Social Vulnerability Assessment

He Pou a Rangi Climate Change Commission

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Revision Summary

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The data analysis and risk models presented in this Urban Intelligence report were generated using our Resilience Explorer® platform, a climate risk assessment tool that brings together different datasets into one comprehensive system.

Through the platform's advanced modelling capabilities, Urban Intelligence processes infrastructure records, historical hazard data, demographics, and economic information to create detailed climate projections. The Resilience Explorer platform's ability to combine diverse data sources and generate evidence-based risk assessments provided the insights needed for practical climate adaptation and resilience planning.

This analytical approach demonstrates how digital tools can turn complex climate data into clear, actionable information that helps communities and organisations prepare for climate change.

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Executive Summary

Coastal flooding is already affecting Aotearoa New Zealand's communities and infrastructure, and these impacts will expand as sea levels rise due to climate change and tectonic subsidence.

This report provides insights at the territorial authority (TA) level into "who" is most at risk from coastal flooding and "why" they may have heightened social vulnerability. Coastal flooding is assessed using a 1% Annual Exceedance Probability (AEP) event under various sea-level rise (SLR) scenarios. A 1% AEP event, often referred to as a '100-year flood', has a 1% chance of occurring or being exceeded in any given year. This does not mean such an event only occurs once every 100 years; in fact, there is more than a 1-in-4 chance of experiencing at least one such event in a 30-year period.

By analysing distributional patterns across geographic and demographic dimensions, this analysis highlights areas where physical risk and social vulnerability compound to create hotspots of disproportionate and inequitable impact. Specifically, this analysis identifies which TAs in Aotearoa New Zealand may face greater community-level burden of harm from coastal flooding due to heightened levels of social vulnerability, both under present-day conditions (0.0m SLR) and in the future under different sea-level rise scenarios (0.2 m, 0.5m and 1.0m SLR).

We used two metrics to explore exposure:

1. People living in properties at risk of direct exposure to 1% AEP coastal flooding. This metric estimates the number of people potentially directly exposed to coastal flooding.

2. People living in properties that may experience isolation. This accounts for people that may become cut off from their wider community or lose access to critical services due to the impact of coastal flooding, even in the absence of directly experiencing inundation. Isolation counts include directly exposed residents.

To assess vulnerability, we developed a vulnerability index (Specific Hazard Vulnerability Index - SHVI). For this we used a set of social vulnerability indicators to provide insights into which groups may experience heightened vulnerability relating to the impacts of coastal flooding. These indicators were grouped into bundles according to shared characteristics e.g. indicators relating to why certain groups may be more likely to experience negative impacts from coastal flooding due to factors affecting their mobility, or financial wellbeing. These bundles of indicators were then grouped into four 'people, health and community' categories, which represent both the sensitivities as well as the type of outcomes or impacts groups may experience:

- Physical health
- Mental health, identity, autonomy and sense of belonging and wellbeing
- Social cohesion, community and cultural wellbeing
- Equity

We combine exposure and vulnerability to calculate a risk score that expresses the share of each TA's population that is both highly vulnerable and directly exposed (or isolated) in a 1% AEP coastal flood. This score identifies the proportion of people who are simultaneously located in hazard-prone areas and fall into the highest two quintiles of vulnerability (quintiles 4 and 5 of the SHVI). This measure gives insights into which TAs are likely to experience a greater degree of harm across their communities arising from exposure or isolation due to coastal flooding.

Social vulnerability can be described as the likelihood or susceptibility of an individual or group to experience harm as a result of their relative positioning within social, cultural, economic and political systems [1], [2], [3]. Social vulnerability helps explain why some individuals, communities, and populations may experience greater adverse consequences from climate hazards such as coastal flooding than others.

Unlike approaches that focus primarily on physical exposure, social vulnerability refers to the characteristics and capacities (including social, political, and economic factors) that shape how people experience and respond to hazards. While we use the term 'vulnerability' throughout this report to refer to populations, we emphasise that vulnerability is not an innate quality of individuals or groups, but rather a fluid state, influenced by those (often shifting) capacities, characteristics, and wider contexts within which people live.

The following subsections outline key trends at the national and TA scale.

Exposure and Isolation Trends Across Aotearoa New Zealand

As sea levels rise, the number of people across Aotearoa New Zealand who will be potentially exposed to, or isolated as a result of, 1% AEP coastal flooding will increase.

In terms of direct exposure, 0.6% of the population nationally (more than 28,900 people) may be exposed during a 1% AEP coastal flood event under present-day conditions (0.0m SLR). These figures continue to increase at different sea-level rise increments:

- 0.2m SLR: 1.1% of residents (approximately 52,700 people)
- 0.5m SLR: 1.6% of residents (approximately 80,130 people)
- 1.0m SLR: 3.1% of residents (approximately 150,900 people)
- 2.0m SLR 5.4% of residents (approximately 264,900 people)

In terms of isolation, 2.8% of the population nationally (more than 142,000 people) may be isolated during a 1% AEP coastal flood event. These figures also continue to increase at different sea-level rise increments:

- 0.2m SLR: 3.7% of residents (approximately 183,000 people)
- 0.5m SLR: 4.8% of residents (approximately 237,900 people)
- 1.0m SLR: 7.4% of residents (approximately 368,000 people)
- 2.0m SLR 10.7% of residents (approximately 528,000 people)

Social Vulnerability Trends Across Aotearoa New Zealand

Approximately half of those potentially exposed or isolated are classified as having heightened social vulnerability (vulnerability quintiles 4 and 5) due to factors that may make them more sensitive to harm.

Of the residents who are potentially exposed to a 1% AEP coastal flood under present-day conditions (0.0m SLR), approximately 16,700 (57.7%) are classified as having higher levels of social vulnerability. For future increments of sea-level rise, these figures change:

- 0.2m SLR: 54.7% of those exposed (approximately 28,850 people)
- 0.5m SLR: 58.1% of those exposed (approximately 46,600 people)
- 1.0m SLR: 58.2% of those exposed (approximately 87,800 people)
- 2.0m SLR 54.8% of those exposed (approximately 145,250 people)

Of the residents who are potentially isolated due to a 1% AEP coastal flood under present-day conditions (0.0m SLR), approximately 68,100 (47.9%) are classified as having higher levels of social vulnerability. For future increments of sea-level rise, these figures change:

- 0.2m SLR: 48.6% of those isolated (approximately 88,900 people)
- 0.5m SLR: 51.6% of those isolated (approximately 122,600 people)
- 1.0m SLR: 51.1% of those isolated (approximately 188,200 people)

- 2.0m SLR 50.3% of those isolated (approximately 266,100 people)

Exposure and Isolation Trends by Territorial Authorities

There are a small number of TAs which more or less consistently have the highest proportion of their total population at risk of direct exposure or isolation to coastal flooding, under present-day conditions and across future scenarios.

Amongst TAs with populations directly exposed to a 1% AEP coastal flood event, Napier City and Buller District consistently have the highest proportion of their total respective populations at risk under present-day conditions and across the 0.2m SLR, 0.5m SLR, and 1.0m SLR scenarios.

For isolation during a 1% AEP coastal flood event, Thames-Coromandel District has the highest proportion of their total population at risk, under present-day conditions and across future sea-level rise increments. Under present-day conditions, 49% of their total population are at risk of isolation. This increases to 78.3% by 1.0m SLR.

The difference between the proportion of exposed or isolated residents amongst the top TAs and others is often significant, indicating disproportionate experiences of risk.

The difference between the proportion of Napier City and Buller District's exposed residents compared to other TAs increases significantly over time. For example, under 1.0m SLR, Napier City and Buller District's exposed populations are 46.7% and 31.7% of their total populations respectively, compared to the next highest TA, Thames-Coromandel District (15.6%).

In terms of isolation, the percentage of Thames-Coromandel District's population isolated under present-day conditions and 0.2m of sea-level rise is more than double that of any other TA.

Social Vulnerability Trends by Territorial Authorities

Territorial authorities are not impacted equally with regard to vulnerability associated with exposure or isolation related to coastal flooding.

Of all directly exposed TAs, Napier City and Buller District are consistently ranked as having the highest and second highest risk scores across present-day, 0.2m, 0.5m, and 1.0m SLR scenarios. This means they have the highest proportion of their total population that are both exposed and have potentially higher vulnerability. Therefore, they may experience the highest community-level burden of harm arising from exposure to coastal flooding. Their risk scores (combining direct exposure or isolation and social vulnerability) are also consistently higher relative to other TAs, and this gap increases significantly under 0.5m and 1.0m SLR. For example, under 1.0m SLR, Napier City and Buller District's respective scores of 32.1% and 28.1% are followed by the next highest, Thames-Coromandel District, at 9.9%.

In terms of isolation, Thames-Coromandel District, Buller District, and Napier City consistently have the highest risk scores and therefore the populations with the highest potential social vulnerability as a proportion of their total respective populations. Kaipara District is consistently in the top 6, while Hauraki District has the highest single risk score (51.9%) at 1.0m SLR.

The sensitivities contributing to, and the outcomes associated with, social vulnerability are diverse and not limited to simply the physical health impacts of being exposed or isolated due to coastal flooding. Amongst those populations exposed or isolated, none of the four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) clearly dominated. Overall, the mental health and social cohesion, community and cultural wellbeing categories tended to make up the greater share of factors associated with vulnerability, and systemic inequities (equity category) the lesser share. **This shows that adaptation responses focused solely on physical health and/or mental health impacts and drivers are unlikely to be effective**.

Limitations

This analysis should be considered a first-pass national assessment. Results are influenced by data availability and methodological constraints and should be interpreted with these in mind. These are discussed in Section 3.5. There is a need for ongoing research, refinement of vulnerability measures, ground-truthing with communities, and continued monitoring. The findings presented here should therefore be understood as part of an iterative process of risk assessment and adaptation planning, rather than a final statement.

Implications

Communities are already at risk of being exposed to and isolated by a 1% AEP coastal flood under present-day conditions (0.0m SLR), indicating that adaptation actions are needed in the short term for certain locations. Exposure and isolation will increase under future sea-level rise scenarios. Several communities will be disproportionately impacted, and a significant portion of the potentially exposed or isolated population falls into groups with potentially heightened social vulnerability. Adaptation efforts need to account for the high proportion of the population who are already considered to have higher vulnerability and seek to not make their circumstances worse.

In some TAs, potentially large portions of the community will require adaptation, adding complexity to local planning processes. Effective adaptation strategies must consider the diversity of factors that contribute to vulnerability and seek to focus on more than physical health as a source of vulnerability. In short, adaptation actions that fail to engage with the breadth of likely needs are unlikely to be effective.

Finally, adaptation should be considered across multiple hazards; focusing on a single hazard without accounting for others may lead to maladaptation or inefficient response.

