secure and healthy housing	People living in low-lying properties	Local data
	People living in single-storey properties	Local data
	People living in houses on Māori land	Māori land online website
	People living in damp and mouldy housing	Local data
	Households with no home or contents insurance	Local data
Enough food and water (and other essentials) to survive	Households without emergency water supplies for 3-7 days	Local data
	Households without emergency food supplies for 3-7 days	Local data
	Households without an emergency plan	Local data
	Households without better emergency preparedness (torch, portable radio, spare batteries, essential first aid and medications)	Local data
	Households experiencing food insecurity	Local data
	Use of local food banks	Local food banks
Decision-making	Inclusion of Māori, iwi, and hapū in civil defence emergency management planning and decision-making	Qualitative assessment
	Inclusion of vulnerable population groups (such as those with health needs and/or disabilities) in civil defence emergency management planning and decision-making	Qualitative assessment
Other individual-level factors of social vulnerability	People who have previously experienced domestic violence	Local data – eg Police
	People who are serving community sentences or who are on parole	Local data - Corrections
	Households with one or more pets	Local data Dog register (local council)
	People who own or manage livestock	Local data

In addition, contextual factors may be useful to provide background information for a social vulnerability assessment. These factors may not necessarily have indicators, but instead may require a qualitative assessment.

Population and societal context

Having contextual information about the population in an area is important for understanding the underlying drivers of vulnerability and population characteristics. Table 14 presents information that may be useful at a regional level, but also at the neighbourhood level if available.

Table 14: Population and social contextual factors that may influence social vulnerability

Population and social context	Rationale	Potential things to consider during vulnerability assessment
Population characteristics and distribution	Understanding the basic population structure of an area is important, as these factors provide baseline population data for interpreting social vulnerability indicators. These factors can also influence health and wellbeing and are important for understanding how to best meet the needs of the population.	Population structure by: • Sex • Age group • Ethnic group • Socioeconomic status • Urban/rural profile
Population density and growth	High population density can mean large numbers of people affected in a relatively small area. Rapid population growth can sometimes result in infrastructure not being able to meet higher levels of demand. These factors can place strain on resources. Population sizes can also grow on a day-by-day or	Population density Recent population growth in the region Flow of people in and out of region • Commuters on weekdays (including workers and students)

Population and social context	Rationale	Potential things to consider during vulnerability assessment
	seasonal basis, due to commuting patterns and tourism.	• Tourist numbers (including by season, location) • Highly mobile populations
Local economy characteristics	Single economies (for example, agriculture, tourism) and primary industries depending on the land (agriculture, extractive industries such as mining) may be more vulnerable or have specific needs in terms of flood risk.	Occupation distribution of local population Local economy characteristics - single economy (eg agriculture, tourism), primary industries depending on the land (extractive industries, agriculture)

Environmental and institutional context

Environmental and institutional contextual factors influence health outcomes and vulnerability to floods at the larger scale (Table 15).

Table 15: Environmental and institutional factors that may influence social vulnerability

Environmental and institutional context	Rationale	Potential things to consider during vulnerability assessment
Development in vulnerable coastal areas, floodplains or watersheds	Development in locations that are prone to flooding contributes to social vulnerability, by increasing people's exposure to flooding.	Extent to which land use plans have up-to-date flood hazard maps Extent to which land use plans control or manage development in flood-prone areas Consideration of the vulnerability of people likely to use buildings in new developments or change of existing use.
Flood mitigation	Flood mitigation, through both human-managed systems and ecosystem services, contribute to social vulnerability, because it can decrease (or increase) the risk of flooding. In flood-prone areas, stormwater infrastructure upgrades can substantially decrease the risk of flooding.	Extent to which flood mitigation systems currently cope with floods Vulnerability of people in areas potentially needing an upgrade of existing flood mitigation
Emergency management and preparedness	Having effective early warning systems, evacuation plans and assistance, and plans for emergency response, is important to ensure that all people will have access to early warning, services and resources during and after a flood. From an organisational perspective, preparedness also includes data preparedness (such as having population and social vulnerability data on hand to inform early response activities), and building links with the community to build resilience, and to make emergency plans to address people's needs.	Quality and effectiveness of early warning system Extent to which local council civil defence works with local iwi and community groups for emergency management and early warning Data preparedness about population vulnerability
Emergency response and disaster relief	Emergency response (including evacuation and rescues, providing emergency shelter, safe drinking water, clothes, food, emergency toilets and emergency healthcare if needed, as well as recovery services) is important for meeting basic needs. It is particularly important that more vulnerable people can access	Planning of evacuation and accessible shelters Number of first responders Percent volunteerism

Environmental and institutional context	Rationale	Potential things to consider during vulnerability assessment
	services, to ensure that existing inequities are not exacerbated.	Extent to which emergency services are likely to be affected by floods (via transport network etc) Consideration of the role of local iwi in providing important resilience factors (eg marae as evacuation shelters) during an emergency

Potential future vulnerability relating to climate change

This section describes considerations of future vulnerability to flooding. We also identify potential data sources about future vulnerability, which could be used in social vulnerability assessments.

Flooding is expected to worsen in the future in New Zealand due to climate change. Climate change is expected to increase both the intensity and likelihood of flooding occurring in the future, through more heavy rainfall days (Ministry for the Environment 2008). There are regional differences; however, heavy rainfall days are projected to either stay the same, or increase, across almost all of New Zealand. In particular, parts of the South Island are likely to experience more heavy rainfall days. Climate change is also predicted to lead to sea level rise, which may exacerbate the impacts of floods, by reducing the fall to the sea (Ministry for the Environment 2017a). This means that river floods may take longer to drain to the sea as there is nowhere for the water to go, and therefore increase the severity of flood events. Low-lying coastal areas are most at risk of these impacts.

The following factors can be considered relating to climate change and social vulnerability.

Table 16: Climate change and aspects relating to social vulnerability

Population and social context	Rationale	Potential things to consider during vulnerability assessment
Flood hazard zones	It is useful to incorporate climate change, by ensuring that the flood hazard zones include climate change impacts. For example, for the Porirua case study, we used flood models produced by Wellington Water that took into account forecasted impacts of climate change (1m sea-level rise and 20% increase in rainfall), and included 200mm freeboard. Some of these are assumptions, and are variable to change.	Flood hazard zones, taking into account the impacts of climate change
Populations living on flood plains	About two thirds of New Zealand's population is estimated to live on flood plains. Continual population growth in floodplains continues to increase the number of people exposed to flooding. However, with climate change impacts, flooding may become more common on floodplains, increasing vulnerability.	Trends in number of people living on flood plains
Māori land in vulnerable locations	People living in houses on Māori land may be vulnerable, as they may not be able to (or may not be able to afford to) move from Māori land. While these areas may not have been at risk of flooding historically, climate change and sea level rise may increase the risk of flooding.	Māori land in areas at risk from future flooding and climate change impacts
Marae and urupā in vulnerable locations	Many marae are situated in low-lying areas or in flood-prone areas. While these locations may not have historically been at risk from flooding, land use changes and climate change has put them increasingly at risk. Māori climate change commissioner Donna Awatere Huata has noted that about 80 percent of marae and urupā	Marae and urupā in vulnerable locations at risk from climate change

Population and social context	Rationale	Potential things to consider during vulnerability assessment
	lie on the coast or near flood-prone rivers.[3] This poses problems for iwi, given the importance that marae have for Māori resilience to natural hazards and overall wellbeing. Many urupā (burial grounds) are also at risk of flooding. Given the importance of cultural identity and spiritual wellbeing to Māori health and wellbeing, impacts on urupā have the potential to have a large negative impact on iwi.	
Population projections	New Zealand's population is projected to grow over the coming 50-100 years. Examining population projections at the small-area level can help inform future considerations with regards to flooding hazards and vulnerability. Population growth in more vulnerable age groups (children and older adults) may increase vulnerability in an area. Stats NZ publishes population projections, at area unit level, by age group, sex and for 5-year points between 2013 and 2043. This may allow local areas to examine predicted age distribution of population in neighbourhoods in their area.	Projected population, by area unit, for years 2013-2043 (available from Stats NZ) • Total population • 0-14 years • 65+ years • 85+ years
Population ageing	Older adults are vulnerable to the negative impacts of flooding, particularly due to the higher prevalence of poor health, disability, and social isolation in older age groups. New Zealand currently has an ageing population, which may be an important driver of vulnerability in the future. For example, the percent of the New Zealand population aged 65 years and over is predicted to rise from 15% in 2016 to 28% in 2068. Similarly, the percent of the population aged 85+ years is predicted to increase from 2% in 2016 to 6% in 2068.	Projected population, nationally, and by small areas, for years 2013-2043 (available from Stats NZ) • 65+ years • 85+ years
Trends in chronic health conditions and drivers of poor health	People with chronic diseases (such as cardiovascular disease, diabetes, chronic obstructive pulmonary disease and cancer) are more susceptible to the impacts of flooding. While trends in cardiovascular disease have been declining, the obesity rate and associated chronic conditions (such as type 2 diabetes) have been increasing over the past 10-20 years. If these trends continue, there may be an increased in the susceptible population with chronic health conditions.	Trends in obesity Trends in type 2 diabetes Trends in cardiovascular disease

[3] Source: www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12195542

18. Implementing the indicators into RiskScape

Summary

- RiskScape is a national research programme co-developed by NIWA and GNS Science. The RiskScape risk modelling software is an open access tool that lets users assess risk to buildings, infrastructure and people from natural hazards. A new version of RiskScape (RiskScape 2.0) is being developed, and is currently available as a command-line interface. A new web-based graphical user interface is under development.
- In this project, we have incorporated the social vulnerability indicators into RiskScape as a resource layer. The indicators are available at meshblock and area unit level.
- The social vulnerability indicators data are currently available In RiskScape 2.0 through a command-line interface. Key end users of this version include risk scientists at NIWA and GNS, PhD students and researchers, and current clients (such as CDEM Groups) who request risk assessments from NIWA and GNS using RiskScape
- When the new user interface has been developed and implemented for RiskScape, the social vulnerability indicators will be made accessible to all end users.
- A tutorial for end-users has been prepared for the command-line interface. In future, a tutorial will also be made available for the new user interface.

This chapter describes how the social vulnerability indicators were included into RiskScape. This component of the project was carried out by Ben Popovich (NIWA) and Kristie-Lee Thomas (GNS Science).

What is RiskScape?

RiskScape is a national research programme co-developed by NIWA and GNS Science that assesses potential impacts of natural hazards on our communities to inform risk-based disaster risk reduction decision making. RiskScape risk modelling software is an open access tool that lets users assess risk to buildings, infrastructure and people from natural hazards. The tool brings together information about assets (such as houses, infrastructure or people), hazards (such as a flood scenario) and vulnerability functions that estimate damage and loss. The modelled outputs from RiskScape, such as direct damage, reinstatement cost, fatalities and injuries, can be used to inform risk-based decision-making.

There are a range of end-users which use the outputs of RiskScape, including:

- central government
- local government
- emergency management
- lifeline/asset managers
- planning and policy
- insurance/reinsurance
- risk consultants
- researchers.

RiskScape 2.0

RiskScape is jointly developed by GNS Science and NIWA, with a recent collaboration signed with the Earthquake Commission to further develop the next generation of RiskScape software (RiskScape 2.0). This version is much more flexible and modular than the existing tool, including having the option for different user experiences to be developed, such as technical command-line interfaces, web-based graphical user interfaces, and better capability to support users modelling using their own data.

The new version of RiskScape (RiskScape 2.0) is under development and is currently only available as a command line interface. A web-based graphical user interface (UI) is currently being developed, to make the new version of RiskScape more user-friendly for end-users. The longer-term vision is to maintain both the command line and UI software versions, as each appeals to different groups of users.

RiskScape and vulnerability

RiskScape has previously focused on development of hazard and vulnerability models to evaluate the direct and indirect socio-economic losses, including:

- physical damage to buildings and infrastructure (expressed as a damage state)
- the cost to reinstatement physical assets
- functional downtime (productive time lost due to the impact of the hazard on the asset)
- human losses (injuries and casualties)
- human displacement.