01

Introduction

1. Introduction

He Pou a Rangi Climate Change Commission is interested in deepening and broadening the national evidence base regarding the risk to people, health and communities resulting from the combination of social vulnerability and exposure to current and potential future coastal flooding. Coastal flooding, also known as coastal inundation, occurs when areas of land are submerged by the sea. Impacts range from 'nuisance events' to powerful storm surges that can damage homes, flood roads, close businesses and isolate residents. The purpose of this report is to provide insights on "who" is potentially at risk due to coastal flooding with increments of sea-level rise and "why" they may have heightened social vulnerability, to inform three forthcoming reports:

1. Second National Climate Change Risk Assessment (NCCRA), due in 2026. The NCCRA will systematically and consistently consider, assess and prioritise the risks to Aotearoa New Zealand's economy, society, environment, and ecology from the current and future effects of climate change. The NCCRA informs the Government's National Adaptation Plan (NAP). The new insights provided in this report can be included in a national risk assessment process, contributing to the People, Health and Communities domain and the six risks within this domain; Social cohesion, community and cultural wellbeing; Equity[1]; Physical health; Mental health, identity, autonomy and sense of belonging and wellbeing; Ability of emergency management system to respond; Social infrastructure and community service.

2. Second National Adaptation Plan Progress Assessment (NAPPA), due in 2026. The purpose of the NAPPA is to assess the implementation and effectiveness of the NAP every two years – with the first report delivered in August 2024. The Commission's approach to assessing the effectiveness of the NAP includes assessing whether the NAP is addressing the most significant climate risks, as well as addressing key challenges for climate adaptation. It also includes assessing progress towards the NAP's 20 objectives and developing key national metrics that provide a more comprehensive and cross-cutting picture of progress. The first NAPPA report focused on a small set of key national metrics, and the Commission is seeking to build on this over time. The bundles of social vulnerability metrics presented in this report, which highlight which groups may experience heightened vulnerability and why, could be a valuable addition to measuring progress towards the reduction of overall social vulnerability.

3. Second National Adaptation Plan (NAP), due in 2028. The NAP is the Government's plan to address the most significant risks identified in the NCCRA. By understanding who is at risk of coastal flooding and why they may have heightened vulnerability, adaptation actions can be more targeted and ultimately more successful.

This report provides a high-level snapshot of the current risk to people, health and communities due to 1% AEP coastal flooding, as it is currently understood. It provides a foundational understanding of which communities in Aotearoa New Zealand may be more at risk from coastal flooding due to heightened experiences of social vulnerability, both now and into the future. Alongside social vulnerability arising from direct exposure to coastal flooding, social vulnerability arising from isolation is also considered.

In addition to providing national-level insights into social vulnerability, this report could also form the starting point for regional or district-level social vulnerability risk assessments. However, it is essential to note that the findings are based on a desktop analysis, utilising existing publicly available demographic data and modelling that represents the extent (not depth) of a 1% AEP coastal flood. Further validation and ground-truthing should occur through direct engagement with potentially affected communities to better inform understandings of social vulnerability risk from coastal flooding.

[1] At the time of commissioning this report, a standalone equity risk was included in the People, Health, and Communities domain for the 2026 NCCRA. The Climate Change Commission removed the equity risk prior to the scoring of risks and instead developed criteria that could be used to embed a focus on equity and distributional factors into the evaluation of all the risks in the assessment. For more, see the Commission's Summary of method report.

1.1 What is Social Vulnerability?

Social vulnerability can be broadly described as the likelihood or susceptibility of an individual or social group to be harmed by a changing climate as a result of their relative positioning within social, cultural, economic and political systems [1], [2], [3]. The exploration of social vulnerability helps explain why some individuals, communities, and populations may experience greater adverse consequences from climate hazards than others. Unlike approaches that focus primarily on physical exposure, social vulnerability refers to the characteristics and capacities (including social, political, and economic factors) that shape how people experience and respond to hazards.

Social vulnerability comprises two main components:

- Sensitivity — the characteristics and structural influences that make people or communities more susceptible to harm when exposed or isolated due to a hazard (e.g. health status, housing quality, dependence on climate-sensitive livelihoods, existing experiences of marginalisation).
- Capacities to anticipate, withstand, cope, adapt, and transform — often described as adaptive capacity, this includes the resources, skills, networks, and institutional supports that people and communities can draw on to reduce harm, support recovery, and adapt to change.

Sensitivities and capacities can change over time due to a wide range of factors, and therefore it is important to recognise that vulnerability is not an innate quality of individuals or groups, but rather a fluid state. When we refer to populations as 'vulnerable' within this report, we do so with the understanding that vulnerability is dynamic and shaped by external influences, rather than a fixed trait.

There are three main ways that social vulnerability with respect to hazards is understood in the academic literature and practice. Firstly, there are assessments of social vulnerability which are conducted based on understanding the geospatial distribution of a population and associated demographic information. These types of assessments give insight into the characteristics of a given population and the wider social, economic, and political influences that influence the sensitivities to harm and adaptive capacities of different sub-population groups. Numerous such indices have been developed to measure and map social vulnerability. One of the most widely used is the Social Vulnerability Index (SoVI) developed by Cutter et al. [4], which combines demographic, social, economic and built environment indicators into composite scores that allow for comparisons across geographic areas. Many international social vulnerability indices and frameworks (e.g. SVI [5], the MOVE framework [6]) draw on Cutter et al.'s original work.

In Aotearoa New Zealand, most indices have been developed by local governments for regional or local use (for example, the Quality of Life Survey used by a number of councils [7]). The most widely used measure of social vulnerability at the national scale is the New Zealand Index of Deprivation (NZDep) [8]. NZDep provides a robust, well-established means of comparing relative material and social deprivation across the country that has informed health, planning, and climate-related research. However, NZDep is designed as a general deprivation index rather than a hazard-specific tool.

The Social Vulnerability Indicators for Flooding and Climate Hazards in Aotearoa New Zealand, developed by Mason et al., is the only national-level tool for evaluating vulnerability to climate change [9], [10], [11]. It includes a range of social, economic, and demographic indicators to estimate relative vulnerability across the country. The index is designed to support national and regional planning by identifying areas and populations that may require additional support before, during, and after hazard events. However, as with SoVI, it does not also consider hazard exposure information, in addition to social vulnerability. Therefore, the use of these assessments does not give nuanced insights into how social vulnerability intersects with exposure to, or isolation due to, an actual hazard.

Secondly, there are exposure analysis assessments that focus solely on exposure to a hazard without considering the different characteristics of affected populations, which may make them more or less sensitive to harm. These approaches often lead to interventions to reduce exposure to a hazard (e.g. sea walls), rather than those which seek to address the drivers of social vulnerability that produce inequitable experiences of harm amongst particular groups [12].

Finally, there are integrative approaches to vulnerability analysis, such as the one undertaken in this report, which undertakes a risk assessment that combines exposure to a hazard alongside information on social vulnerability. This allows for more nuanced insight into who may be disproportionally negatively affected amongst directly and indirectly exposed populations. Within Aotearoa New Zealand, an example of this type of approach is the Department of Internal Affairs 2022 report 'Vulnerable Communities Exposed to Flood Hazard', which identified 44 communities across the country that are exposed to flooding hazards, experience high levels of socioeconomic deprivation, and had no plans to build flood protection infrastructure [13]. However, while providing useful insights, this report did not consider vulnerability indicators beyond deprivation.

In this integrative assessment we draw on Mason et al. [11], Cutter et al. [4] and Atkinson et al. [8] to compile bundles of indicators relevant to communities at risk of coastal flooding. In particular, we frame these indicators around the second NCCRA's People, Health and Communities domain and four of the six elements at risk within this: Social cohesion, community and cultural wellbeing; Equity; Physical health; Mental health, identity, autonomy and sense of belonging and wellbeing [14]. The remaining two categories (Ability of emergency management system to respond; Social infrastructure and community services) primarily lie outside the scope of this report, because understanding risk to them is more usefully explored by taking a broader approach which includes risk to physical infrastructure, governance, economic, and institutional systems. However, we do consider how social vulnerability arises due to isolation from the emergency management system (e.g. hospitals, fire stations) and isolation from social infrastructure and community services (e.g. schools) as part of the isolation analysis within each of the other four people, health and community categories. For example, groups who may be more likely to experience negative physical health impacts if they become isolated were included, in part, because they may be cut off from the emergency management system.

By framing the indicators around these people, health and community categories, this report not only provides insights into which communities may be exposed to coastal flooding or associated isolation, but also the reasons why particular groups of people in those communities may be more sensitive to harm. The metrics used to assess risk are described in more detail in the following section (Section 1.2).

By analysing distributional patterns across geographic and demographic dimensions, this analysis highlights areas where physical risk and social vulnerability compound to create hotspots of disproportionate and inequitable impact. This analysis directly supports the Commission's previous recommendation to "consistently consider and address distributional impacts and inequities in all adaptation measures" [14], providing the evidence base necessary for equitable adaptation planning. This is simply because adaptation actions can be more effectively tailored to the underlying reasons for heightened experiences of vulnerability and thereby more likely to achieve effective (and efficient) outcomes for at-risk communities.

Before digesting the remainder of this report, it is important to note the shortcomings of all quantitative social vulnerability assessments and indices, and the methodological challenges that exist. Social vulnerability assessments focus primarily on measures of sensitivity, as adaptive capacity can be hard to distinguish and measure relative to sensitivity. As a result, social vulnerability assessments are generally deficit-focused and make a number of assumptions about what may influence whether certain groups have heightened social vulnerability compared to others, often struggling to account for factors that could make groups resilient. A second challenge is the limits imposed by national-scale data availability and access, which constrain the type of indicators that can be used. Finally, data on population characteristics and distribution are kept the same for the present day and future states. This means that although the hazards and exposure to them change over time as the climate changes, the population used in the analysis remains the same. As such, this report is indicative and can be used to shape priorities and identify potential hotspots, but should not be used as the sole source of information to inform decision-making directly.

Ground truthing the indicators and findings with communities, new indicator development, methodological advances and ongoing monitoring (including via NAPPA) will be essential. It should also be reiterated that the indicators and social vulnerability analysis used in this assessment have been developed specifically with coastal flood hazards in mind. As such, they are not wholly transferable to other hazards as they may not capture the nuanced differences between various hazards and how they may affect people and communities.

1.2 Exposure Metrics for Understanding Social Vulnerability

In addition to social vulnerability indicators, this report uses two metrics for understanding social vulnerability risk from coastal flooding in Aotearoa New Zealand by exposure type: **people at risk of direct exposure to coastal flooding**, and those at risk of **isolation** associated with coastal flooding.

Within each of these metrics, we then use a range of social vulnerability indicators to consider who might experience heightened social vulnerability and why, at the TA scale.

These metrics provide an initial baseline to support monitoring and evaluation of social vulnerability which can inform adaptation planning and action over time. While these metrics alone do not provide a comprehensive basis for specific policy recommendations, they represent an important step in developing a more complete understanding of the risks to people and communities posed by coastal flooding.

Future assessment of the metrics used to assess social vulnerability in this report will continue to improve our understanding of social vulnerability and risk.

1.2.1 Exposure – Social Vulnerability of Populations in At-Risk Areas

The first of the two exposure metrics examined in this report is **people at risk of direct exposure** to 1% AEP coastal flooding. This metric estimates the number of people living in properties directly exposed to coastal flooding. When people are located within a hazard-prone area, they are considered exposed. Exposure describes the presence of people or assets in areas where they could experience flooding; it does not itself determine the scale of impact. The degree to which negative consequences may result from that exposure depends on vulnerability, which reflects both inherent sensitivities and limited capacities to withstand, cope, adapt, or transform. Risk, in turn, arises from the interaction of hazard, exposure, and vulnerability, together with the uncertainty associated with these components [15] (Figure 1-1).