However, more research is required to enhance risk modelling to evaluate social vulnerability; that is, moving from injury and casualties, to how people's livelihood and wellbeing may be impacted from natural hazards and climate change.

Previously, Kwok (2016) investigated how social vulnerability factors for earthquakes could be incorporated into RiskScape, recommending development of indicators and application through creating resource datasets to overlay with modelled losses in RiskScape. Following on from this work, this project set out to prepare indicator datasets for incorporation into RiskScape, and to implement a resource layer in the new version of RiskScape that identifies vulnerable populations exposed to flooding.

Implementing the indicators into RiskScape

For the purposes of this project, we focused on:

- identifying how to include social vulnerability indicators into RiskScape, so that the data works alongside the existing models
- preparing a tutorial for how to use the social vulnerability indicators in the command-line interface of RiskScape; users of the command-line interface include risk scientists at NIWA and GNS, PhD students and researchers, and current clients (such as CDEM Groups) who request risk assessments from NIWA and GNS using RiskScape
- promoting the indicator dataset and tutorial through the website and RiskScape newsletter.

The social vulnerability dataset was configured into a RiskScape-compatible format, and built into a resource layer. RiskScape is structured like other common risk modelling frameworks. Though there is a great deal of user customisation possible, the principle model type operates by overlaying an asset layer, a hazard layer, and a vulnerability function which together produce a loss result.

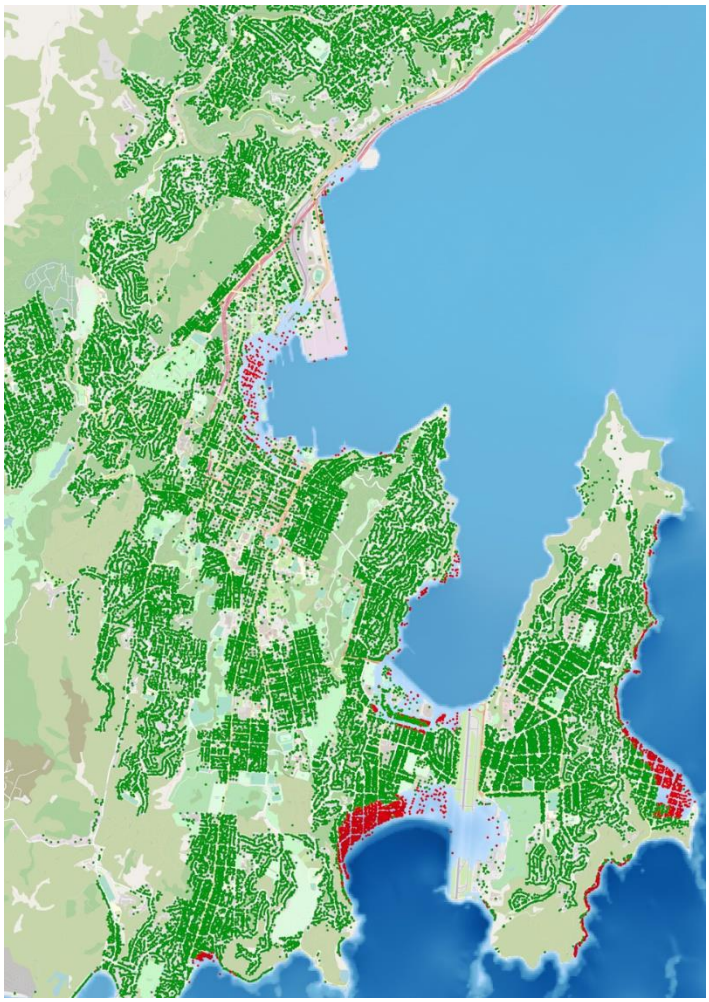
Including other types of data to inform analyses is a feature which was implemented early in the development process. This extra data within the RiskScape framework is called a resource layer, and may include anything from physical attributes such as soil maps, to social information such as demographics presented via geospatial files. The social vulnerability indicators developed through this project were configured into a shapefile that can be read into RiskScape as a resource layer, to inform analyses about vulnerable populations in the area of interest.

As RiskScape is a flexible modelling framework, data is not built directly into the source code, but rather sits alongside the program. Hence while the indicators are a good source of information for risk modellers and are fully compatible with the RiskScape framework, neither they nor any other individual piece of data are an internal part of the system. This modular structure is beneficial in that the indicators can be more easily applied to any analysis if properly configured, whereas a hardcoded structure would require significant reworking of the source code to apply the indicators to additional analyses when they arose.

Outputs from this project

The social vulnerability indicators developed through this project were configured into a shapefile that can be read into RiskScape as a resource layer, to inform analyses about vulnerable populations in the area of interest. Figure 13 provides an example of the type of result that is now possible in RiskScape 2.0 (command-line interface version), to which social vulnerability indicators will be able to be added.

Figure 13: Screenshot of exposure result for Wellington, using RiskScape 2.0



Including the social vulnerability indicators as a resource layer in RiskScape has several benefits.

- The resource layer will allow RiskScape users to identify populations vulnerable to hazard scenarios and information about those populations to inform risk analysis.
- The resource layer will provide data to test and analyse evolving social vulnerability risk modelling methods as recommended previously (Kwok 2016).
- Assessments of social vulnerability could be applied through RiskScape, for example using previously developed methods (Paton et al 2006), and guided by recent research (Kwok et al 2019, Kwok et al 2016, Kwok et al 2018).
- When methods are developed to combine impact loss outputs (such as building damage and infrastructure outage) with the social vulnerability indicators, RiskScape could provide useful outputs for emergency management, policy and planning sectors such as evaluating potential post-disaster needs, response priorities and informing recovery trajectories.

Once RiskScape2.0 software is fully developed and released with the new and improved user interface, the social vulnerability indicator resource layer will be made available, along with a tutorial on how to use the layer. A tutorial will also be developed for the new user interface, to train RiskScape users how to use the new version, including university students and professionals working in central and local government.

In the meantime, if you are interested in using the social vulnerability indicators as part of your RiskScape analysis, please contact Ben Popovich (Benjamin.Popovich@niwa.co.nz) or Kristie-Lee Thomas (k.thomas@gns.cri.nz).

RiskScape is available on the following website: https://www.riskscape.org.nz/. For more information about the RiskScape redevelopment, see: https://www.gns.cri.nz/Home/News-and-Events/Media-Releases/Riskscape

19. Implementing the indicators into local government processes and land use planning

Summary

- Land use planning has a key role to play in reducing exposure and susceptibility to natural hazards, by managing the location and design of land use activities. There are a number of mechanisms available to land use planners through the Resource Management Act 1991 (RMA), including:
    - restricting development in areas subject to natural hazards, either by reducing existing risk (eg managed retreat), avoiding future development, or mitigating the potential effects (eg raised floor levels in areas of flood inundation)
    - restricting the location of critical buildings (eg hospitals) and vulnerable land uses (eg early childhood education facilities, schools, aged residential care facilities) in areas subject to natural hazards
    - protection of natural flood buffers during the planning process (eg requiring esplanade strips to protect riparian margins under section229(a)(v) of the RMA)
    - requiring urban design that promotes resilience (eg connectivity of routes for evacuation, installation of emergency rainwater tanks, communal open space areas to encourage social connectedness)
    - recovery planning to promote resilience in rebuilding after an event has occurred
    - ensuring policies facilitate emergency/temporary housing solutions, for example at schools, marae and public places.
- There is an opportunity to recognise vulnerable populations within a risk-based planning framework for natural hazards. For this project, two methods have been identified. The first method involves including 'vulnerable activities' (such as schools, assisted living facilities, marae, health services, pharmacies, aged care facilities, and social housing, similar to point locations identified earlier in this report) into the consequences table of the risk-based approach to natural hazards developed by Saunders et al (2013).
- The second method, an adaptation of the first, addresses vulnerability by controlling the location of activities that accommodate vulnerable people and/or activities, through the categorisation of activities as Hazard Sensitive Activities, Potentially Hazard Sensitive Activities, and Less Hazard Sensitive Activities. A case study using Porirua City Council has been provided.
- Both methods represent an advancement on current planning practice seen in New Zealand to recognise social vulnerability to natural hazards.
- Annual Plans and Long Term Plans can be effective tools for addressing natural hazard risk to existing vulnerable activities, because they cover council infrastructure upgrades and hazard mitigation works.
- Vulnerable communities and activities are often poorly represented in the public consultation processes of Annual Plans and Long Term Plans. Recommendations have been developed on submission writing, to support vulnerable people, and the groups representing them, in the decision-making process.

This chapter summarises how the social vulnerability indicators and a social vulnerability lens can be included into land use planning and other local government processes.

In particular, this section outlines two possible pathways for incorporating social vulnerability into land-use planning, by including an adaptation of the risk-based planning approach to natural hazards previously developed by Saunders et al (2013) into the District Plan. Other opportunities to include social vulnerability into local government processes are also discussed, including decision-making about infrastructure upgrades and hazard mitigation works, recovery planning, and supporting participation of vulnerable populations in local government decision-making.

This component of the project was carried out by James Beban and Sarah Gunnell (Urban Edge Planning). For full details of this work, see the report *Incorporating social vulnerability into land use planning and local government processes for managing natural hazards and climate change in New Zealand* (Beban & Gunnell 2019), available on the EHI website (www.ehinz.ac.nz/our-projects/social-vulnerability-indicators).

Introduction

Land use planning has a key role to play in reducing exposure and susceptibility to natural hazards, by managing the location and design of land use activities (for example, by avoiding residential or commercial development on hazard prone land, or setting minimum floor levels to mitigate the risk of flooding in buildings). Local government can also reduce exposure and susceptibility to natural hazards through other processes, including infrastructure upgrades and hazard mitigation.

Social vulnerability indicators can provide an evidence base upon which to make these land use planning decisions and other decisions. However, the use of quantitative information to assess the vulnerability of different communities to disasters in local government[4] processes in New Zealand is limited. Additionally, a 2014 review of natural hazards provisions in District Plan chapters found that only 2.9% of District Plans mentioned vulnerable populations, and 11.6% mentioned vulnerable facilities (Saunders et al 2014). The authors suggest these low figures may reflect a current lack of guidance on how to identify vulnerability in a community, or what factors to consider when assessing vulnerability.

Legislative context for local government

Natural hazards are managed in New Zealand under a number of statutes, with the three primary pieces of legislation relevant to vulnerable activities being the Civil Defence Emergency Management Act 2002, the Resource Management Act 1991, and the Local Government Act 2002.

The Civil Defence Emergency Management Act 2002 (CDEM Act) provides the framework under which natural hazards in New Zealand are to be managed. It sets out the duties, responsibilities and powers of central and local government, lifeline utilities and emergency services. It establishes an 'all-hazards' approach that seeks to achieve the sustainable management of hazard risk through the '4 R's' of reduction, readiness, response and recovery. The CDEM Act requires the formation of a number of regional CDEM Groups[5], and each must prepare a CDEM Group Plan that details how the risks that threaten their region will be managed.

[4] Local government in New Zealand consists of regional, city and district councils, as well as unitary authorities that have the functions of both a regional and district/city council.
[5] CDEM Groups are made up of representatives from territorial authorities, regional council, emergency services and lifeline utilities.

The Resource Management Act 1991 (RMA) is the primary piece of legislation under which land use planners operate to guide where people live, work and recreate, primarily through zoning of different activities. The RMA is implemented through a hierarchy of planning instruments, including National Policy Statements (NPS), National Environmental Standards (NES), Regional Policy Statement (RPSs), Regional Plans, and District Plans (Saunders 2017). Councils prepare two key RMA documents: Regional Policy Statements (RPSs) and District Plans. RPSs are prepared by regional councils, and set the overarching outcomes sought for a region, including for natural hazards. District Plans must give effect to RPSs, and take the regional outcomes sought and implement them at a local government level.