In this report, we not only consider direct exposure but also integrate social indicators to provide insights into why certain population groups may experience heightened social vulnerability to coastal flooding. By quantifying the exposure of people and examining the characteristics that contribute to vulnerability, decision-makers can better understand the scale of the challenge and prioritise adaptation efforts accordingly.

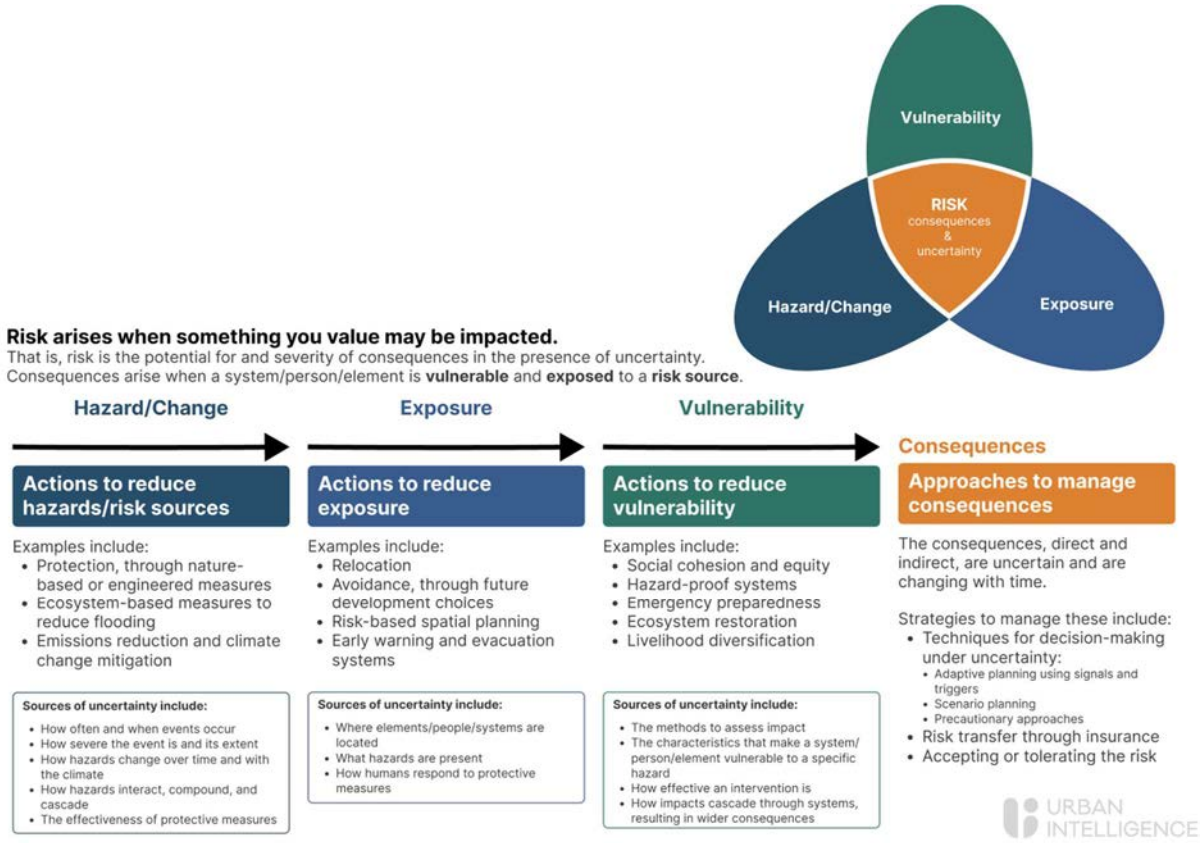

Figure 1-1 Risk is where there are consequences and associated uncertainty. Consequences arise when something of value (like a community, asset, or ecosystem) is exposed and vulnerable to a risk source (e.g. a hazard).

1.2.2 Isolation – Social Vulnerability of Populations at Risk of Becoming Cut Off

The second exposure metric, isolation, focuses on people that may become cut off from their wider community or critical services due to the impact of coastal flooding on the transport network. In some areas, isolation may occur decades earlier than direct exposure because transport routes are often more exposed and vulnerable than residential properties [16]. In this report we consider which communities may be most exposed to coastal flooding-related isolation, as well as the population groups within those communities who may experience heightened social vulnerability, and why.

The risk of isolation is particularly salient for several reasons:

4. Loss of Access to Essential Services: Isolation signals a loss of access to and from essential services like healthcare, supermarkets, workplaces, education facilities, emergency services, and cultural sites of significance. This loss of access can have profound impacts on community wellbeing and resilience during an emergency and also in their day-to-day functioning following an event.

5. Disruption to Critical Infrastructure: Isolation often indicates potential disruption to horizontal infrastructure that is frequently co-located with roadways. When a property loses road access, other essential services like electricity, water, and internet may also be affected, compounding the challenges faced by isolated communities.

6. **Exacerbation of Inequities**: The NCCRA identified the risk of exacerbating existing inequities and creating new ones due to the differential distribution of climate change impacts as extreme and urgent (H2) [17]. This risk is closely linked to people's ability to access resources, participate in daily life, and respond to challenges. Isolation can amplify these inequities.

7. **Economic Resilience:** Isolation, especially when recurring, can decrease the resilience of local economies through regular disruption of business activities, supply chains, and workforce mobility. This can have flow-on effects for people's financial well-being, including their ability to earn an income that enables them to access the goods and services they need.

From a policy perspective, understanding isolation risk allows for better consideration of if, where, and how to administer support to reduce vulnerability in the face of coastal flooding and sea-level rise.

1.3 Report Structure

The following section outlines the methods used to conduct the analysis of social vulnerability risk from coastal flooding across Aotearoa New Zealand (**Section 2**). This includes an explanation of how 1% annual exceedance probability (AEP) coastal flooding is calculated for different increments of sea-level rise (**Subsection 2.1**), followed by descriptions of how exposure to coastal flooding and coastal flood-related isolation were calculated (**Subsection 2.2**). The remainder of the methods section details the indicators used to assess the social vulnerability of exposed or isolated populations, including the process of bundling indicators together to be able to provide more detailed insights into the reasons why particular groups may experience heightened social vulnerability compared to others.

The key results from our analysis are presented in **Section 3**. In **Subsections 3.1** and **3.2**, overall exposure to coastal flooding and overall isolation arising from coastal flooding are presented at the national level, and by the 20 most affected territorial authorities (TAs). Additional insights into the potential social vulnerability of exposed or isolated populations are provided. The top 20 TAs are ranked according to which have the highest proportion of their population who are exposed or isolated and are classified as potentially having heightened social vulnerability. This gives insights into which TAs may experience the highest community-level burden of harm from coastal flooding. Additionally, the results show how the four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) reflect potential social vulnerability and associated outcomes amongst those who are exposed or isolated due to coastal flooding. All results are provided for present-day conditions, as well as under three future sea-level rise scenarios: 0.2m, 0.5m, and 1.0m sea-level rise. Key trends are also discussed.

High-level reflections on the remaining two people, health and community categories included in the upcoming NCCRA (ability of emergency management system to respond; social infrastructure and community services) can be found in **Subsections 3.3** and **3.4** respectively.

Limitations of the analysis undertaken in this report are discussed in **Subsection 3.5**, followed by reflections on implications and avenues for future analysis and development of social vulnerability risk assessment (**Subsection 3.6**).

A glossary of key terms is provided in **Section 4**, along followed by a list of the data generated as part of the analysis **Section 5**.

Appendices at the conclusion of the report provide further detail about the data sources and indicators used, as well as present a more comprehensive breakdown of results by TA.

02

Method

2. Method

In this section we detail the method used to inform the extent of the coastal flooding hazard for four different increments of sea-level rise; 0.0m (present day), 0.2m, 0.5m and 1.0m. Next, we discuss how exposure of people and residential property to coastal flooding and isolation is calculated and analysed. Finally, we establish a set of social vulnerability indicators and bundles under the various people, health and community categories that are relevant for coastal flooding. A complete list of datasets used in this report can be found in Appendix A.

2.1 Coastal Flooding Hazard

We use the extreme sea-level rise scenario maps developed by the National Institute of Water and Atmospheric Research (NIWA) [18] to provide information on the extent of coastal flooding. This is constituent with the approach applied in Urban Intelligence's previous report on the exposure and isolation of infrastructure to coastal flooding [19]. The 1% annual exceedance probability (AEP) inundation extents show how mean extreme sea-level (coastal flooding caused by storm events with large tides, waves, and storm surge) will change with 10cm increments of sea-level rise between 0 and 2 metres. These extents are generated using a 'bathtub' approach and verified against sea-level run-up observations following large storm-tide events. Although commonly referred to as a 1-in-100-year event, a 1% AEP event has a >63% chance of occurring at least once within a 100-year period and more than a 1-in-4 chance of occurring at least once within 30 years.

This work focuses specifically on 1% AEP coastal inundation events. Although these events are not expected to occur every year, they are important to assess because large populations and critical infrastructure in Aotearoa New Zealand are located in low-lying coastal areas, and the long lifespans of these assets mean they are likely to experience at least one such event during their lifetime. This focus provides a baseline for understanding community exposure and social vulnerability to extreme flooding. Future studies could extend this work by considering more frequent events such as nuisance flooding, which create different challenges for day-to-day resilience and adaptation planning.

The method employed offers a first-pass assessment, providing a foundation for understanding the risk of sea-level rise and coastal flooding to communities. However, several limitations should be noted to provide context for the current findings and priorities for future refinement:

• Simplified modelling: The analysis relies on a bathtub modelling approach, which assumes a static water surface and does not account for dynamic factors such as waves, currents, or changes in the coastline over time. Model accuracy depends on the quality of the digital elevation data, which may not capture all hydrologic/hydraulic features or existing protection measures (e.g. stormwater infrastructure, ditches, canals). More detailed local or regional studies using hydraulic models could provide more accurate results where available.

• Scale: The nationwide model captures trends at the territorial authority (TA) level. In some areas, regional or TA-level models may provide more detailed hazard mapping. Where assumptions and timesteps can be aligned, these could be integrated into future assessments for greater local resolution.

• Exposure definition: In this analysis, residential buildings (and therefore people) are classified as affected when flooding depth exceeds 0 cm. This reflects the structure of the NIWA national hazard data, which provides extents rather than depth thresholds. While appropriate for a first-pass assessment, this approach likely over-estimates the number of people and assets affected, since very shallow flooding may not cause disruption or damage in practice. Future studies could incorporate hazard depth and asset-specific thresholds to refine exposure estimates and improve vulnerability assessments. Hazard-data limitations are further discussed in Section 3.5.

• Dynamic processes: This study provides a baseline but does not incorporate coastal dynamics such as erosion, ongoing subsidence, or the implementation of future protection measures. These factors will influence how coastal inundation hazards evolve over time.

These considerations draw attention to the importance of ongoing research and accessibility of hazard and climate models. The results presented here provide a starting point for future, more detailed assessments.

2.2 Exposure of People

We apply two metrics to assess the exposure of residential property and therefore people to coastal flooding: (1) people directly at risk where their property is within the flood hazard extent, and (2) people indirectly at risk due to isolation from their wider community or from access to critical services. Estimating these metrics first requires an accurate representation of where people live.