Further, sections 61(2A) and 74(2A) of the RMA require that Regional and District Plans take into account any relevant planning document that has been lodged by a recognised iwi authority, such as iwi/hapū management plans. Iwi and hapū management plans identify matters of importance to local Māori and can include valuable information on past natural hazards events, as well as key factors for consideration when managing the effects of natural hazards, for example the diversion or damming of waterways to reduce flood risk (Saunders 2017).

The Local Government Act 2002 (LGA) states that the purpose of local government is to enable democratic local decision-making that meets the current and future needs of communities, in terms of infrastructure, services and regulatory performance in a cost-effective manner. In particular, the LGA states that local government shall have particular regard to the avoidance and mitigation of natural hazards.

While none of the above pieces of legislation currently contain the term vulnerability, these statutes can be used by local government to reduce social vulnerability to natural hazard events, including flooding.

Mechanisms available to reduce social vulnerability through land use planning under the RMA

Land use planning has a vital role to play in the reduction of social vulnerability and the strengthened resilience of our communities. There are a number of mechanisms available to land use planners through the RMA, including:

1. restriction of development in areas subject to natural hazards, either by reducing existing risk (eg managed retreat), avoiding future development, or mitigating the potential effects (eg raised floor levels in areas of flood inundation)
2. restricting the location of critical buildings (eg hospitals) and vulnerable land uses (eg early childhood education facilities, schools, aged residential care facilities) in areas subject to natural hazards
3. protection of natural flood buffers during the planning process (eg requiring esplanade strips to protect riparian margins under section229(a)(v) of the RMA)
4. requiring urban design that promotes resilience (eg connectivity of routes for evacuation, installation of emergency rainwater tanks, communal open space areas to encourage social connectedness)
5. recovery planning to promote resilience in rebuilding after an event has occurred
6. ensuring policies facilitate emergency/temporary housing solutions, for example at schools, marae and public places.

Incorporating social vulnerability into risk-based planning

Most Regional Policy Statements (RPSs) are now directing a risk-based approach to the management of natural hazard risk. Given this, there is an opportunity to recognise vulnerable populations and communities within a risk-based planning framework. This subsection gives an overview of the risk-based planning approach, and then provides two possible ways of including social vulnerability into the risk-based planning approach.

The risk-based planning approach

In recent years, land use planning in New Zealand has been moving towards a risk-based approach that considers not only the likelihood of a natural hazard event, but also the potential consequences. GNS Science has developed a toolkit that outlines an approach to risk-based planning (Saunders et al 2013). This toolkit takes a matrix approach to the management of natural hazard risk, where both the consequences of a natural hazard event and the likelihood of the event are considered. Table 17 outlines the consequence table that was developed as part of the risk-based approach. A full summary of the five steps associated with the risk-based approach is also available.[6]

Table 17: Consequences table for the risk-based approach, developed by Saunders et al (2013)

Severity of Impact	Built				Economic	H&S
	Social/Cultural	Buildings	Critical Buildings	Lifelines		
Catastrophic (V)	≥25% of buildings of social/cultural significance within hazard zone have functionality compromised	≥50% of affected buildings within hazard zone have functionality compromised	≥25% of critical facilities within hazard zone have functionality compromised	Out of service for > 1 month (affecting ≥20% of the town/city population) OR suburbs out of service for > 6 months (affecting <20% of the town/city population)	> 10% of regional GDP	> 101 dead and/or > 1001 injured
Major (IV)	11-24% of buildings of social/cultural significance within hazard zone have functionality compromised	21-49% of affected buildings within hazard zone have functionality compromised	11-24% of buildings within hazard zone have functionality compromised	Out of service for 1 week – 1 month (affecting ≥20% of the town/city population) OR suburbs out of service for 6 weeks to 6 months (affecting <20% of the town/city population)	1-9.99% of regional GDP	11-100 dead and/or 101-1000 injured
Moderate (III)	6-10% of buildings of social/cultural significance within hazard zone have functionality compromised	11-20% of affected buildings within hazard zone have functionality compromised	6-10% of buildings within hazard zone have functionality compromised	Out of service for 1 day to 1week (affecting ≥20% of the town/city population) OR suburbs out of service for 1 week to 6 weeks (affecting <20% of the town/city population)	0.1-0.99% of regional GDP	2-10 dead and/or 11-100 injured
Minor (II)	1-5% of buildings of social/cultural significance within hazard zone have functionality compromised	2-10% of affected buildings within hazard zone have functionality compromised	1-5% of buildings within hazard zone have functionality compromised	Out of service for 2 hours to 1 day (affecting ≥20% of the town/city population) OR suburbs out of service for 1 day to 1 week (affecting <20% of the town/city population)	0.01-0.09% of regional GDP	<= 1 dead and/or 1-10 injured
Insignificant (I)	No buildings of social/cultural significance within hazard zone have functionality compromised	< 1% of affected buildings within hazard zone have functionality compromised	No damage within hazard zone, fully functional	Out of service for up to 2 hours (affecting ≥20% of the town/city population) OR suburbs out of service for 1 day (affecting <20% of the town/city population)	< 0.01% of regional GDP	No dead No injured

In this consequences table, the Social/Cultural and Critical Buildings columns (under Built consequences) allow for the consideration of vulnerable activities.

Critical buildings are buildings which have a post-disaster function, and include:

- buildings and facilities designed as essential facilities
- buildings and facilities with special post disaster functions
- medical emergency or surgical facilities
- emergency services facilities such as fire and police stations
- designated emergency shelters
- designated emergency centres and ancillary facilities
- buildings and facilities containing hazardous materials capable of causing hazardous conditions that extend beyond property boundaries.

[6] The toolkit is also available at https://www.gns.cri.nz/Home/RBP/Risk-based-planning/A-toolbox

Social and cultural buildings are buildings that are of social and cultural importance, and include:

- places of worship
- museums
- art galleries
- marae
- educational facilities.

A proposed method for including social vulnerability into the risk-based approach

Using the consequences table in Table 17 as a basis, it is possible to modify the table to incorporate vulnerable activities. This requires removing some of the existing activities from the definitions of 'critical building' and 'social and cultural buildings', and including them in a new column entitled 'vulnerable activities'.

Given this table is intended to be used for land use planning purposes, the measurement and definition of what constitutes a 'vulnerable activity' would need to be limited to point source activities, for the purposes of simplicity and measurability. (This means social factors such as employment of an individual, marital or family status, and migrancy status would not form the basis of the vulnerability assessment, but rather the sensitivity of activities, for example early childhood centres, retirement villages, and medical facilities.)

As a prerequisite, vulnerable activities need to be defined. For the purposes of land use planning and the requirement for these to be based on point source locations or activities, a potential definition for vulnerable activities is as follows:

> Vulnerable activities are defined as buildings that accommodate any of the following activities:
>
> - assisted living facilities
> - schools and early childhood education centres (ECE)
> - hospices
> - marae
> - medical and health service facilities
> - mental health facilities
> - pharmacies
> - retirement villages/aged care facilities
> - respite care or rehabilitation facilities
> - social housing or residential units constructed by social housing providers.
>
> Note: with the above new definition, educational facilities and marae would be removed from the 'social/cultural buildings' definition, and medical emergency facilities would be removed from the 'critical buildings' definition.

Populating the consequences table with a new column for 'vulnerable activities'

The second step is to populate the consequence table with a new column. As the definition of vulnerable activities is based upon activities within structures, and for the purposes of consistency across the table, the metric of 'percentage of buildings whose functionality are affected' would be the most appropriate. These would align with the same thresholds as social and cultural buildings and critical buildings (which already have thresholds defined within the consequence table). The column for the table would therefore be as presented in Table 18.

Table 18: Proposed additional column for consequences table to incorporate vulnerable activities

Severity of Impact	Vulnerable Activities
Catastrophic	≥25% of buildings containing vulnerable activities within the hazard zone have their functionality compromised
Major	11% – 24% of buildings containing vulnerable activities within the hazard zone have their functionality compromised
Moderate	5% – 10% of buildings containing vulnerable activities within the hazard zone have their functionality compromised
Minor	1% – 5% of buildings containing vulnerable activities within the hazard zone have their functionality compromised
Insignificant	No buildings containing vulnerable activities within the hazard zone have their functionality compromised

The above thresholds would mean that, as the risk from a natural hazard event increases (either due to increasing likelihood of an event, or the consequences from the event increasing (or both occurring), a resource consent category would get more restrictive, and there would be greater thresholds that a development associated with a vulnerable activity would need to meet, to get resource consent approval.

The Saunders et al (2013) risk-based toolkit represents the current main piece of non-statutory guidance on this matter, and the foundations of the process represent best practice. The addition of a column to accommodate vulnerable activities is feasible, and would result in consistent consent levels as the current approach seeks to achieve. The inclusion of this column would also prompt land use planners to actively turn their mind to vulnerable activities, which could lead to a wider recognition of vulnerability within the District Plan.

An alternative method of including vulnerable activities into a District Plan: Porirua City Council Proposed Natural Hazards Chapter

This subsection provides a case study using an adaptation of the above method, to demonstrate another way of using land use planning under the RMA to recognise and address social vulnerability.

This case study uses Porirua City Council, which is currently undertaking a full review of its District Plan. As part of this review, the Council has proposed a risk-based approach to the management to the following natural hazards: flooding, tsunami, fault rupture, sea level rise, and coastal erosion. This risk-based approach has used an adaptation of Saunders et al (2013), modifying aspects of the consequence approach to simplify the resulting objective, policies and rule framework and attempt to recognise the differing vulnerability of activities to natural hazards. In this example, vulnerability is addressed by controlling the location of a number of activities that accommodate vulnerable people, such as aged care facilities, schools, and early childhood education facilities, to avoid an increase in risk to those who are least resilient to the effects of natural hazards.

Given that the District Plan considers natural hazards together in a similar way, this case study refers to all the natural hazards listed above, not just flooding.

Identifying activities based on their sensitivity to natural hazards

The proposed approach took two steps. The first step was to categorise activities based on their sensitivity to natural hazards, with respect to the potential risk to life, vulnerability of the activity to natural hazard and building damage. This step used the Building Importance Category under the Building Code as a starting point to determine whether an activity was a:

- Hazard Sensitive Activity
- Potentially Hazard Sensitive Activity, or
- Less Hazard Sensitive Activity.

This is based upon the approach used in the Ministry for the Environment's guidance document *Planning for Development of Land on or Close to Active Faults* (Kerr et al 2003).

A planning lens was then applied to the categorisation of buildings, to ensure that they aligned with the non-statutory guidance that applies to natural hazards, and to ensure that no perverse outcomes would be achieved in terms of risk to life, and vulnerability of the activity.

This assessment resulted in activities such childcare facilities, retirement premises, and marae being considered as Hazard Sensitive Activities. The proposed categorisation of activities in terms of their sensitivity is shown in Table 19.

Table 19: Proposed hazard sensitivity classification of land use activities

Hazard provisions sensitivity classification	**Land Use Activities**
Hazard Sensitive Activities	• Childcare Centres • Community Facilities • Educational Facilities • Emergency Service Facilities • Hazardous Facilities • Hospital Activities • Marae • Medical and Health Service Activities • Residential Units and Minor Residential Units • Retirement Village Premises • Service Stations • Subdivision that creates a building platform within an identified hazard area for the purpose of accommodating an identified hazard sensitive activity • Visitor Accommodation
Potentially Hazard Sensitive Activities	• Buildings associated with primary production (excluding Residential Units, Minor Residential Units, Residential Activities or buildings identified as Less Hazard Sensitive Activities) • Commercial Activities • Industrial Activities • Retail Activities • Rural Industrial Activities • Buildings associated with Sport and Recreation Activities • Subdivision that creates a building platform within an identified hazard area for the purposes of accommodating an identified potentially hazard sensitive activity
Less Hazard Sensitive Activity	• Accessory buildings used for non-habitable purposes • Buildings associated with primary production (excluding Residential Units, Minor Residential Units, Residential Activities or buildings associated with more than the initial processing of products) • Buildings as defined under Leisure Activities

	• Buildings associated with marina operations (above MHWS) • Recreational activities • Subdivision that creates a building platform within an identified hazard area for the purposes of accommodating an identified less hazard sensitive activity

Note: If an activity is proposed in a natural hazard overlay and is not identified in the above table, it would be assessed as a potentially hazard sensitive activity.

The sensitivity table also accounts for change in activities in existing buildings. This is a change in approach from how existing planning is undertaken for natural hazards, where consent is normally triggered for new buildings, but not for a change of activity in existing buildings. The sensitivity table allows for the consideration in the change in risk as a result of differing activities establishing themselves within a hazard area. This means that if a new sensitive activity (including the identified vulnerable activities) relocates into an existing building with an identified natural hazard overlay, then the potential risk to that activity from being present in the hazard area would need to be considered.

Identifying hazards as low, medium or high

The second step was to map and rank the hazard return periods around whether they represented a low, medium or high hazard. The differing hazard areas are shown in Table 20.

Table 20: Natural hazard and coastal hazard ranking for Porirua City

Natural Hazard Overlay	**Respective Hazard Ranking**
Flood Hazard – Stream Corridor	High
Ohariu Fault Rupture Zone – (20m or closer either side of the Ohariu Fault)	
Flood Hazard – Overland Path	Medium
Pukerua Fault Rupture Zone – (20m or closer either side of the Pukerua Fault)	
Flood Hazard – Ponding	Low
Moonshine Fault Rupture Zone – (20m or closer either side of the Moonshine Fault)	
Ohariu Fault Rupture Zone (excluding 20m either side of Ohariu Fault)	
Pukerua Fault Rupture Zone (excluding 20m either side of the Pukerua Fault)	
Coastal Hazard Overlay	**Respective Hazard Ranking**
Tsunami – 1:100 year inundation extent	High
Coastal erosion and inundation - existing sea level	
Tsunami – 1:500 year inundation extent	Medium
Coastal erosion and inundation - 1m Sea Level Rise Scenario	
Tsunami 1:1000 year inundation extent	Low

Implementation into the District Plan

The District Plan then combines the sensitivity of the activity with the hazard ranking, with an increasing activity status (i.e. restrictions and making resource consent process more difficult with higher level of proof that the activity is appropriate on the site and the hazard risks are addressed) as the sensitivity of the activity and the potential severity of the hazard increases.

The proposed objectives, policies and rules seek to ensure the following four outcomes are achieved:

- avoid development for Hazard Sensitive Activities in the High Hazard Area (Non-Complying Activity)
- discourage development for Hazard Sensitive Activities in the Medium Hazard Area, and Potentially Hazard Sensitive Activities in the High Hazard Area, unless appropriate mitigation measures are incorporated into the proposal
- generally allow, subject to mitigation measures, Hazard Sensitive Activities in the Low Hazard Area and Potentially Hazard Sensitive Activities in the Medium Hazard Area, and
- allow for Less Hazard Sensitive Activities in all Hazard Areas (Low, Medium and High) and Potentially Hazard Sensitive Activities in the Low Hazard Area (via a Controlled Activity status).

The activity status that aligns with the above outcomes are detailed in Table 21.

Table 21: Activity status for different sensitivity activities across the hazard zones

Hazard Ranking	**High**	**Medium**	**Low**
Hazard Sensitive Activity			
Potentially Hazard Sensitive Activity			
Less Hazard Sensitive Activity			

Key	**Activity Status**
	Permitted
	Controlled
	Restricted Discretionary
	Discretionary
	Non-Complying

Small-scale additions to buildings for Hazard Sensitive Activities and Potentially Hazard Sensitive Activities are provided for in all Hazard Areas, subject to mitigation measures to reduce the potential damage, and that the risk to life and surrounding properties is low and will not be increased by the proposal.

The above framework should deliver an outcome whereby there is greater consideration around the appropriateness of activities within natural hazards overlay. The sensitivity table is a step forward in terms of considering vulnerability within land use planning, and while there are opportunities for further improvements through a more refined sensitivity table, it does represent an advancement on current practice seen in many District Plans.

Other local government plans and policies

Other local government plans, policies and strategies that have implications for vulnerable activities include the following, prepared under the Local Government Act 2002:

- Annual Plans
- Long-Term Plans (LTPs)
- Growth Strategies.

Annual and Long Term Plans

The Annual Plan and Long Term Plan processes can be some of the most effective tools for addressing natural hazard risk to vulnerable activities, because they cover council infrastructure upgrades and hazard mitigation works. Through the Long Term Plan, the location of critical infrastructure (such as wastewater and potable water treatment plants) outside of hazard zones can

be planned for. Climate change considerations can also be integrated into future transport and infrastructure planning.

Vulnerable communities and activities are often poorly represented within the submission phase of these processes, and as a result can be overlooked or lose funding. A weighting consideration for vulnerable activities, within the priority ranking for infrastructure renewal, would balance the under-representation that these activities experience within this competitive process. Additionally, improved representation of vulnerable communities and activities, and improved access to political power in local government, could support infrastructure renewals in more vulnerable areas, and improve resilience (see below for more details).

Growth Strategies

Growth Strategies identify where cities and towns are likely to expand into, in the medium- to longer-term. There is the opportunity within these plans to include specific recognition of where the future vulnerable activities within a town or city will be located, and to ensure that these areas are outside of known natural hazard areas.

Consideration can also be given to social housing providers that have large land holdings (such as Housing New Zealand), to make sure any potential intensification of social housing in these areas is appropriate, given the natural hazard profile of the area.

Ensuring the needs and concerns of vulnerable populations are heard and addressed

Most local government plans are required to go through a consultative process, which provides the opportunity for public to have their say in the decision-making process. During these submission phases, vulnerable communities and activities are often poorly represented. Improved access to political power in local government has the ability to improve the resilience of vulnerable populations, by ensuring their needs and concerns are heard and addressed.

The guidance document (Beban & Gunnell 2019) provides a number of recommendations on how individuals with vulnerabilities (and groups that represent them) can achieve greater recognition with local councils, and present more effective submissions.

Ways to gain greater recognition include:

- Be on a steering group or focus group, if there is the opportunity.
- Be on council's list of interested parties, to be advised when documents have been released for public comment.
- Keep a weekly watch on key council websites to see what plans, policies and strategies are being consulted on.
- Submit on local government strategies and plans during the consultation period (see below).

To help make effective submissions on local government strategies and plans, individuals with vulnerabilities (and groups that represent them) could do the following.

- Concentrate efforts on the six documents that have the greatest influence on the local council and can include measures to protect vulnerable activities. These six documents are Annual Plans, Long Term Plans, District Plans (and relevant plan changes), Regional Policy Statements, Urban Growth Strategies, and CDEM Group Plans.

- These plans have differing timeframes for consultation for renewal. If the submission phase is missed, it can take a long time before the issue can be readdressed within these documents. Typical timeframes include:
    - Annual Plans – annually
    - Long Term Plans – every three years
    - Urban Growth Strategies – every five years
    - District Plans – every 10 years
    - Regional Policy Statements – every 10 years
    - CDEM Group Plans – every 10 years.
- When submitting on a plan, policy or strategy, make sure the submission is relevant to the topic being consulted on.
- Be factual in the submissions. If you can, support points raised in the submission with evidence; this will hold more weight than emotional arguments with no evidence.
- Write your submissions in plain English. When you are identifying a problem, make sure you identify acceptable solutions to the problem. Submissions that are solution-focused have a greater uptake.
- Verbally present the submission at the hearing, as these submissions are generally more effective. Ensure that you present and summarise the main points of the submission within the allocated time (which may be between 2 minutes and 30 minutes, depending on the committee). It is possible to request the presenting times in advance of attending the hearing so the verbal submission can be tailored to the hearing.
- Requests for changes to an issue will need to appear to be reasonable. This may not be the a best-practice outcome, but it is better to get some improvement to and recognition of an issue or outcome through a reasonable response, rather than getting nothing from being unreasonable. Normally, changes to an issue occur through numerous small incremental changes, as opposed to one large step change.
- Acknowledge good points or positives in a plan, policy or strategy when they exist. This makes the submission appear balanced, and will provide greater weighting towards the issues and solutions raised in the submission.
- In some instances, expert support may be required to support a submission, particularly in relation to Regional Policy Statements, District Plans, and CDEM Group Plans. Experts who know their way through the legislation and what matters can be included in submissions. This is likely to result in more uptake on the matters raised in submission.

20. Disseminating the indicator information and data

Summary

To meet the needs of our end-users, we produced the indicator data in a number of formats:

- a national dataset of social vulnerability indicators, by territorial authority, area unit and meshblock (where possible) (Excel)
- a heatmap in Excel, to show area units with high and low values
- spatial datasets (shapefiles) of indicators, at the territorial authority, area unit and meshblock levels
- a resource layer of the social vulnerability indicators in RiskScape
- metadata (information about how each indicator was defined and created).

We have also produced guidance for end-users:

- a toolkit for using the indicators
- a document with detailed information about indicator rationale, data sources, examples of potential uses, and case studies
- a user guide for RiskScape users wanting to use the social vulnerability resource layer
- a user guide for land use planners, on how to incorporate vulnerability into the District Plan.

For the case study for Porirua, we have produced:

- an interactive online map (Story Map) for Porirua, to demonstrate how the indicators can be used in real life
- a case study document for Porirua, with static maps of social vulnerability indicators at the area unit level

This chapter summarises the needs of end-users, and describes the various outputs from this study. These outputs are available for download from the Environmental Health Indicators (EHI) website: www.ehinz.ac.nz/our-projects/social-vulnerability-indicators).

Identifying end-user needs

We previously identified that end-users needed three main types of information from this project:

- information and evidence about social vulnerability to flooding – identifying the types of vulnerabilities and reasons for these vulnerabilities
- social vulnerability indicators for local areas, including data tables, maps, spatial datasets (shapefiles) and metadata
- guidance and ideas about how to implement social vulnerability indicators into different sectors, including civil defence and land use planning, to reduce the impact of floods on health and wellbeing.

In particular, technical users (such as data analysts and spatial Geographic Information System (GIS) experts) need the following from the indicators:

- data tables available to download (eg in csv or Excel format)
- spatial datasets (shapefiles) available to download and use in their own GIS systems
- metadata for indicators, outlining the details such as data sources, definitions, and analytical techniques used, as well as any issues or uncertainties in the data quality.

Key outputs from this project

The key outputs from this project include indicator data, guidance for end-users, and a case study for Porirua. All of these outputs are available on the EHI website www.ehinz.ac.nz/our-projects/social-vulnerability-indicators

1. Indicator data

To meet the needs of our end-users, we produced the indicator data in a number of formats:

- List of social vulnerability indicators
- Excel tables of indicators, by meshblock, area unit and territorial authority
- Heatmap of social vulnerability indicators by area unit, to show areas with high and low indicator values within territorial authorities
- Spatial datasets (shapefiles) of indicators, at meshblock, area unit and territorial authority level
- Metadata with information about how each indicator was defined and created.

2. Porirua case study

As part of the project, we carried out a case study for Porirua, to give an example of how the indicators might be applied and/or used. The case study outputs include:

- **An online interactive map (Story Map) for Porirua**, which included:
  - social vulnerability indicators
  - point locations
  - up-to-date flood hazard maps
  - information about social vulnerability
  - different dimensions of social vulnerability
- **A case study document** about social vulnerability in Porirua, with maps of Porirua area units, and numbers of vulnerable populations (produced for a draft set of social vulnerability indicators).

The Story Map provides an example of how the indicators can be combined with flood hazard information/data to provide useful information for end-users.

3. Indicator guidance for end-users

We have provided guidance about the indicators for end-users in the following documents.

Social vulnerability indicators for flooding: Toolkit for users

We have produced a toolkit to help people use the social vulnerability indicators (Mason et al 2019b). This toolkit explains why certain groups are vulnerable to the impacts of flooding, gives the list of indicators and other potential geographic point locations and data sources to include in a social vulnerability assessment, and some ideas about how to use the indicators to reduce vulnerability.