2.2.1 Estimating Population Distribution

The first step to determining who is exposed is to identify which residential properties are affected. We then assign people to these properties using dasymetric modelling. To enable this analysis, we utilise a property dataset that combines property boundaries, addresses, building outlines, and valuation rolls. Details of the sources are in Appendix A.

This represents an improvement on the dataset used in the 2024 National Infrastructure Exposure & Property Isolation Assessment report [19], which, without valuation roll data, was unable to distinguish between property types. Every address point was treated as a potential residence, meaning that residential dwellings, commercial warehouses, industrial facilities, and civic buildings were all assumed to have equivalent exposure. This lack of classification required broad assumptions about property use, reduced the accuracy of exposure estimates, and made it impossible to focus the population distribution only on residential dwellings.

Our updated property dataset enables us to distinguish residential from non-residential properties at a national scale. This change reduces the number of properties included in the analysis by nearly half a million compared with the address-point approach, reflecting the removal of non-residential properties that were previously included. The inclusion of building footprints and legal boundaries also increases the spatial accuracy of exposure calculations by ensuring hazard intersections are assessed against the actual extent of a property rather than an estimated point location.

Once residential properties are identified, we apply dasymetric mapping to assign people and their demographic characteristics to them. This spatial redistribution technique reallocates aggregate census population counts (at the Statistical Area 1 level) into residential properties, preserving demographic totals but improving locational accuracy. For count-based variables (e.g. number of elderly residents, children, or people of a given ethnicity), the Statistical Area 1 (SA1) total is distributed proportionally across all residential properties within that area. For attribute-based variables that are reported at the SA1 level (e.g. household crowding index), each household within the SA1 is assumed to take on the same value, as these statistics are not reported at the individual household level.

In this report, we use the 2023 Census together with the updated property dataset to overcome these issues. Population is allocated only to properties classified as residential, with commercial, industrial, and civic sites receiving zero allocation. This ensures that population estimates are concentrated in locations where people reside overnight, while retaining the integrity of demographic totals and attributes (e.g. age, ethnicity, employment status) at the SA1 level.

2.2.2 Population Directly Exposed to Flooding

The first metric estimates the number of people whose residential property is located within a coastal flood hazard extent. We define direct exposure as occurring where a residential property, and therefore its associated population, intersects spatially with the modelled inundation area. This measure quantifies the number of people who may experience flooding at their place of residence, independent of any subsequent vulnerability or damage assessment.

The analysis is conducted in two steps. First, the set of residential properties is identified using the property dataset described in Section 2.2.1. Each property has an associated population count derived from dasymetric redistribution of census data. Second, the residential property polygons are spatially intersected

with the flood hazard extents. Any residential property with a footprint that overlaps the flood zone is classified as exposed, and the assigned population is counted as directly exposed.

It is important to note that this exposure metric identifies the potential for impact but does not capture the severity of consequences. A property intersecting the hazard extent may or may not sustain damage, depending on the building's robustness, floor levels, and exposure intensity. Comprehensive risk assessment would require depth information and hazard-asset vulnerability functions to link exposure with damage, but such analysis is beyond the scope of this national-scale assessment given current data availability.

2.3 Population at Risk of Isolation

The second metric estimates the number of people who may become indirectly exposed to coastal flooding through isolation from their wider community or critical services. People are considered at risk of isolation if no publicly accessible driving route exists between their residential property and essential destinations once flooded roads are removed from the network [16]. This measure complements direct inundation exposure by capturing cascading accessibility impacts that can occur even if a household itself remains dry [16].

We define a household as isolated if it loses access to all of the following destinations: fire stations, hospitals, and primary schools. These facilities are consistently available at the national scale, are often colocated with other activity centres, and serve as proxies for broader access to essential services and opportunities. While not a perfect representation of all forms of access, loss of connectivity to these destinations is a robust and scalable indicator of when residents are likely to be cut off from basic services.

The road network is derived from OpenStreetMap (OSM) and recompiled to exclude any road links that intersect with the hazard extent. Because the hazard data provide only flood extents (in/out of hazard) rather than depth, any intersection is treated as rendering a road impassable (i.e. >0 cm). Bridges are excluded from this intersection analysis because flood extents often extend beneath bridge spans without inundating the deck itself. Without depth information it is not possible to determine whether bridges are overtopped and including them as inundated would risk systematically overestimating isolation. If a destination facility itself intersects the hazard extent, it is considered closed and therefore excluded as a viable destination.

Routing is then conducted using the Open Source Routing Machine (OSRM) to determine whether a viable path exists between each residential origin and the essential destinations. OSRM uses the OpenStreetMap (OSM) road data to calculate shortest-path distances across the modified network. If no possible route exists to any fire station, hospital, and primary school, the household is classified as isolated.

Once isolation status is determined for each property, we apply the dasymetric population weights described in Section 2.2.1 to estimate the number of people affected. Each isolated property is assigned a population count, and these counts are then aggregated to provide the distribution of affected populations. Results are reported at the territorial authority level, consistent with census reporting units.

Although the conceptual method to establish isolation is consistent with that applied in Urban Intelligence's National Infrastructure Exposure & Property Isolation Assessment report [19], the transition to an improved property dataset and the use of 2023 Census data significantly improves accuracy. These changes ensure that population is allocated only to residential dwellings, reduce misclassification of non-residential properties, and provide more up-to-date demographic information.

It is important to note that this analysis captures physical isolation: the loss of road connectivity to essential services due to flooding. However, communities may also experience functional isolation, where physical access remains possible but services cannot operate because of cascading infrastructure failures (e.g., loss of electricity, water, or communications) [20]. Such compounding burdens have been shown to substantially increase disruption of businesses and displacement of people in hazard events.

2.4 Indicators of Social Vulnerability for Coastal Hazards

Once we have established what residential properties are potentially exposed and isolated and allocated people to different properties, the next task is understanding how vulnerable people are to a 1% AEP coastal flood. To this end, we used a set of social vulnerability indicators to provide insights into which groups may experience heightened vulnerability to the impacts of coastal flooding, whether through direct exposure or isolation.

We collated indicators available from the 2023 census. Indicators were selected based on existing literature (e.g. EHINZ [21], Atkinson et al. [8], Cutter et al. [4]), and data availability. Indicators were grouped into bundles according to shared characteristics e.g. indicators relating to the physiological reasons why certain groups may be more likely to experience negative physical health impacts from coastal flooding. Only publicly accessible, national scale, consistently collected data was used to underpin these bundles. The full set of indicators is listed in Table 2-1, with rationale for inclusion provided in Appendix B.

Table 2-1 National scale, publicly available indicators used in the indicator bundles.

Age 65 years and older	Households with no access to a private vehicle	People living in households with an equivalised income below an income threshold ($55,000 and under)
Age 0-14	No English	People aged 15-64 unemployed
Age - Less than 1 year old (proxy for pregnant women)	Years since arrival in New Zealand (0)	People aged 15 years and older not in the labour force
Ethnicity (Non-European)	New to neighbourhood (Years at Residence under 1 year)	People aged 15–64 years without any qualifications
Ethnicity (Māori only)	No access to a mobile phone	Dwellings with no access to a fridge
Disability	No access to the internet	Dwellings with no access to electrical supply
Rainbow/LGBTIQ+	Household crowding index - crowded	Dwellings with no access to tap water that is safe to drink
Households with older adults (65 years and older) living alone	Sector of landlord - total households in rented occupied private dwellings (Renters)	Industry - Health Care and Social Assistance
Single-person household	Dwelling damp (always or sometimes)	Industry - Public Administration and Safety
Households with children (0-14)	Dwelling mouldy (always or sometimes)	Industry - Agriculture, Forestry and Fishing
Single-parent households	People aged 15-64 receiving a main means tested benefit	

2.4.1 Key People, Health and Community Categories and Indicator Bundles

To organise the indicators, we drew on the People, Health and Communities domain from the upcoming 2026 NCCRA, which identifies six "key risks" to "people's identity, health, sense of community and social norms, and cultural values and traditions" [22]. We used these to form categories to guide the grouping of the indicator bundles according to the different ways in which people may be disproportionately affected by exposure to, or isolation as a result of, coastal flooding. The people, health and community categories are:

- Social cohesion, community and cultural wellbeing
- Equity
- Physical health
- Mental health, identity, autonomy and sense of belonging and wellbeing
- Ability of emergency management system to respond
- Social infrastructure and community services

For this assessment we adopted the following definitions for each of these people, health and community categories:

- Physical Health: The ways in which particular population groups may be more likely to experience negative physical health impacts as a result of exposure to coastal flooding or isolation arising due to coastal flooding. This can include being more likely to experience (or be more sensitive to) physical health impacts such as injuries or waterborne illnesses, because they are more likely to be exposed to coastal flooding, such as those with mobility issues or working in the emergency response. Some groups may also experience heightened social vulnerability because of physiological factors (e.g. young children have less developed immune system responses), or because they have existing co-morbidities (e.g. respiratory illnesses, cardiovascular conditions, cancers, chronic illnesses). Others may experience heightened social vulnerability due to existing inequities that increase the likelihood of experiencing negative health effects following a hazardous event (e.g. housing status, not having enough food or water to cope during a shortage).
- Mental Health, Identity, Autonomy and Sense of Belonging and Wellbeing: How direct exposure to coastal flooding or isolation arising from coastal flooding may disproportionately affect the mental health of certain groups. This can include groups who may have smaller social networks that they can draw on in times of stress and uncertainty (e.g. new residents to Aotearoa New Zealand), or reduced ability to access social support or connections (e.g. older people living alone). Those with less resources to prepare for or recover from a flooding event may also disproportionally experience financial stress that negatively affects mental wellbeing. Negative mental health impacts can also be exacerbated by factors that influence people's exposure to coastal flooding (e.g. occupation, awareness of the hazard and local knowledge) and their existing housing status (e.g. tenants, those living in damp housing).
- Equity: The ways in which coastal flooding is likely to exacerbate existing inequities (i.e. unequal and unfair experience of impacts) if preventive or adaptive measures are not taken to reduce disproportionate impacts. We included indicators that identify groups already experiencing systemic social, economic, health and housing inequities, who are therefore likely to experience worsening (or additional) inequities as a result of direct exposure to, or isolation arising from, coastal flooding. This includes populations more likely to be discriminated against or marginalised (e.g. disabled people, Rainbow/LGBTIQ+ populations, migrants, non-European ethnicity groups), those experiencing housing inequities (e.g. renters, those living in poor quality housing), and those on low or no incomes (e.g. unemployed people).
- Social Cohesion, Community and Cultural Wellbeing: This category covers who may be most adversely impacted as a result of coastal flooding undermining social cohesion and community wellbeing. This

includes those already experiencing inequities, and those who may be particularly reliant on being able to access their social connections for wellbeing. It also includes those who may be disproportionately affected if coastal flooding exposure or isolation leads to displacement. Temporary or permanent displacement can disrupt and alter the make-up of communities, affecting multiple aspects of people's wellbeing, including disrupting social support networks and potentially undermining their sense of belonging to community or place. This includes both those who are displaced, and those who remain in place. We also recognise that there are wider determinants of social cohesion and community wellbeing. For example, social cohesion is likely to be undermined if decisions about how to adapt to coastal flooding create tensions or disagreements amongst affected residents. This category also covers adverse impacts on cultural wellbeing as a result of coastal flooding. While we acknowledge that all people may have their ability to practice their culture or access places of cultural importance affected by coastal flooding, we also recognise that as tangata whenua, Māori may disproportionately experience negative effects arising from displacement or the reduced ability to undertake cultural practices due to coastal flooding (e.g. ability to access mahinga kai, damage sustained to marae).