Social vulnerability indicators for flooding: Rationale, indicators and potential uses

Throughout this project, we have gathered ideas about how the social vulnerability indicators could be used to help reduce vulnerability in the community. We have compiled this document as a summary of the vulnerability dimensions, available indicators, other potential indicators and datasets, examples of how the indicators could be used, and case studies (Mason et al 2019a). These are ideas and suggestions that can be used as a prompt or a checklist for addressing specific types of vulnerability in a community.

Incorporating social vulnerability into local government processes for managing natural hazards and climate change in New Zealand

A guidance document has been prepared for land use planners and local government, outlining some key ways that land use planning and other local government processes can incorporate social vulnerability to strengthen resilience in our communities (Beban & Gunnell 2019). This report includes an example of how social vulnerability can be included in a District Plan, as well as a range of other mechanisms available to land use planners to include social vulnerability thinking into land use planning. This report was prepared by James Beban and Sarah Gunnell (Urban Edge Planning Ltd).

Factsheet: Health and wellbeing impacts of floods

We have produced a factsheet summarising the potential impacts of flooding on health and wellbeing in this factsheet, available on the EHI website.

4. RiskScape

Resource layer in RiskScape, and tutorial for RiskScape users

This part of the project, led by Ben Popovich (NIWA) and Kristie-Lee Thomas (GNS Science), produced a resource layer in RiskScape with the social vulnerability indicators, available by meshblock and area unit. A tutorial was also developed to guide RiskScape 2.0 command-line interface users on how to use the resource layer (see Chapter 18 for more details). When a web-based RiskScape graphical user interface is developed in future, another tutorial will be developed to guide users on how to use the social vulnerability resource layer.

These outputs have been designed for RiskScape users, including risk scientists at NIWA and GNS, PhD students and researchers, as well as current clients such as CDEM Groups who request risk assessments from NIWA and GNS using RiskScape.

RiskScape is available on the following website: https://www.riskscape.org.nz/. For more information about the RiskScape redevelopment, see: https://www.gns.cri.nz/Home/News-and-Events/Media-Releases/Riskscape

If you are interested in using the social vulnerability indicators as part of your RiskScape analysis, please contact Ben Popovich (Benjamin.Popovich@niwa.co.nz) or Kristie-Lee Thomas (k.thomas@gns.cri.nz).

21. Discussion and conclusion

Summary

- This project has successfully developed a set of social vulnerability indicators for flooding in New Zealand, with specific relevance to impacts on people's health and wellbeing. As well as a national indicator dataset, we have identified additional information that could be included at a local level, to enhance understanding of local social vulnerability and resilience.
- This project provides valuable information to support priorities of the new National Disaster Resilience Strategy, including providing nationally-consistent data to help identify and understand social vulnerability, a critical component of understanding risk.
- This project supports the main theme of the National Disaster Resilience Strategy that *we all have a role to play in a disaster resilient nation*. This project brought a variety of sectors together to work on a commonly important topic of social vulnerability to flooding. In addition to the CDEM sector, we identified the importance of the health sector and housing sector (particularly social housing providers) in reducing vulnerability to natural hazards. As part of this project, we provided end-users with practical outputs to inform risk reduction, readiness, response and recovery initiatives.
- Māori, iwi, hapū, and Te Ao Māori perspectives play a critical role in disaster readiness, reduction, response and recovery in New Zealand, in particular through marae, social connectedness, knowledge and Mātauranga Māori and existing leadership structures. Māori also face unique challenges, such as the location of marae and houses on Māori land in flood hazard zones, where people have deep connections to the whenua (land) and relocation is not an easy or particularly feasible decision.
- The results of this study highlight the importance of considering social vulnerability alongside resilience. Understanding the social vulnerability of an area helps to identify susceptible populations and the high-priority areas for resilience-building work.
- Further work in this area could include updating indicators with up-to-date data, implementing new indicators, creating interactive Story Maps for the rest of New Zealand, and broadening the applicability of the indicators to other natural hazards (including those related to climate change).

This chapter reflects on the social vulnerability indicators project as a whole, which includes identifying the project successes, potential implications for the New Zealand context, strengths and challenges of this project, as well as recommendations for future work.

Project successes

This project has successfully developed a set of social vulnerability indicators for flooding in New Zealand and has met the research objectives. As part of this project, we developed the following key outputs: (i) a conceptual framework for understanding social vulnerability; (ii) a national dataset of social vulnerability indicators; (iii) a list of other potential information that could be included in social vulnerability assessment; (iv) data visualisation tools and examples; and (v) useful toolkits and user guides for using the indicators in emergency management, land use planning, and in the risk modelling software RiskScape.

Through the conceptual framework, we have provided a way of thinking about and understanding social vulnerability and resilience. The conceptual framework brought together several established,

international conceptual frameworks and models, using the MOVE framework for vulnerability assessment (Birkmann et al 2013) as a foundational basis. We adapted and extended this framework specifically for social vulnerability, by including the circle of resilience (Wisner et al 2012). The circle of resilience allows a visual representation of how resilience (and vulnerability) is multi-faceted, and that people can be both vulnerable and resilient, for different reasons. This framework also highlights dimensions of social vulnerability that can be difficult to measure with nation-wide quantitative data, such as decision-making and leadership, and having enough food and water to cope with a shortage. Using a conceptual framework approach allows for these dimensions to have visibility within the indicator set, even if indicators within these dimensions do not have national data and/or are measured using proxy indicators. Incorporating a Māori model of health (including physical, mental, social and spiritual health) (Durie 1985) into the conceptual framework also allowed a broad range of negative impacts from flooding, and a Māori perspective, to be considered.

Based on the conceptual framework, we have identified a set of social vulnerability indicators for flooding, with nation-wide data available. This national dataset of social vulnerability indicators helps to describe and measure the different dimensions of social vulnerability, at as fine a geographic level as possible. In effect, the national indicator dataset provides a community profile of areas across New Zealand, using a consistent approach to measurement. Communities can then use and adapt the indicator set, to meet their needs and best reflect the needs of their community.

As well as the national dataset of indicators, we have provided alternative sources of data, and additional indicators and point locations that could be included in a more in-depth assessment of social vulnerability in a local area. Collating this data for all regions in New Zealand is unfeasible in this project, due to logistics, inconsistent measurement, and the time required to collate the data across the country. However, this additional information can be highly valuable within a local context and for end-users, and therefore we felt this information to be an important part of the outputs of this project. This approach is supported by a previous New Zealand study that identified that a comprehensive or detailed vulnerability assessment is crucial for providing a deeper understanding of vulnerability to natural hazards (Khan 2012).

A key success of this project was the Story Map, our online interactive map that allows end-users to explore our case study area of Porirua and examine the social vulnerability indicators and point locations alongside flood hazard zones. Many people in the CDEM and health sectors in New Zealand do not have access to their own Geographic Information System (GIS) for exploring spatial data, although they may be able to liaise with GIS staff in local and regional councils. The Story Map addressed this gap in readily-accessible information, by providing a user-friendly set of maps and social vulnerability information able to be explored online by any user, including people working within CDEM groups.

Importantly, our project also identified uses for the indicators in practice, through emergency planning and preparedness, response and recovery activities, and through risk reduction activities such as land use planning. An underlying theme of our discussions with stakeholders was that the indicators and Story Map allowed recognition and reminders of vulnerabilities in the community, to share with others and allow a consistent understanding across agencies. Identifying these potential uses of the indicators was also crucial for informing the indicator selection, as it helped ensure that there was direct line of sight from the conceptual framework, to indicator selection, and finally to potential uses for the indicators.

Additionally, our project has identified key ways that social vulnerability can be incorporated into local government processes, including land use planning. For example, consideration of land use activities relating to vulnerability and resilience (such as schools and aged care facilities) can be included in

District Plans, to ensure that consideration of vulnerable populations is part of decision-making at the local level. This project has identified a method that can be used to incorporate vulnerability into a District Plan natural hazards chapter and has provided an example using Porirua City Council. In this way, we have expanded on the existing risk-based planning approach, to include vulnerability.

Implications for New Zealand

This project provides valuable information to support the approach of the new National Disaster Resilience Strategy. In particular, the national set of indicators provide data to help end-users identify and understand social vulnerability to flooding at a community level, which is an important objective in the strategy to understand risk. Furthermore, our nationally-consistent approach to understanding and measuring social vulnerability, as well as a national dataset of social vulnerability indicators, will help to improve the information and intelligence system that supports decision-making in emergencies. The social vulnerability indicators provide information to support an equitable response to flooding, to help prevent exacerbation of existing inequalities after a flood.

Our work supported the central theme of the National Disaster Resilience Strategy, that *we all have a role to play in a disaster resilient nation*. Our project worked with several sectors that contribute to reducing vulnerability to natural hazards, including the civil defence sector, local councils, and health sector. Additionally, our framework and indicators suggested other important sectors for considering resilience to natural hazards. For example, the housing sector has a key role to play, both in building resilient housing (particularly social housing for more vulnerable people), as well as ensuring that vulnerable people (such as disabled people) are housed in suitable accommodation that does not increase their vulnerability to natural hazards. A resilience and emergency management perspective could inform and influence the national housing debate, such as through making housing more resilient to natural hazards, accessible to all, and able to support residents during and after a disaster (for example through emergency rainwater tanks).

This project highlighted the strengths that Māori, iwi, hapū, and Te Ao Māori perspectives bring to resilience to natural hazards in New Zealand. In previous disasters, marae have been opened by iwi and hapū to the wider community to provide shelter, safety, social support and food/kai, to help during response phases. Aspects of Te Ao Māori that contribute to resilience to natural hazards include existing physical structures (such as marae), social structures (including networks of people across whānau, hapū and iwi, and tikanga), and existing leadership structures. These helped to inform the social vulnerability dimensions of *Safe, secure and healthy housing* (which includes emergency shelters and marae), *Social connectedness*, *Enough food and water to cope with shortage, Knowledge, skills and awareness to face natural hazards,* and *Decision-making and leadership*. In this way, we highlight the multi-faceted resilience that Māori have, and show that simply using socioeconomic indicators as a proxy for resilience will not accurately represent the full resilience of Māori.

Māori also face unique challenges, such as the location of marae and houses on Māori land in flood or other hazard zones, and the inhibitions of being able to relocate due to cultural reasons, financial reasons, and having a lack of land to relocate to. Potential ways to build resilience for Māori include systems and processes that improve partnerships between CDEM and iwi and hapū, ensuring that marae are well-prepared and resourced for anticipating and responding to disasters, and reducing risk to Māori houses, marae and wahi tapū in flood hazard zones.

More broadly, the results of this study highlight the importance of considering social vulnerability alongside resilience. Understanding the social vulnerability of an area helps to identify susceptible populations and high-priority areas for resilience-building work. The indicators can also help civil

defence practitioners to target, prioritise, and adapt their existing activities to ensure that information is cognisant of the needs of their community.

This project adds a useful and complementary set of indicators to the existing indicator sets measuring vulnerability and resilience in the New Zealand disaster risk reduction context. By focussing on social vulnerability and taking a public health approach, we have provided a robust method for assessing social vulnerability to flooding. These indicators can be used to complement other assessments of vulnerability and resilience, such as the New Zealand Resilience Index, which focuses on resilience more broadly. Our set of indicators also provide a practical approach to measuring social vulnerability and identification of relevant uses for the indicators.

Strengths and challenges

A key strength of this project was the use of a robust indicator development process. As part of this process, we used a conceptual framework to guide indicator selection, which ensured that the indicators were grounded in the theory of vulnerability and resilience. Using a conceptual framework approach also allows indicators to be easily updated, changed or added to in future by researchers and end-users. Given the conceptual basis for these indicators, although they were developed specifically for flooding, these indicators are likely to be useful for considering other natural hazards.