- Ability of the Emergency Management System to Respond: Whether or not the emergency management system has the capacity and ability to respond to a coastal flood event is an important determinant of how much harm may be experienced by individuals or communities. This can include whether the emergency management system is prepared and sufficiently resourced to respond, whether emergency responders are harmed during the response, and whether people can access emergency management services in a timely manner. Such services may include, but are not limited to, ambulance, police, fire service, evacuation centres, temporary accommodation, and emergency food assistance. In this report, we have focused on residents who may experience heightened social vulnerability if they are isolated from the emergency management system (in this instance, hospitals and fire stations) and therefore are unable to access services such as these in a timely manner. These groups are also likely to be the same who are more susceptible to harm if they can, in theory, continue to physically access these services, but those services become overwhelmed or are unable to operate at full capacity during an event.
- Social Infrastructure and Community Services: Harm can arise when people are unable to access the infrastructure and community services that support their social, physical, mental and cultural wellbeing (e.g. schools, healthcare providers, social service providers, community facilities, recreation facilities). Similarly to the 'Ability of the Emergency Management System to Respond' category, we have used proxies to consider those who may experience heightened social vulnerability if they become isolated from social infrastructure and community services due to coastal flooding, and are therefore unable to access them.

For this analysis we focused primarily on the first four categories (Physical Health, Mental Health, Equity, Social Cohesion, Community and Cultural Wellbeing) to identify where population groups who are likely to experience heightened social vulnerability may be concentrated in areas exposed to or isolated by coastal flooding.

These four categories represent both the sensitivities and the type of outcomes or impacts groups may experience. For example, some groups may have existing physical health sensitivities that are likely to be exacerbated and result in poor physical health outcomes from exposure to coastal flooding (e.g. older adults), while others may experience heightened social vulnerability due to physical health impacts only in the event of exposure to coastal flooding (e.g. households with children). Both those with existing physical health sensitivities and more latent (or potential) sensitivities are more likely to experience negative physical health outcomes as a result of exposure to a hazard. For social cohesion and community wellbeing, we considered who may be adversely impacted as a result of coastal flooding undermining social cohesion and community wellbeing, with recognition that when individuals or groups are experiencing negative wellbeing outcomes, this further undermines or reinforces declining overall community and social wellbeing. In this way, the people, health and community categories represent both sensitivities and indicate what type of potentially negative outcomes could be experienced.

Within each of the people, health and community categories, indicator bundles were developed to further highlight why certain groups are likely to be disproportionately affected due to existing or latent sensitivities

(see Figure 2-1). For example, within the Physical Health category, we grouped indicators together into bundles relating specifically to groups who may disproportionally experience negative physical health impacts due to factors affecting their mobility. Some indicators contribute to multiple bundles where appropriate. A full visual breakdown of the individual indicators that make up each bundle can be found in Appendix C. Table 2-2 describes each of the bundle types.

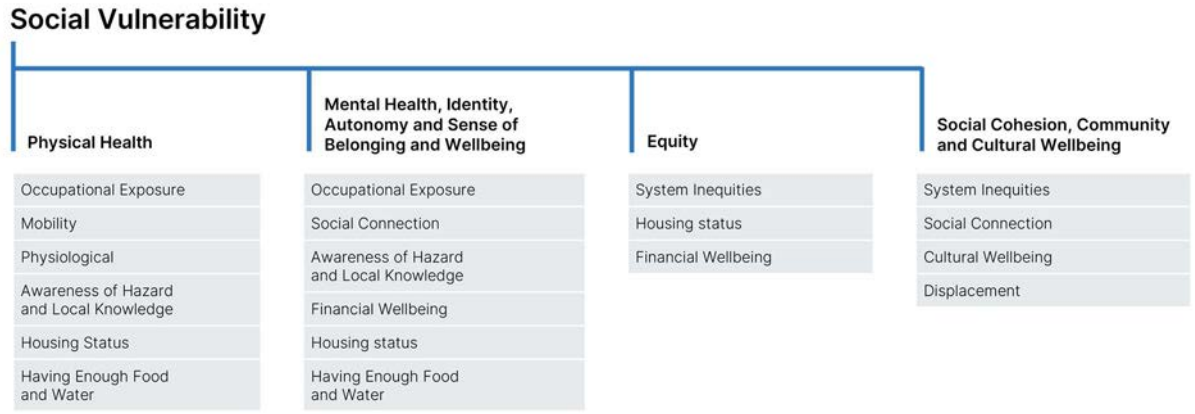

Figure 2-1 Key people, health and community categories and indicator bundles. The order in which the indicator bundles are listed does not indicate a hierarchy of importance.

Table 2-2 Indicator bundle descriptions.

Mobility: People who experience mobility issues may be at greater risk of physical health impacts in the event of coastal flooding, where these mobility issues impede their ability to get out of harm's way in a timely manner. For example, disabled people and young children are more likely to be reliant on others to evacuate, and pregnant people may have additional difficulties evacuating. Households with children are also likely to take longer to evacuate due to adults providing assistance to their dependents.
Physiological: Some populations are more likely to have physiological factors that increase their risk of experiencing negative physical health impacts when exposed to coastal flooding, or isolated as a result of it. For example, older adults, children, disabled people and pregnant women may be more susceptible to disease or injuries due to pre-existing health conditions or immune system status.
Occupational Exposure: Employees within certain industries may disproportionally experience negative physical or mental health impacts associated with coastal flooding, due to their occupation. In particular, those working in emergency response (public administration) or healthcare and social assistance roles during a coastal flood event may be at greater risk of stress, trauma, injury, death, diseases, and stress-related physical impacts as a result of that work. For example, if they become physically cut off during a flood event, they may be more likely to persist in attempting to leave their residence in order to directly assist others or access their workplace to do so, rather than isolating in place. They may also be required to work extensive hours as part of their role, which may negatively impact their mental health. Those working in primary industries, and particularly in agricultural and fisheries sectors, may experience heightened financial stress where coastal flooding also affects the natural resources or infrastructure that their livelihoods depend on.
Awareness of Hazard and Local Knowledge: Some populations may be at greater risk of physical or mental harm from coastal flooding if they are not aware of a hazardous event occurring, have less understanding of what to do during an event, and/or have less local knowledge about where

to go to evacuate or access help. This can include those with no English who have difficulty understanding emergency information or asking for assistance, as well as people new to the area or country, who may have less knowledge of what to do during a coastal flood or where to go to escape harm. People without access to a mobile phone or internet are also more likely to have difficulties accessing emergency information, including alerts to evacuate or avoid coastal areas. Those with lower literacy may also have greater difficulties following written emergency communications, increasing their response time. The higher people's direct exposure to coastal flooding or the lower their ability to get the help and resources they need due to exposure or isolation, the greater the likelihood of experiencing negative mental health impacts such as stress, trauma, and anxiety.

Housing Status: Those already experiencing housing inequities are likely to have these exacerbated where direct exposure to coastal flooding worsens poor quality housing conditions (e.g. damp, mould), increases overcrowding (e.g. due to damage to housing making bedrooms unusable), or causes tenants to be evicted from their homes. These impacts can have negative implications for both physical and mental health, including stress, depression, anxiety, and respiratory illness. Tenants may be particularly affected, given their reliance on their landlord to undertake actions to address flood-related damage or dampness that require modifications to the property. Housing status indicators were only deemed relevant in this assessment in relation to direct exposure, as isolation is unlikely to increase the risk of experiencing negative health impacts due to housing status.

Enough Food and Water: People on low incomes or living in households without access to basic amenities (e.g. no fridge, no electrical supply, no safe tap water) are less likely to have sufficient food and water stocks to be able to cope with a shortage as a result of being exposed to coastal flooding, or isolated as a result of it. Where people have insufficient access to nutritional food or safe drinking water, this can be stressful and also presents an increased risk of negative physical health impacts, especially if shortages occur over a prolonged period.

Social Connection: Some populations are likely to be disproportionately affected as a result of coastal flooding or associated isolation, due to a reduced ability to access social connections that support their social, cultural, physical and mental wellbeing. This includes populations who may already have fewer social connections (e.g. newly arrived migrants, single-person households), or who may rely particularly strongly on social connections for wellbeing (e.g. children).

Financial Wellbeing: People experiencing financial hardship may face greater difficulties being able to afford to pay for any damage or losses resulting from exposure to coastal flooding. They are also less likely to have insurance cover. Further, those experiencing financial difficulties may be disproportionately affected if they are unable to access employment or support services in the event of becoming isolated due to coastal flooding. Exacerbation of financial hardships can create significant stress and worry, undermining mental wellbeing.

Systemic Inequities: Negative impacts from exposure to coastal flooding or flood-related isolation are likely to disproportionately affect those already experiencing systemic inequities resulting from discrimination, marginalisation, racism or ongoing legacies of colonialism. For example, disabled people are likely to experience additional barriers navigating bureaucratic processes to receive assistance following a flood. Those who do not identify as European are similarly likely to face barriers when flooding requires them to engage with the health, social and welfare systems that already create inequitable outcomes. Rainbow/LGBTQI+ populations may also experience heightened discrimination, for example when seeking alternative accommodation, especially where there is increased competition for reduced housing supply post-flood. In turn, when inequities are exacerbated, this negatively affects overall community wellbeing.

Cultural Wellbeing: As tangata whenua, Māori are likely to disproportionately experience negative impacts on cultural wellbeing where coastal flooding negatively alters the natural environment, undermines their ability to undertake cultural practices, or disrupts access to whenua or sites of cultural significance

Displacement: Some populations are likely to be disproportionately affected by dislocation due to coastal flooding, which can undermine social cohesion or community wellbeing. For populations that are dislocated, this includes those who may find it particularly difficult to adjust to a new location because it may take them further from their existing networks and services (e.g. households without a vehicle, disabled people, children), people who have less financial resources

(e.g. low income), and populations who may face greater difficulties finding suitable alternative accommodation (e.g. disabled people, Rainbow/LGBTIQ+ populations, tenants). It also includes the negative impacts on wellbeing for Māori if they become physically distanced from their whenua or other sites of cultural significance. For those remaining in communities in which others are leaving due to coastal flooding or isolation risk, those who may be disproportionally affected include populations who may rely particularly strongly on existing social connections for wellbeing (e.g. children, older adults living alone), those at heightened risk of discrimination or marginalisation when community stress levels increase, and those who may have less financial resources to cope if wide-scaled dislocation negatively affects the economic wellbeing of their community.

The remaining two key people, health and community categories (Ability of Emergency Management System to Respond, Social Infrastructure and Community Services) were included in a different manner. We considered how social vulnerability arises due to isolation from the emergency management system (e.g. hospitals, fire stations) and isolation from social infrastructure and community services (e.g. schools) as part of the isolation analysis within each of the other four people, health and community categories. For example, groups who may experience heightened social vulnerability due to experiencing negative physical health impacts if they become isolated were included, in part, because they may be cut off from the emergency management system.

Assessments of the emergency management system's capacity to respond to coastal flooding also require indicators that go beyond spatial population-based metrics, to include aspects such as governance, economic, and institutional metrics. Analysis of how coastal flooding may affect infrastructure related to emergency management, as well as social infrastructure that supports community wellbeing, is also required. A first assessment of how coastal flooding may directly affect key assets that form part of the emergency management system (fire stations, hospitals, marae) was undertaken as part of the National Infrastructure Exposure & Property Isolation Assessment [19].

It is important to note that there are a number of indicators in this assessment which we use as proxies for those at greater risk of negative impacts due to coastal flooding. This is because more direct measures are not publicly available at the Statistical Area 2 (SA2) or TA level. For example, health data about people with existing physical or mental health conditions. Similarly, there are few indicators that are routinely collected at the national level and available at the SA2 or TA level which provide insights into how hazards such as coastal flooding may disproportionately affect social cohesion, community wellbeing and cultural wellbeing. Census data provides little ability to gain nuanced insights into how coastal flooding may affect cultural wellbeing, besides simply relying on ethnicity indicators which we have done here. Although direct measures are always preferable to the use of proxies, we use proxies to ensure the factor is included in the bundles in some form.

More broadly, we recognise that the direct and indirect impacts of coastal flooding will vary depending on factors such as the severity and duration of flooding, the time of day or week when it occurs, and how long communities remain isolated due to effects on transportation networks. Our assessment does not assume specific event characteristics such as warning times or evacuation outcomes; rather, it identifies the people and communities located in areas exposed or isolated by a 1% AEP coastal flood. The social vulnerability indicators then provide insight into how these groups may experience different types of consequences, ranging from disruption, stress, and reduced access to services through to property damage, injury, displacement, and loss of life. This enables a clearer understanding of which population groups are more likely to be disproportionately affected if a coastal flood occurs, supporting decision-makers to anticipate and plan for a wide spectrum of possible outcomes.

2.5 Constructing the Specific Hazard Vulnerability Index (SHVI)

The Specific Hazard Vulnerability Index (SHVI) is a composite measure of social vulnerability to coastal flooding. It is constructed independently of exposure and hazard extents. The SHVI draws on census indicators that represent demographic and social characteristics associated with greater difficulty in withstanding, coping with, adapting to, or transforming in response to flood impacts.

Indicators are first normalised, then grouped into bundles representing related characteristics. Bundles are aggregated into broader 'people, health and community' categories (i.e. physical health, mental health, equity, social cohesion, community and cultural wellbeing). Finally, category scores are combined into an overall risk score for each SA1, which can be aggregated to higher geographies (e.g. TAs). This hierarchical design allows the SHVI to be decomposed into categories, bundles, and indicators, ensuring transparency about what drives vulnerability in each location (Figure 2-2).

These steps are described in further detail in the following subsections.

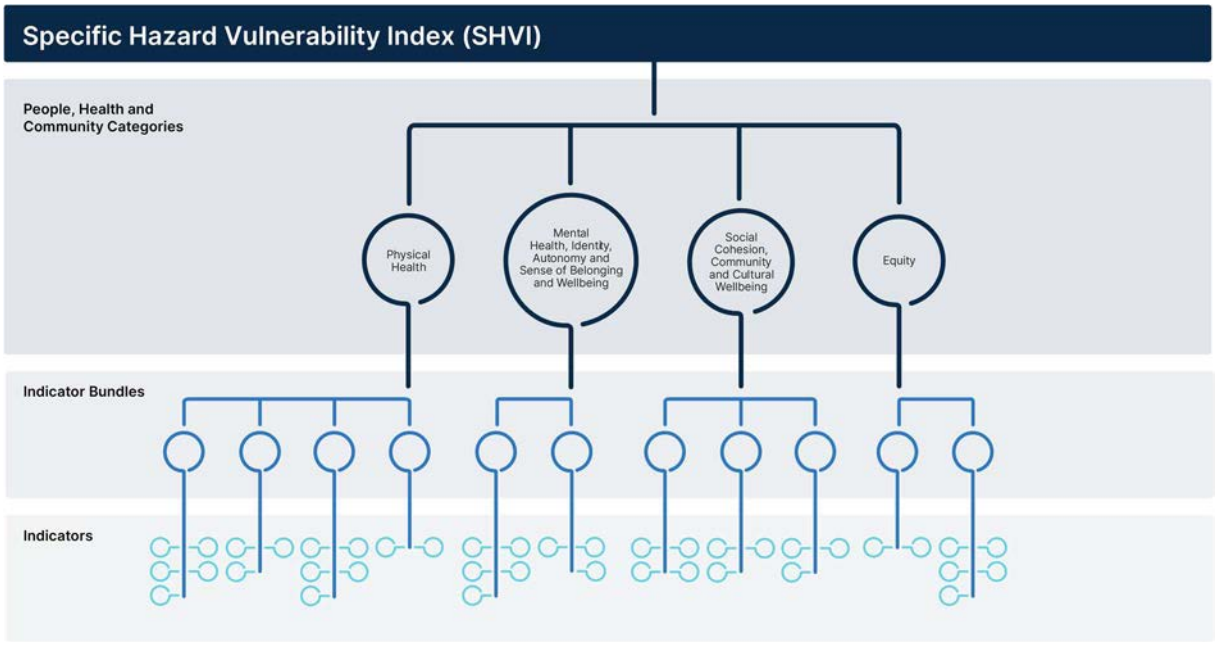

Figure 2-2 Structure of the relationship between the people, health and community categories, indicator bundles and indicators.

2.5.1 Data Preparation and Normalisation

The first step in constructing the SHVI was to prepare the census indicators so they could be meaningfully compared across SA1s. All indicators were expressed as ratios, ensuring comparability across SA1s with different population sizes[2]. Expressing indicators as proportions ensures that vulnerability is measured consistently across SA1s, regardless of how many people live there. This step standardises the social characteristics of each SA1, while the exposure analysis (described separately) accounts for how many people are actually located within flood-prone areas. This was done to make sure the results would be focused on SA1s where a greater proportion of the population were exposed and isolated, rather than SA1s with a larger number affected because of a higher total population. For each indicator, we computed a proportion using "Total stated" as the denominator, consistent with Stats NZ census practice. "Total stated" is the sum of the people who responded to a particular question and excludes responses in categories such as "Not elsewhere included", "Not stated", "Response unidentifiable", and "Response outside scope".

[2] SA1s are designed by Stats NZ to contain relatively consistent populations—generally 100–200 residents, with a maximum of about 500 [23]. This design means that urban SA1s are geographically smaller but hold similar population counts to rural SA1s, so using proportions does not underplay vulnerability in denser areas such as Auckland.

Where people, health and community categories and bundles were constructed from multiple underlying indicators, category counts were first summed (or, where appropriate, subtracted) before calculating proportions. These proportions were then standardised to z-scores (subtracting the mean and dividing by the standard deviation). Standardisation ensures that each variable contributes on a comparable scale, regardless of its absolute prevalence or distribution [4], [24]. For indicators where higher values indicate lower vulnerability (i.e. protective indicators), values were reverse-coded prior to standardisation so that higher scores consistently reflect higher vulnerability.

The SHVI is then built stepwise: 1) individual indicators are 2) combined into bundles, and then 3) aggregated into people, health and community categories, and finally 4) averaged into the overall index. Each step uses normalised values, so no single indicator or category can dominate the results. This process also minimises double counting, as correlated indicators within a bundle are either reduced via principal component analysis (PCA) (see Section 2.5.2) or averaged, ensuring they do not disproportionately influence the higher-level categories.

For variables only available at SA2, the SA2-level proportion (computed using the same Total stated convention) was uniformly assigned to constituent SA1s. Bundle scores were then derived using either PCA or averaging, as described below.

2.5.2 Dimensionality Reduction at Bundle Level

Bundles that included more than three (≥4) variables were reduced to a single component score using principal component analysis (PCA). PCA identifies orthogonal linear combinations of variables that capture the greatest variance within the dataset. In this context, it extracts the weighted combination of indicators that best represents their shared pattern while minimising redundancy where variables are strongly correlated. Applying PCA to larger bundles ensures that indicators measuring the same or similar social phenomena do not overrepresent that dimension within the index.

The use of PCA in vulnerability indices has precedent in both the hazards-of-place model [4] and subsequent applications in health and environmental vulnerability mapping [25], [26], [27]. The first principal component (PC1) was extracted as the bundle score for each SA1 and rescaled to the [0,1] interval for interpretability. One limitation of PCA is that it identifies components based on statistical variance, rather than theoretical/practical importance. This means variables that are important conceptually but contribute less variance may be down-weighted. This trade-off is acceptable because PCA prevents correlated indicators from disproportionately influencing results, and is commonly used when constructing vulnerability indices.

For smaller bundles (two or three indicators), PCA was not used. With so few variables, the first component is typically indistinguishable from a simple mean, and loadings can become unstable. Instead, scores for these bundles were calculated as the arithmetic mean of normalised indicators, consistent with practices in NZDep [28].

2.5.3 Aggregation of Bundles and Categories

Bundle scores were aggregated to ‘people, health and community’ category scores using simple arithmetic means, reflecting equal weighting across bundles within a conceptual category. Category scores were then averaged to produce the overall SHVI scores. Importantly, this aggregation was conducted at the national scale, ensuring comparability across all areas. By applying a consistent national benchmark, the SHVI maintains integrity as a measure of relative vulnerability across the whole country.

This hierarchical averaging approach also supports transparency and interpretability, as the overall SHVI can be decomposed into categories, bundles, and individual indicators to show what drives vulnerability in each location.

Alternative aggregation methods, such as expert weighting or data-driven weighting, could have been used. We adopted equal weighting across bundles and categories to maintain transparency, reproducibility, and comparability with indices such as NZDep. This choice ensures that the SHVI can be readily decomposed into categories, bundles, and indicators to understand local drivers of vulnerability.

2.6 Combining Exposure (Direct and Isolation) and Social Vulnerability to Create a Risk Score

In addition to the SHVI, we calculate a risk score that expresses the share of each TA's population that is both directly exposed (or isolated) and may experience relatively high social vulnerability in a 1% AEP coastal flood. This score identifies the proportion of people who are simultaneously located in hazard-prone areas and fall into the highest two quintiles of vulnerability (quintiles 4 and 5 of the SHVI). The choice of quintiles 4–5 to represent 'high vulnerability' is consistent with other social indices, but different cut-offs could be applied. We use quintiles for interpretability in this report.

This percentage-based risk score highlights TAs where the combination of exposure and high vulnerability creates the greatest potential for severe consequences at the community scale. It ensures that results are not dominated solely by population size (large TAs with many people exposed but relatively few with heightened social vulnerability) nor by very small numbers of people with relatively high social vulnerability in low-exposure areas. Instead, it balances both dimensions, making it possible to compare relative risk across TAs.

2.7 Impacts over Time

To understand how the risk score (Section 2.6) changes with rising sea levels, we combined our exposure, isolation, and social vulnerability results with climate change projections and vertical land movement data from the NZ SeaRise: Te Tai Pari O Aotearoa programme [29]. This programme provides location-specific sea-level rise projections out to the year 2300 for every ~2km of Aotearoa New Zealand's coastline, enabling estimation of when exposure and isolation may occur under different increments of sea-level rise.