Furthermore, this indicator development process included a strong focus on end-users and their needs, which meant that the end products are fit for purpose. Including stakeholders from central government (MCDEM), local government (CDEM and land use planners), iwi, hapū and the health sector has ensured that the indicators and outputs are relevant and useful for these sectors. The potential uses for indicators identified in the toolkit were developed in collaboration with stakeholders, drawing on their knowledge and experience. Additionally, we have developed an innovative approach to incorporating vulnerability into land use planning through District Plans, and we have provided a case study example that can be used by other territorial authorities.

A further strength of the indicators is that, while they were developed specifically for flooding, the indicators will also be useful for understanding vulnerability to a variety of other natural hazards. The indicators can be considered as a ‘community profile’, which can guide work at the local level within the civil defence, health and other social sectors.

A significant strength was our use of data visualisations to share and disseminate the indicators information, with the Story Map an unexpected success in this project. Additionally, we designed a heat map for the indicators, to allow stakeholders to see all indicators for an area ‘at-a-glance’, while still retaining valuable information about the types of vulnerability and number of people affected.

A major challenge for this project was acquiring up-to-date data. Due to data collection issues with the 2018 Census resulting in lengthy delays to outputs and reduced quality and usefulness, we were unable to include the 2018 Census data in this project. Instead, we used 2013 Census data, which is readily available and robust, although now comparatively old. Since 2013, several social changes have occurred in New Zealand, including a housing crisis and a change in government. It is unknown to what extent the 2013 data is still representative. Nonetheless, these indicators can be used as a starting point for understanding social vulnerability and can be complemented with more up-to-date data, as well as 2018 Census data when it is released.

For some indicators, we had difficulty sourcing nation-wide data, in particular for the dimensions of *Enough food and water to cope*, *Decision-making and leadership,* and the health and disability dimensions. The data sources available for the dimension *Enough food and water* (such as emergency preparedness surveys) were not sufficiently robust enough or at a fine enough geographic

level to use as indicators. However, we made use of proxy indicators (mainly focussed on aspects of socioeconomic deprivation), to help identify areas where people may struggle. For the *Decision-making* dimension, we used a proxy of level of voting participation, at the territorial authority and/or ward level. However, important supplementary information for this dimension includes whether Māori and local iwi/hapū, as well as vulnerable population groups (such as people with disabilities), are included in civil defence emergency management in the local area. For the physical and mental health dimensions, we identified potential data sources and indicators, but were unable to complete the indicator implementation within the project timeframe. For the decision-making, physical health and mental health dimensions, we have noted the potential indicators in the indicator list, given their importance; however, data is currently not available for them.

We found having stakeholder engagement throughout the project highly beneficial, particularly having an end-user perspective on the types of indicators to include, data requirements for indicators, and the best ways of sharing the indicator data. However, we found there was changing involvement of personnel from agencies throughout the project, due to competing demands of workloads and other priorities. This meant that stakeholders were often coming in new to the project, for example when they attended a workshop. Nonetheless, this did not necessarily have a negative impact on the project, as workshop participants were still able to provide their perspective, and new connections were made. We faced similar challenges with our stakeholder engagement with Ngāti Toa Rangatira, who are also very busy and have multiple demands on their time. We are grateful to Rawiri Faulkner for leading the engagement with Ngāti Toa and providing a Ngāti Toa perspective on the social vulnerability project.

Recommendations for further work and research

The results and outputs from this study show that a range of additional work could be carried out to update the indicators and make them more widely useable and relevant across New Zealand. We have identified the following further work that could be carried out in future:

- updating the indicators with the latest data available at the time (including 2018 Census data when it is published)
- implementing the proposed health indicators
- creating Story Maps for other regions of New Zealand
- investigating co-occurrence and distribution of multiple vulnerabilities in populations
- further developing social vulnerability indicators for Māori communities
- developing ways to use the social vulnerability indicators in community engagement.

In particular, there was widespread support among our stakeholder group for future work to extend the Story Map approach to other regions of New Zealand.

Conclusion

This project has succeeded in developing and implementing a set of social vulnerability indicators for flooding in New Zealand. As part of this, we have developed a conceptual framework that helps people to understand, and remember, the different dimensions of social vulnerability. This project has resulted in the development of a set of indicators for the whole country, as well as the identification of additional information that could be included at a local level, to enhance people's understanding of local vulnerability and resilience. The indicator toolkit, data outputs and case study outputs (including the interactive Story Map) will help end-users in their ability to access and use the indicators, to help reduce vulnerability to flooding in their local area.

This project has also highlighted key aspects of Māori resilience to natural hazards. These include the physical structures (marae), social structures (close connections with iwi/hapū and whānau), Māori cultural values and practices, and existing leadership structures. These aspects of resilience reflect many of the dimensions of resilience in our conceptual framework. Māori also face unique challenges, including the location of marae and houses on Māori land in flood hazard zones.

These indicators will support a deeper understanding of vulnerability to flooding in New Zealand and will contribute to reducing New Zealanders' vulnerability to flooding and other natural hazards. In particular, this project provides valuable information to support the National Disaster Resilience Strategy, including by providing nationally-consistent data to help identify and understand social vulnerability in order to understand risk. The results of this study highlight the importance of considering social vulnerability in order to inform emergency preparedness, resilience-building, and risk reduction activities in New Zealand.

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Appendix 1: Previous social vulnerability indicators and related work

This appendix gives information about previous international social vulnerability indicators and related work (Table 22).

Table 22: Summary of international social vulnerability indicators and indices

Name	Reference	Country	Method	Description	Topics of variables	Comments
Social Vulnerability Index (SoVI)	Cutter et al (2003)	United States (county-level)	Created an index, using statistical methods	Created a single index by reducing 42 variables to 11 key variables (using principal components analysis and weighted variables). Developed for the United States, at the county level. Used in other countries.	Personal wealth, age, density of built environment, single-sector economic dependence, housing stock and tenancy, race, ethnicity, occupation, infrastructure dependence.	Variables were a mix of demographic characteristics, built environment, and infrastructure characteristics. Including built environment and infrastructure indicators may have led to an urban bias. The index used the American concepts of race and ethnicity.
Medical vulnerability index (MoVI)	Cutter	United States		Identified aspects of health that make people more vulnerable to natural hazards. Covered physical health needs, psychological health needs, healthcare access, and health system capability.	Disability and low health perception, chronic illness and medical dependence, limited healthcare access, dialysis dependents, domestic violence propensity, special needs institutions, alcohol abuse, drug abuse, mental health, developmental disability.	
Cologne flood vulnerability indicators	Birkmann et al (2013)	Cologne, Germany	Created indices, using conceptual approach	Identified indicators for vulnerability to assess the social dimension towards floods. Using MOVE framework, derived indices for flood exposure, susceptibility and lack of coping capacity, then combined into overall social vulnerability index.	Number of people living in flood-prone areas, percentage of people able to evacuate themselves and others without external help (estimated based on age structure per household and information about invalids, people with experience with floods.	Combined indicators into exposure index, susceptibility index (unable to evacuate themselves and others), and lack of coping capacity index (based on previous experience with flooding).
Social determinant of vulnerability framework	Atyia Martin (2015)	International; implemented in Boston, United States	Identified key indicators, using analysis of literature (grounded theory approach)	Identified key interrelated social factors relating to people having disproportionate exposure to risk, and a decreased ability to avoid or absorb potential losses.	Children, older adults (65+ years), people with disabilities, chronic and acute medical illness, social isolation, low-to-no income, people of colour.	

Name	Reference	Country	Method	Description	Topics of variables	Comments
				Adverse outcomes included injury/illness/death, displacement, property damage/loss, loss of employment, access to services, domestic violence.	Also found following indicators were important: women, less than high school diploma, limited English proficiency, renters, lack of vehicle.	
Urban Municipality Flood Vulnerability Index	Rasch (2016)	Brazil	Created index, using statistical analysis (factor analysis and an additive model)	Identified about 26 indicators, and created an index	Age (<15, 65+ years), disability, health, education, household income, owner-occupied homes, not working, access to mobile phone, TV, radio; land use plan indicating flood-prone areas, risk plan for environmental hazards; presence of slums, tenements, informal settlements; preparedness for floods, distance of area to primary road, access to cars, housing quality, household size, location of dwellings, population density, piped drinking water, sewage disposal system	
Social Flood Vulnerability Index (Flood Hazard Research Centre)	Tapsell et al (2002)	United Kingdom	Created an index, using equal weights to sum to an index	Identified range of indicators, and created an index.	Financially deprived people (as defined by the Townsend Index, which uses unemployment, overcrowding, non-car ownership, non-home ownership), long-term sick, single parents, elderly (75+ years).	
Social vulnerability index for disaster management	Flanagan et al (2011)	United States	Created an index for four social vulnerability domains, and overall	Identified 15 indicators across the following domains: socioeconomic status, household composition and disability, minority status and language, housing and transportation. Used percentile-rank across all census tracts in the US for each variable, added together to get indices. Tested a case study for Hurricane Katrina deaths and displacement.	Individuals below poverty line; unemployed; per capita income; people with no high school diploma; 65 years and older; people aged 17 years or younger, people aged 5+ years with a disability, percent male or female householder with no spouse present and with children under 18, minority groups, people aged 5+ years who speak English less than 'well', multi-unit structures, mobile homes, household crowding, no vehicle available, people in group quarters (correctional institutions, nursing homes, college dormitories, military quarters)	Categorised indicators by domains. Useful ideas about practical implementation of social vulnerability indicators for disaster management, and included feedback from key users.

Name	Reference	Country	Method	Description	Topics of variables	Comments
Social vulnerability indicators for earthquakes	Kwok (2016)	New Zealand	Based on literature	Identified a set of social vulnerability indicators for earthquakes in New Zealand. Adapted from SoVI 2006-2010 (Cutter) and previous indicator sets. Also identified sets of indicators for civil defence practitioners, health practitioners, and RiskScape. Focussed mainly on earthquake-related deaths as the health outcome of interest (CHECK)	Poverty (people living in poverty, households with no cars, female-headed households, renters, unemployment, low educational attainment, employment in service industry, children living in married couple families); wealth (median house value, household income, per capita income); race and ethnicity (non-European, limited English proficiency); elderly (households receiving superannuation, people aged <5 or 65+ years, median age); gender (female, female participation in work force); care dependency, medical disability, healthcare access (people living in nursing and skilled-nursing facilities, people with disabilities, hospitals per capita.	No data sources were identified for these indicators, and the indicators were not implemented (ie no data sources were identified, and no indicator definitions or data outputs were created). The study used the United States conceptualisations of race and ethnicity, which may not be as relevant in the New Zealand context.
Vulnerability assessment – Hutt Valley case study	Khan (2012)	Hutt Valley, New Zealand	Comparison of indicators, indices	Used 38 proxy indicators to compare different vulnerability assessment approaches, including: NZDep2006; an index based on principal components analysis; composite vulnerability indices using weighted and unweighted variables; specific vulnerability indicators	Proxy indicators cover demographics (population distribution, crowding, gender, age, disability and migration), social (family type, education, language, ethnicity) and economic (income, source of income, employment, occupation, housing condition, communication) Specific indicators included elderly, disabled, single parents, Māori, Pacific Asian	Found that the different vulnerability assessments showed different spatial patterns (eg focussed on economic vulnerability). Suggested using different vulnerability assessments to get a comprehensive view.
New Zealand Index of Deprivation (NZDep2013)	Atkinson et al (2014)	New Zealand		Created a small-area index of socioeconomic deprivation for New Zealand, based on nine variables from the 2013 Census. Mostly used in the health sector, and validated against smoking status. Previous versions of the NZDep have included 1991, 1996, 2001 and 2006.	Having no access to Internet at home (< 65 years); receiving a means-tested benefit (18-64 years); living in equivalised households with income below an income threshold; unemployed (18-64 years), having no qualifications (18-64 years), not living in own home, living in single-parent family (< 64 years), living in crowded households, having no access to a car	Helpful at giving a single snapshot picture of the socioeconomic deprivation of a small area (meshblock or census area unit). Difficult to deconstruct the index, to determine which key factors are driving deprivation in an area. The predecessor, NZDep2001 (from the 2001 Census) has previously been trialled as a

Name	Reference	Country	Method	Description	Topics of variables	Comments
						proxy social vulnerability indicator for earthquakes (Paton et al 2006).
New Zealand Indices of Multiple Deprivation	Exeter et al (2017)	New Zealand	Conceptual approach – indicators selected for theoretical ability to measure an aspect of relative deprivation	Recently developed as indices for the social sector, covering seven domains of deprivation.	Employment Income Crime Housing Health Education Geographical access	Developed and published at 'data zone' scale (intermediary scale created between meshblock and area unit).
New Zealand Index of Neighbourhood Social Fragmentation	Ivory et al (2012)	New Zealand	Used nine census variables and principal components analysis	Index developed to measure neighbourhood-level social fragmentation, using Census data.	Less sharing of norms and values: fewer school-aged children, more recent immigrants (< 1 year), more non-NZ language speakers; less place attachment (less home ownership, less residential stability, more single-person households, fewer married adults, more non-family households; fewer social resources (fewer long-term residents (>15 years)	Developed using 1996 and 2001 Census data, and does not appear to have been updated since then.
Resilience Index New Zealand	Pearson et al (2013)	New Zealand	Statistical analyses	This index was constructed as an index of health resilience to deprivation.	'Resilient' areas defined as neighbourhoods with high levels of socioeconomic deprivation (based on NZDep) but lower-than-expected mortality.	This study found some neighbourhood characteristics were associated with resilient factors. However, no underlying framework or conceptual model was used to identify resilience.
New Zealand Resilience Index (NZRI) - Trajectories toolbox	Stevenson et al (2018)	New Zealand (ongoing project)		Currently creating a composite index of place-based resilience to natural hazards. Based on a multi-capital model, with the index divided into 6 capital-based sub-indices: community, economic, social, built environment, natural environment, institutional	Engaging in voluntary work, lived in current area for 5+ years, total hospital discharges by DHB per 1000 population, number of industries (ANZIC codes for businesses) represented in an area, resident population not employed in the primary sector, working fulltime, has post=-high school education, equivalised household income, infrastructure independency systemic resilience metric, percent of commercial buildings that meet at least 34% of new building standard, percent change in natural land use between 1990 and	Indicators selected from a literature review and indicator bank of more than 1000 indicators; thematic content review used to identify topics; 15 indicators selected from these. Index designed to summarise resilience at the small-area (CAU) level, and to provide comparisons between areas and across time. The NZRI is referred to in MCDEM's

Name	Reference	Country	Method	Description	Topics of variables	Comments
					2012, percent registered historic sites damaged/destroyed since 2000, percent completeness of hazard planning from district plans, number of hospital beds per 1000 people, average distance to designated Community Emergency Response Centre, Number of emergency shelters per 1000 people, percent of households with emergency water for three days.	proposed National Disaster Resilience Strategy.

Appendix 2: Evaluation of data sources and indicators against selection criteria

This appendix provides details about potential data sources identified for the social vulnerability indicators. Table 23 summarises the 2013 and 2018 Census datasets and National Collections health administrative datasets (such as the National Minimum Dataset (NMDS) of hospitalisations, cancer registrations dataset, and pharmaceuticals dataset), assessed against the relevant indicator selection criteria about data sources. Table 24 presents the final set of social vulnerability indicators, assessed against the indicator selection criteria.

Table 23: Assessing the 2013 Census and 2018 Census data sources against relevant indicator selection criteria

Selection criteria relating to data sources	**2013 Census**	**2018 Census**	**National Collections health administrative datasets**
Data availability	Currently available at meshblock, area unit and territorial authority, from Stats NZ website and NZ.Stats website Additional data tables can be requested from Stats NZ	No disaggregated attribute data has been released yet (as at October 2019) Data quality issues may mean that some variables are not released at all	NMDS, Cancer registrations, pharmaceuticals datasets are available as confidentialised unit record data, upon request to the Ministry of Health; the data request process may take some time Virtual Diabetes Register is based on the National Collections datasets Datasets allow us to look at past-year health service utilisation Data linkage to a population register is needed in order to determine lifetime/chronic health conditions (eg through the Health Tracker dataset, Chronic Conditions dataset, or IDI)
Methodologically sound measurement (for data collection)	Good coverage (97.6% of New Zealanders) Generally considered to be a high-quality dataset	Poor coverage (only 83.3% of New Zealanders completed an individual form, and 68.2% of Māori) More likely to be more vulnerable people who did not respond Stats NZ are currently working on imputing data using other data sources; however, it is unclear whether this will be successful for all variables, or only population counts.	Robust health administrative collections, with good coverage as used for payments Datasets are continually updated Only measures people who access health system; will not count those people who have unmet needs for health care
Able to be disaggregated	Able to be disaggregated to meshblock, area unit, territorial authority, and other geographies (eg ward, Auckland local boards, district health boards, regional councils)	Data will be output in a different geography: - Statistical Area 1 (SA1s): based on meshblocks, but with some meshblocks combined to give sufficient population numbers to report on - Statistical Area 2 (SA2s): similar to existing area units	Able to be disaggregated to area unit level
Timely	Data relates to March 2013, so is six years out of date; since 2013, there has been a rise in	Data relates to March 2018, so is much more recent than 2013 data.	Some delays in accessing data (1-3 years delay)

	population numbers, housing issues, and homelessness		
Summary	**Good source of data** that is currently available, including at small area levels **Some caution needed**, as the data is currently 6 years old, and some things may have changed	**Potentially a good source of data in future, depending on what is made available** However, there are **major data quality issues** due to a low response rate **Only when disaggregated attribute data is released in 2020** will we be able to determine: - quality and reliability of data - whether data is available for all indicators.	**Good sources of data** about health service utilisation. Some limitations, in terms of timeliness of data Linked datasets may be needed in order to determine lifetime / chronic conditions

Table 24: Demonstration of indicators against selection criteria

Social vulnerability dimensions	**Indicator**	**Data source**	**Indicator selection criteria**									
			Scientifically valid	**Data availability**	**Methodologically sound measurement**	**Able to be disaggregated**	**Timely**	**Intelligible and easily interpreted**	**Consistent with other indicator programmes**	**Comparable over time**	**Sensitive to change**	**Public health importance**
Exposure (direct impacts	Usually resident population	2013 Census*	y	y	y	y	Old	y	y	y*	y	y
	Number of households	2013 Census*	y	y	y	y	Old	y	y	y*	y	y
Exposure (indirect impacts, via infrastructure outages)	People who work outside of the territorial authority	2013 Census*	y	y	y	y	Old	y	y	y*	Every 5 years	y
	People who use public transport to get to work	2013 Census*	y	y	y	y	Old	y	y	y*	Every 5 years	y
	People living in rural and/or remote communities	2013 Census*	y	y	y	y	Old	y	y	y*	Every 5 years	y
Children	Children aged 0–4 years	2013 Census	y	y	y	y	Old	y	y	y*	Every 5 years	y
	Children aged 0–14 years	2013 Census	y	y	y	y	Old	y	y	y*	Every 5 years	y
	Households with at least one child aged 0-4 years	2013 Census	y	y	y	y	Old	y	y	y*	Every 5 years	y
	Households with at least one child aged 0-14 years	2013 Census	y	y	y	y	Old	y	y	y*	Every 5 years	y
	Households with at least one child aged 5-16 years	2013 Census	y	y	y	y	Old	y	y	y*	Every 5 years	y
	Households with at least one child aged 0-16 years	2013 Census	y	y	y	y	Old	y	y	y*	Every 5 years	y

Social vulnerability dimensions	Indicator	Data source	Indicator selection criteria									
			Scientifically valid	Data availability	Methodologically sound measurement	Able to be disaggregated	Timely	Intelligible and easily interpreted	Consistent with other indicator programmes	Comparable over time	Sensitive to change	Public health importance
Older adults	Older adults aged 65+ years	2013 Census	y	y	y	y	Old	y	y	y*	Every 5 years	y
	Older adults aged 75+ years	2013 Census	y	y	y	y	Old	y	y	y*	Every 5 years	y
	Older adults aged 85+ years	2013 Census	y	y	y	y	Old	y	y	y*	Every 5 years	y
	Households with an older adult aged 65+ years living alone	2013 Census	y	y	y	y	Old	y	y	y*	Every 5 years	y
Physical health needs	Pregnant women (estimated by a proxy of children born in last year)	2013 Census	proxy	y	proxy	y	Old	A bit tricky	n	y*	Every 5 years	y
Mental health needs	People with a psychological or psychiatric impairment	Disability small-area estimates online tool (Stats NZ)	y	y	y	Only to TA	Old	y	y	?	Every 5 years	y
Disability	People with a disability, overall and separately: • Physical • Vision • Hearing • Psychological or psychiatric impairment	Disability small-area estimates online tool (Stats NZ)	y	y	y	Only to TA	Old	y	y	?	Every 5 years	y
Having enough money to cope	Socioeconomic deprivation	NZDep2013 deciles (Atkinson et al 2014)	y	y	y	y	Old	y	y	y	Every 5 years	y
	Unemployed people	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Not in the labour force	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	People with minimal education	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Single-parent households	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Households with no access to a car	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	People working in the primary industries	2013 Census	y	y	y – note includes fisheries as well	y	Old	y	y	y	Every 5 years	y
	Older adults (65+ years) living alone	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y

Social vulnerability dimensions	Indicator	Data source	Indicator selection criteria									
			Scientifically valid	Data availability	Methodologically sound measurement	Able to be disaggregated	Timely	Intelligible and easily interpreted	Consistent with other indicator programmes	Comparable over time	Sensitive to change	Public health importance
Social connectedness	People living in a neighbourhood for less than a year	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Single-parent households	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Single-person households	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Neighbourhoods with higher levels of rental properties	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Households with at least one child aged 0-4 years	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Households with at least one child aged 0-14 years	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Households with at least one child aged 5-16 years	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Households with at least one child aged 0-16 years	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Recent immigrants (in the past 0 / 0-1 years)	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
Knowledge, skills and awareness of natural hazards	People living in a neighbourhood for less than a year	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	People who do not speak English	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Recent immigrants (in the past 0 / 0-1 years)	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Households with no access to the Internet	2013 Census	y	y	y	y	Old – likely out of date	y	y	y	Every 5 years	y
	Households with no access to a mobile phone	2013 Census	y	y	y	y	Old – likely out of date	y	y	y	Every 5 years	y
	Households with no access to a telephone	2013 Census	y	y	y	y	Old – likely out of date	y	y	y	Every 5 years	y
Safe, secure and healthy housing	People living in rental housing	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	Crowded households	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	People living in crowded households	2013 Census	y	y	y	y	Old	y	y	y	Every 5 years	y
	People who are homeless or severely housing deprived	Amore (2016) (based on Census data and other data)	y	y	y	Only to TA	Old	y	y	y	Every 5 years	y
Enough food and water (and other	People living in rental housing	2013 Census	proxy	y	y	y	Old	y	y	y	Every 5 years	y
	Single-parent families	2013 Census	proxy	y	y	y	Old	y	y	y	Every 5 years	y

Social vulnerability dimensions	Indicator	Data source	Indicator selection criteria									
			Scientifically valid	Data availability	Methodologically sound measurement	Able to be disaggregated	Timely	Intelligible and easily interpreted	Consistent with other indicator programmes	Comparable over time	Sensitive to change	Public health importance
essentials) to survive	Socioeconomic deprivation	NZDep2013 deciles (Atkinson et al 2014)	proxy	y	y	y	Old	y	y	y	Every 5 years	y
Decision-making and leadership	Level of voting participation	2016 Local Body Elections voting participation data	y	y	y	Only to TA	y	y	y	y	y	y
Other individual-level factors of social vulnerability	Health-care workers and first responders – place of usual residence	2013 Census	y	y – but first responders tricky	y	y	Old	y	y	y	Every 5 years	y
	Health-care workers and first responders - workplace	2013 Census	y	y – but first responders tricky	y	y	Old	y	y	y	Every 5 years	y
	Households with at least one health-care worker and/or first responder	2013 Census	y	y – but first responders tricky	y	y	Old	y	y	y	Every 5 years	y
	Currently registered dog owners	National Dog Database (DIA)	y	y	y	Only to TA, but local councils may have better data	y (financial year ending June 2019)	y	y	y	Annual	y
	Currently registered dogs	National Dog Database (DIA)	y	y	y	Only to TA, but local councils may have better data	y (financial year ending June 2019)	y	y	y	Annual	maybe

Appendix 3: Metadata for indicators

This appendix provides details about potential data sources identified for the social vulnerability indicators.