For each residential property, we identified the minimum sea-level rise increment at which it becomes exposed or isolated, and associated the property with the nearest NZ SeaRise projection site (based on Euclidean distance). Rather than fixing results to a single Shared Socioeconomic Pathway (SSP), we report exposure, isolation, and the associated risk score as a function of sea-level rise increments. This allows the results to be flexibly combined with any SSP or emissions scenario, depending on the decision-making context.

03

Key Results

3. Key Results

The results are organised into two sections: direct exposure and isolation, assessed for present-day conditions (0.0m) and under 0.2m, 0.5m, and 1.0m sea-level rise increments (Sections 3.1 and 3.2).

Each section comprises:

1. An overview of the total population at risk from 1% AEP coastal flooding
2. Identification of the 20 most affected TAs ranked by their risk score, with detailed discussion of the top five
3. For the top 20 TAs, a breakdown of social vulnerability by sensitivities and outcome type, according to the four people, health and community categories. Further detail is provided on the top five TAs
4. A summary of observed social vulnerability trends.

Understanding which TAs have the highest proportion of people directly exposed or isolated, and the characteristics that increase their vulnerability, can support the design of more effective response and adaptation strategies. These characteristics shape how different groups experience hazards, perceive risks, and respond to or accept risk reducing actions. Importantly, these characteristics do not inherently define vulnerability: different groups may have strengths, coping mechanisms, social networks, resources or cultural practices that enhance resilience. The results should therefore be considered in the wider context of adaptive capacities to ensure interventions are equitable, appropriate, and effective.

3.1 Direct Exposure

3.1.1 Direct Exposure - Overall

Overall, more than 28,900 New Zealanders (approximately 0.6% of residents) are at risk of direct exposure to a 1% AEP coastal flood under present-day conditions (0.0m SLR) (Figure 3-1). This number is projected to increase to approximately 52,700 under 0.2m SLR (1.1% of residents), 80,130 under 0.5m SLR (1.6% of residents), and 150,900 under 1.0m SLR (3.1% of residents). At 2.0m of sea-level rise, approximately 264,900 New Zealanders are at risk of direct exposure (5.4% of residents).

Of those exposed under present-day conditions (0.0m SLR), approximately 16,700 (57.7%) are classified as potentially having heightened social vulnerability, based on sociodemographic characteristics associated with higher vulnerability. This trend continues throughout the future scenarios:

- 0.2m SLR: 28,850 (54.7%)
- 0.5m SLR: 46,600 (58.1%)
- 1.0m SLR: 87,800 (58.2%)
- 2.0m SLR: 145,250 (54.8%)

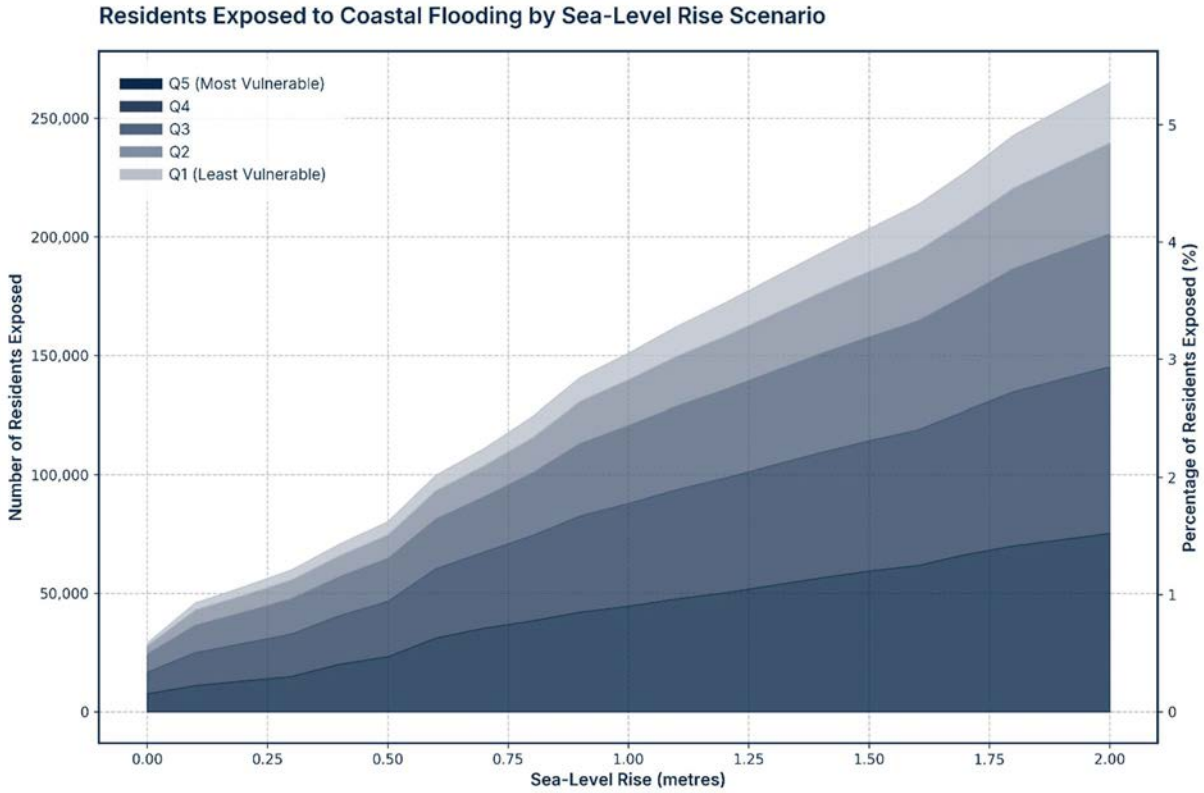

Figure 3-1 This graph shows the total percentage of residents potentially exposed to a 1% AEP coastal flood with different increments of sea-level rise. The different lines show what proportion of all exposed residents are classified within each quintile, with quintiles 4 and 5 being high and highest vulnerability respectively.

3.1.2 Direct Exposure - By Territorial Authority

The distribution of residents potentially exposed to a 1% AEP coastal flooding is not uniform across Aotearoa New Zealand. Some territorial authorities have greater numbers of potentially affected residents, and a higher percentage of those residents may be more likely to experience negative impacts as a result of any exposure. The following section describes, for each TA, the number of people exposed and the share classified as having heightened social vulnerability (quintiles 4–5 of the SHVI) under present day (0.0 m), 0.2 m, 0.5 m, and 1.0 m sea-level rise.

The TAs are ranked by their risk score, which is a function of both the proportion of their total population who is potentially exposed to coastal flooding, and the proportion of those exposed who are classified as having heightened social vulnerability (i.e. classified into quantiles 4 and 5 of higher and highest vulnerability). As described previously, this is done to avoid the dominance of larger TAs with high numbers of people exposed, that represent only a small proportion of the TA's total population. It also avoids the opposite problem where a small number of people are exposed, but of those few people, all of them are likely to have heightened social vulnerability.

3.1.3 Direct Exposure - By TA (Present Day)

Across TAs, Napier City has the highest total percentage of their usually resident population at risk of direct exposure to coastal flooding under present-day conditions (12.8% of their total population, approximately 8,190 people in total) (Figure 3-2). They are followed by Buller District (8.2% of their total population, approximately 854 people), Thames-Coromandel District (5.6% of their total population, approximately 1,790 people), Kaipara District (5.3% of their total population, approximately 1,386 people), and Kaikōura (2.3% of their total population, approximately 98 people).

In terms of social vulnerability, Napier City also has the population with the highest potential social vulnerability, as a proportion of their total population under present-day conditions (0.0m SLR) (Figure 3-2). It has a risk score of 10.2% (Table 3-1). Of their exposed residents specifically, 79.9% are classified as potentially having heightened social vulnerability. This calculation is based on the sum of quintile 4 and 5 in Figure 3-2. Following Napier, Buller District has the population with the next highest potential social vulnerability, as a proportion of their total population (risk score of 7.8%). Of their exposed residents specifically, 95.6% are classified as having potentially heightened social vulnerability. The next highest ranked TAs, with the highest proportion of exposed residents classified as having heightened social vulnerability as a proportion of their total population, are:

- Kaipara District - 5.1% risk score (95% of exposed residents are classified as having heightened social vulnerability)
- Thames-Coromandel District - 4.1% risk score (72.3% of exposed residents are classified as having heightened social vulnerability)
- Kaikōura District - 1.5% risk score (65.3% of exposed residents are classified as having heightened social vulnerability)

The risk scores for all top 20 ranked TAs are available in Appendix D.

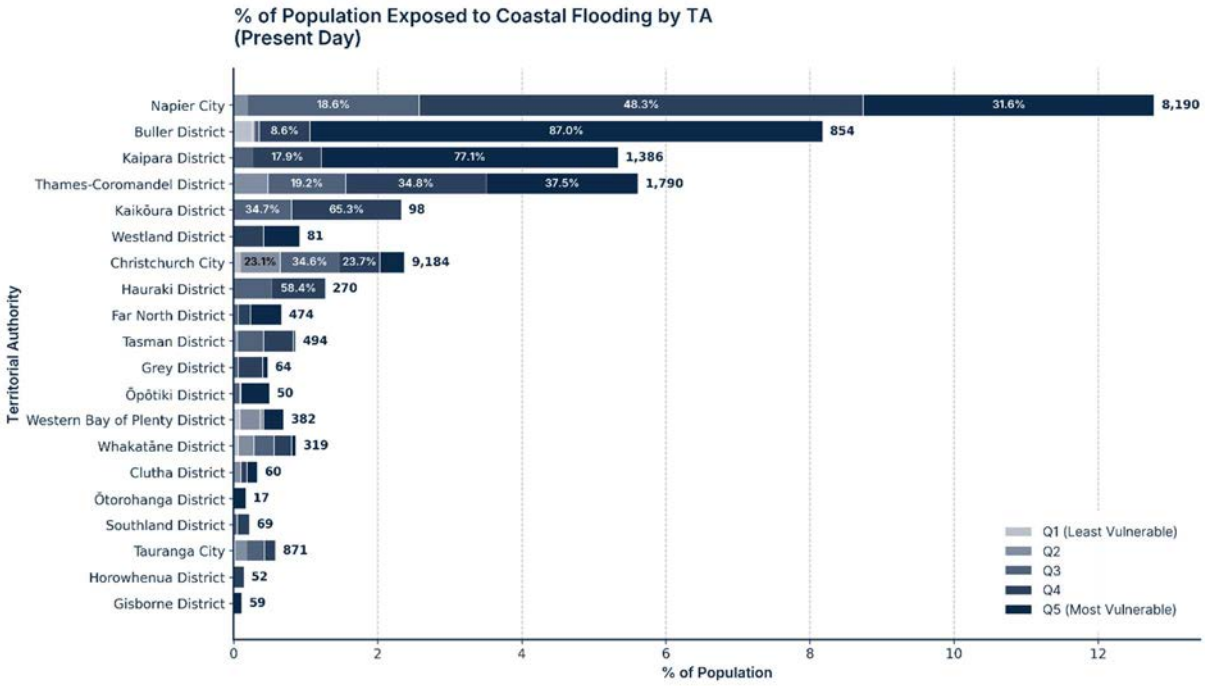

Figure 3-2 This graph shows the total percentage of residents directly exposed to sea-level rise under present-day conditions, by TA. For each TA, the quintiles Q4 and Q5 show what percentage of exposed residents are considered to potentially have heightened social vulnerability. The TAs are ranked by risk score i.e. which have the highest proportion of their total population that are both at risk of exposure and potentially have heightened vulnerability to 1% AEP coastal flooding. The risk scores for the top 20 ranked TAs are available in Appendix D.