Table 25: Metadata for the social vulnerability indicators

Dimension of social vulnerability	Indicator	Data source	Description	Numerator	Denominator	Geography
Exposure (direct impacts	People usually resident in an area	2013 Census	Census usually resident population	n/a	n/a	MB, AU, TA
	Households in an area	2013 Census	Total households in occupied private dwellings	n/a	n/a	MB, AU, TA
Exposure (indirect impacts, via infrastructure outages)	People who work outside of the territorial authority that they live in	2013 Census	Workplace address, among employed usually resident population aged 15+ years	People who reported a workplace address outside of the TA that they lived in	Total stated, among employed population 15+ years	AU
	People who use public transport to get to and from work	2013 Census	Main mode of transport to get to work on Census day, among employed people aged 15+ years	People who reported using a bus or train to travel to work on Census day	People who travelled to work on Census day (total stated)	AU, TA
	People living in rural and/or remote communities (proxy)	2013 Census	Urban/rural classification	Urban/rural classification (main urban, secondary urban, minor urban, rural centre, rural	n/a	MB, AU
Children	Children aged 0–4 years	2013 Census	Age by sex, for the census usually resident population	0–4 years	Total people	MB, AU, TA
	Children aged 0–14 years	2013 Census	Age by sex, for the census usually resident population	0–14 years	Total people	MB, AU, TA
	Households with at least one child aged 0-4 years	2013 Census (customised table)	Counting households with children in private dwellings, age of youngest child	Households with at least one child aged 0-4 years	Total households	MB, AU, TA
	Households with at least one child aged 0-14 years	2013 Census (customised table)	Counting households with children in private dwellings, age of youngest child	Households with at least one child aged 0-14 years	Total households	MB, AU, TA
	Households with at least one child aged 0-4 years	2013 Census (customised table)	Counting households with children in private dwellings, age of youngest child	Households with at least one child aged 0-4 years	Total households	MB, AU, TA
	Households with at least one child aged 0-14 years	2013 Census (customised table)	Counting households with children in private dwellings, age of youngest child	Households with at least one child aged 0-14 years	Total households	MB, AU, TA
Older adults	Older adults aged 65+ years	2013 Census	Age by sex, for the census usually resident population	65 years and over	Total people	MB, AU, TA
	Older adults aged 75+ years	2013 Census	Age by sex, for the census usually resident population	75 years and over	Total people	MB, AU, TA
	Older adults aged 85+ years	2013 Census	Age by sex, for the census usually resident population	85 years and over	Total people	MB, AU, TA
	Households with an older adult (65+ years) living alone	2013 Census (customised table)	Total households in occupied private dwellings	Households with one person aged 65+ years	Total households	MB, AU, TA
Physical health needs	Pregnant women (estimated by a proxy of children born in last year)	2013 Census	Age by sex, for the census usually resident population	Babies aged less than 1 year old	Total people	MB, AU, TA (estimates)
Mental health needs	People with a psychological or psychiatric impairment	Disability small-area estimates online tool (Stats NZ)	Small-area estimates, by TA and 5-year age group (note these are estimates only, and as such have associated statistical uncertainty)	Estimated number of people with a psychological or psychiatric impairment	TA population (sum of all age groups in 'overall' category)	TA

Dimension of social vulnerability	Indicator	Data source	Description	Numerator	Denominator	Geography
Disability	People with a disability People with a physical disability People with a vision disability People with a hearing disability People with a psychological or psychiatric impairment	Disability small-area estimates online tool (Stats NZ)	Small-area estimates, by TA and 5-year age group (note these are estimates only, and as such have associated statistical uncertainty)	Estimated number of people with each type of disability	TA population (sum of all age groups in 'overall' category)	TA
Having enough money to cope	Socioeconomic deprivation	NZDep2013 deciles (Atkinson et al 2014)	NZDep2013 deciles were developed by the University of Otago from nine Census variables. NZDep2013 data is available at both the meshblock and area unit level.	NZDep2013 decile of AU	N/A	MB, AU
	People who are unemployed	2013 Census	Work and labour force status, for the census usually resident population aged 15 years and over	People aged 15+ years and who were unemployed	Total people stated (among those aged 15+ years)	MB, AU, TA
	People who are not in the labour force	2013 Census	Work and labour force status, for the census usually resident population aged 15 years and over	People aged 15+ years and who were not in the labour force	Total people stated (among those aged 15+ years)	MB, AU, TA
	People with minimal education	2013 Census	Highest qualification, for the census usually resident population aged 15 years and over	People aged 15+ years and who had no qualification	Total people stated (among those aged 15+ years)	MB, AU, TA
	Single-parent households	2013 Census	Family types, for families in occupied private dwellings	One parent with child(ren)	Total households	MB, AU, TA
	Households with no access to a car	2013 Census	Number of motor vehicles, for households in occupied private dwellings	Households with no motor vehicle	Total households stated	MB, AU, TA
	People working in the primary industries (by residential address)	2013 Census	Industry (ANZSIC06 division), for the employed census usually resident population aged 15 years and over	Agriculture, forestry or fishery	Total employed census usually resident population aged 15+ years	MB, AU, TA
	People working in the primary industries (by workplace address)	2013 Census	Industry (ANZSIC06 division), for workplace address, for the employed census usually resident population aged 15 years and over	Agriculture, forestry or fishery	Total employed census usually resident population aged 15+ years (by workplace)	MB, AU, TA
Social connectedness	Households with an older adult (65+ years) living alone	2013 Census	Sex and age group, for people in one-person households in occupied private dwellings	One-person households with a person aged 65+ years	Total households stated	MB, AU, TA
	People living in a neighbourhood for less than a year	2013 Census	Years at usual residence, for the census usually resident population	0 years	Total people stated	MB, AU, TA
	Single-parent households	2013 Census	Households in private occupied dwellings, household composition	Households with single-parent families	Total households stated	MB, AU, TA
	Single-person households	2013 Census	Household composition, for households in occupied private dwellings	One-person households	Total households stated	MB, AU, TA
	Households living in rental housing	2013 Census	Tenure of household, for households in occupied private dwellings	Dwellings not owned and not held in family trust	Total households stated	MB, AU, TA
	Households with at least one child aged 0-4 years	2013 Census	Households with at least one child aged 0–4 years	Households with at least one child aged 0–4 years	Total households stated	MB, AU, TA

Dimension of social vulnerability	Indicator	Data source	Description	Numerator	Denominator	Geography
	Households with at least one child aged 0-14 years	2013 Census	Households with at least one child aged 0–14 years	Households with at least one child aged 0–14 years	Total households stated	MB, AU, TA
	Households with at least one school-aged child (aged 5-16 years)	2013 Census	Households with at least one child aged 5–16 years	Households with at least one child aged 5–16 years	Total households stated	MB, AU, TA
	Households with at least one school-aged child (aged 0-16 years)	2013 Census	Households with at least one child aged 0–16 years	Households with at least one child aged 0–16 years	Total households stated	MB, AU, TA
	Recent immigrants (0 years)	2013 Census	Years living in New Zealand	0 years	Total people stated	MB, AU, TA
	Recent immigrants (0-1 year)	2013 Census	Years living in New Zealand	0-1 years	Total people stated	MB, AU, TA
Knowledge, skills and awareness of natural hazards	People living in a neighbourhood for less than a year	2013 Census	Years at usual residence, for the census usually resident population	0 years	Total people stated	MB, AU, TA
	People who do not speak English	2013 Census	Languages spoken (up to six recorded), for the census usually resident population	(Total people stated) – (English)	Total people stated	MB, AU, TA
	Recent immigrants (0 years)	2013 Census	Years living in New Zealand	0 years	Total people stated	MB, AU, TA
	Recent immigrants (0-1 year)	2013 Census	Years living in New Zealand	0-1 years	Total people stated	MB, AU, TA
	Households with no access to the Internet	2013 Census	Access to telecommunications, for households in occupied private dwellings	(Total households stated) - (access to the internet)	Total households stated	MB, AU, TA
	Households with no access to a mobile phone	2013 Census	Access to telecommunications, for households in occupied private dwellings	Cellphone/mobile phone, no or not stated	Total households	MB, AU, TA
	Households with no access a telephone	2013 Census	Access to telecommunications, for households in occupied private dwellings	Telephone, no or not stated	Total households	MB, AU, TA
Safe, secure and healthy housing	Households living in rental housing	2013 Census	Tenure of household, for households in occupied private dwellings	Dwellings not owned and not held in family trust	Total households stated	MB, AU, TA
	Crowded households	2013 Census	Crowded households (as defined by needing one or more bedrooms, according to the Canadian National Occupancy Standard, or CNOS)	Households with 1+ bedrooms needed	Total households stated	AU, TA
	People living in crowded households	2013 Census	People living in crowded households (as defined by needing one or more bedrooms, according to the Canadian National Occupancy Standard, or CNOS)	People living in households with 1+ bedrooms needed	Total people stated	AU, TA
	People who are homeless or severely housing deprived	Amore (2016) (based on Census data and other data)	People in severe housing deprivation. This includes those: (i) without habitable accommodation (living rough, or in a mobile dwelling not in a motor camp), (ii) living in non-private dwellings (night shelters, camping grounds, boarding houses etc), and (iii) living as a temporary resident in a severely crowded household.	People who are severely housing deprived (Includes: people without habitable accommodation; people living in non-private dwellings; people living as a temporary resident in a severely crowded household)	Total people	TA
Enough food and water (and other essentials) to survive	Households living in rental housing	2013 Census	Tenure of household, for households in occupied private dwellings	Dwellings not owned and not held in family trust	Total households stated	MB, AU, TA
	Single-parent households	2013 Census	Households in private occupied dwellings, household composition	Households with single-parent families	Total households stated	MB, AU, TA

Dimension of social vulnerability	Indicator	Data source	Description	Numerator	Denominator	Geography
	Socioeconomic deprivation	NZDep2013 deciles (Atkinson et al 2014)	NZDep2013 deciles were developed by the University of Otago from nine Census variables. NZDep2013 data is available at both the meshblock and area unit level.	NZDep2013 decile of AU	n/a	MB, AU
Decision-making	Voter turnout	2016 Local Authority Elections	Level of voter turnout in the local authority elections	Number of registered voters who voted in the local authority election	Number of registered voters	TA
Other individual-level factors of social vulnerability	Health-care workers and first responders	2013 Census	Industry (ANZSIC06 division), for the employed census usually resident population aged 15 years and over	Health Care and Social Assistance	Total people stated (among employed people aged 15+ years)	MB, AU, TA
	Health-care workers and first responders	2013 Census	Industry (ANZSIC06 division), for workplace address, for the employed census usually resident population aged 15 years and over	Health Care and Social Assistance	Total people stated (among employed people aged 15+ years)	MB, AU, TA
	Households with at least one health-care worker and/or first responder	2013 Census	Counting employed usual residents in private occupied dwellings, industry by household (ANZSIC06)	1 or more people working in specified industries (police services, fire protection and other emergency services, health care and social assistance)	Total people stated (among employed people aged 15+ years)	MB, AU, TA
	Number of currently registered dog owners	National Dog Register, Department of Internal Affairs	Registered dog owners	Number of currently registered dog owners	n/a	TA (local councils would have lower geographic level)
	Number of registered dogs	National Dog Register, Department of Internal Affairs	Registered dogs	Number of currently registered dogs	n/a	TA (local councils would have lower geographic level)