Figure 3-3 shows how the four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) contribute to the SHVI, as it relates to exposure to coastal flooding under present-day conditions. Although the relative percentage contributions vary somewhat across the top 20 TAs and are not equal relative to one another, there are few people, health and community categories that clearly dominate. The most notable difference is the lower relative contribution of equity amongst Kaikōura District (15%), Southland District (16%), Horowhenua District (16%) and Hauraki District (17%). The overall trends by people, health and community category are:

- Physical health ranges from 20% (Tauranga City, Western Bay of Plenty District, Tasman District, Thames-Coromandel District) to 27% (Hauraki District, Southland District)
- Mental health ranges from 24% (Gisborne District, Tauranga City, Whakatāne District, Napier City) to 30% (Kaikōura District, Southland District)
- Social cohesion, community and cultural wellbeing ranges from 25% (Napier City, Westland District) to 34% (Western Bay of Plenty District, Tasman District)
- Equity ranges from 15% (Kaikōura District) to 25% (Napier City, Gisborne District).

For the five TAs with the highest risk scores:

- Napier City: All categories contribute equally (25%), with the exception of mental health (24%)
- Buller District: Mental health contributes the largest share (28%), and equity the least (20%)
- Kaipara District: Similarly, mental health contributes the largest share (27%), and equity the least (22%)
- Thames-Coromandel District: Social cohesion is the largest category at 32%, compared to equity at 19%
- Kaikōura District: Similarly, social cohesion is the largest category at 31%, compared to equity at 15%.

A further breakdown of the relative contribution of the indicators within each bundle can be found in Appendix E.

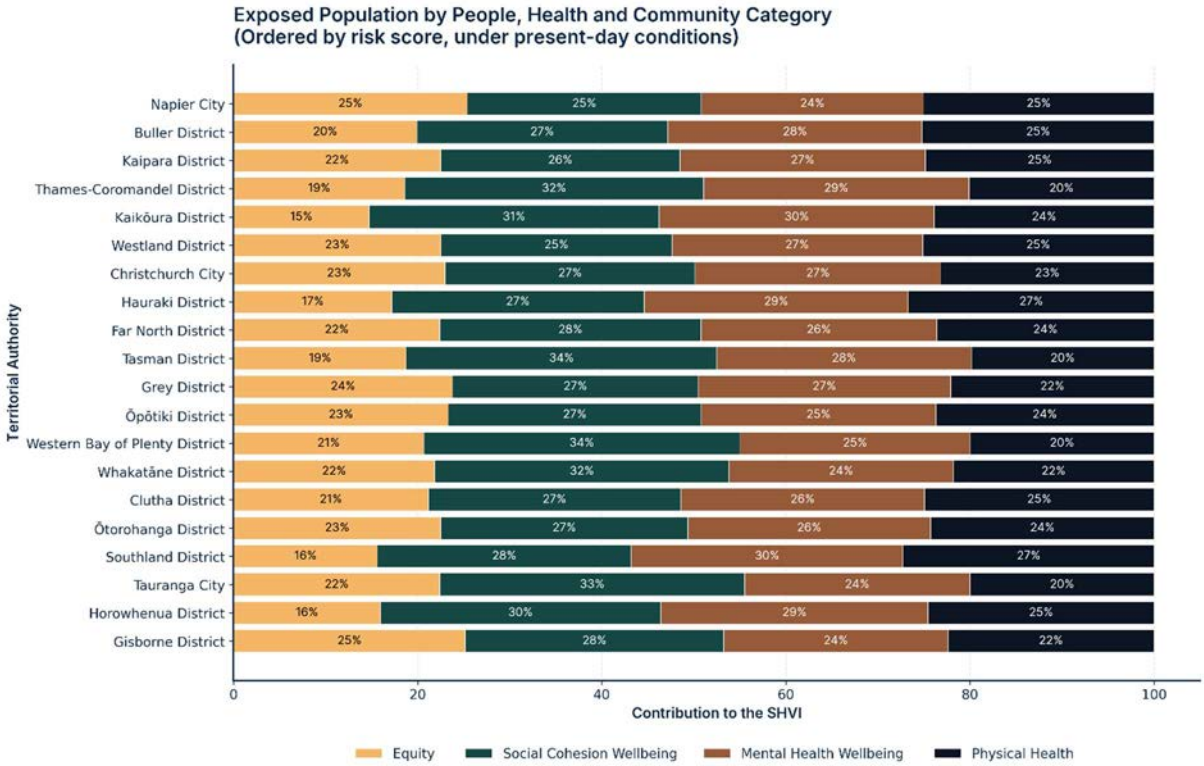

Figure 3-3 This figure demonstrates the relative contribution of the people, health and community categories to the outcomes and sensitivities of the populations with heightened social vulnerability from exposure to 1% AEP coastal flooding (quintiles 4 and 5) under present-day conditions (i.e. contribution to the SHVI). The top 20 TAs are shown, ranked according to their risk scores (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

3.1.4 Direct Exposure - By TA (0.2m SLR)

Under 0.2m SLR, Napier City remains the TA with the highest total percentage of their usually resident population at risk of direct exposure to coastal flooding under present-day conditions (19.5% of their total population, approximately 12,490 people in total) (Figure 3-4). Napier is followed by Buller District (13.3% of their total population, approximately 1,393 people), Hauraki District (11.2% of their total population, approximately 2,362 people), Thames-Coromandel District (7.8% of their total population, approximately 2,474 people), and Whakatāne District (6.9% of their total population, approximately 2,534 people).

In terms of social vulnerability, Napier City continues to have the population with the highest potential social vulnerability, as a proportion of their total population, under 0.2m SLR (Figure 3-4). It has a risk score of 13.6% (Table 3-1). Of their exposed residents specifically, 69.7% are classified as potentially having heightened social vulnerability. This calculation is based on the sum of quintile 4 and 5 in Figure 3-4. Following Napier, Buller District has the population with the next highest potential social vulnerability, as a proportion of their total population (risk score of 12.7%). Of their exposed residents specifically, 95.2% are classified as potentially having heightened social vulnerability. The next highest ranked TAs, with the greatest proportion of exposed residents classified as potentially having heightened social vulnerability as a proportion of their total population, are:

- Whakatāne District - 6% risk score (87.4% of exposed residents are classified as having heightened social vulnerability)
- Kaipara District - 5.4% risk score (94.6% of exposed residents are classified as having heightened social vulnerability)

- **Thames-Coromandel District** - 4.9% risk score (63% of exposed residents are classified as having heightened social vulnerability)

The risk scores for all top 20 ranked TAs are available in Appendix D.

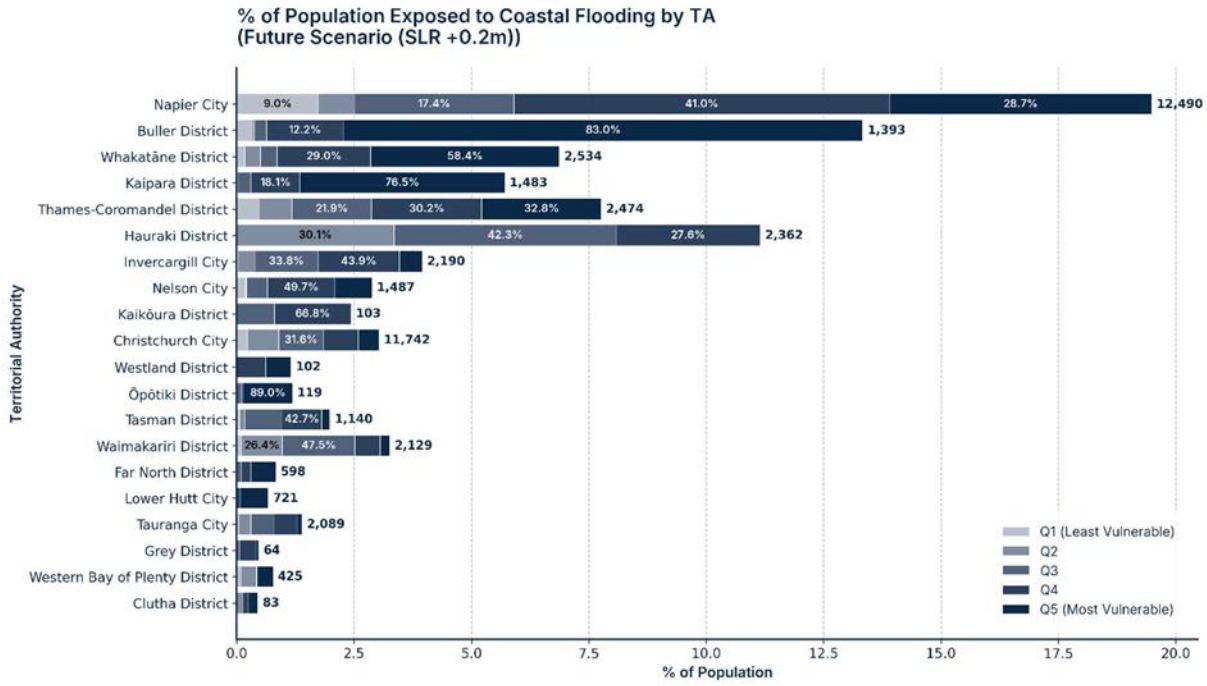

Figure 3-4 This graph shows the total percentage of residents directly exposed to sea-level rise under 0.2m SLR, by TA. For each TA, the quintiles Q4 and Q5 show what percentage of exposed residents are considered to have heightened social vulnerability. The TAs are ranked by risk score i.e. which have the highest proportion of their total population that are both at risk of exposure and potentially have heightened social vulnerability to 1% AEP coastal flooding. The risk scores for the top 20 ranked TAs are available in Appendix D.

Figure 3-5 shows how the four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) contribute to the SHVI, as it relates to exposure to coastal flooding under 0.2m SLR. There are few people, health and community categories that clearly dominate, though again the most notable difference is the lower relative contribution of equity amongst Kaikōura District. Social cohesion, community and cultural wellbeing also tend to contribute the highest share across the TAs. The overall trends by people, health and community category are:

- **Physical health** ranges from 18% (Nelson City) to 26% (Westland District)
- **Mental health** ranges from 23% (Invercargill City) to 30% (Kaikōura District)
- **Social cohesion, community and cultural wellbeing** ranges from 25% (Lower Hutt City, Westland District) to 34% (Western Bay of Plenty District, Tasman District)
- **Equity** ranges from 15% (Kaikōura District) to 25% (Invercargill City, Lower Hutt City)

For the five TAs with the highest risk scores:

- Napier City: Social cohesion contributes the greatest share (30%), while the other three categories contribute relatively equally (24% for mental health, 23% for physical health and equity)
- Buller District: Mental health continues to contribute the largest share (28%), and equity the least (20%)
- Whakatāne District: Social cohesion makes up the largest share (30%), and physical health the least (22%)
- Kaipara District: Mental health continues to contribute the largest share (27%), and equity the least (22%)
- Thames-Coromandel District: Social cohesion remains the largest category at 32%, compared to equity at 17%

A further breakdown of the relative contribution of the indicators within each bundle can be found in Appendix E.

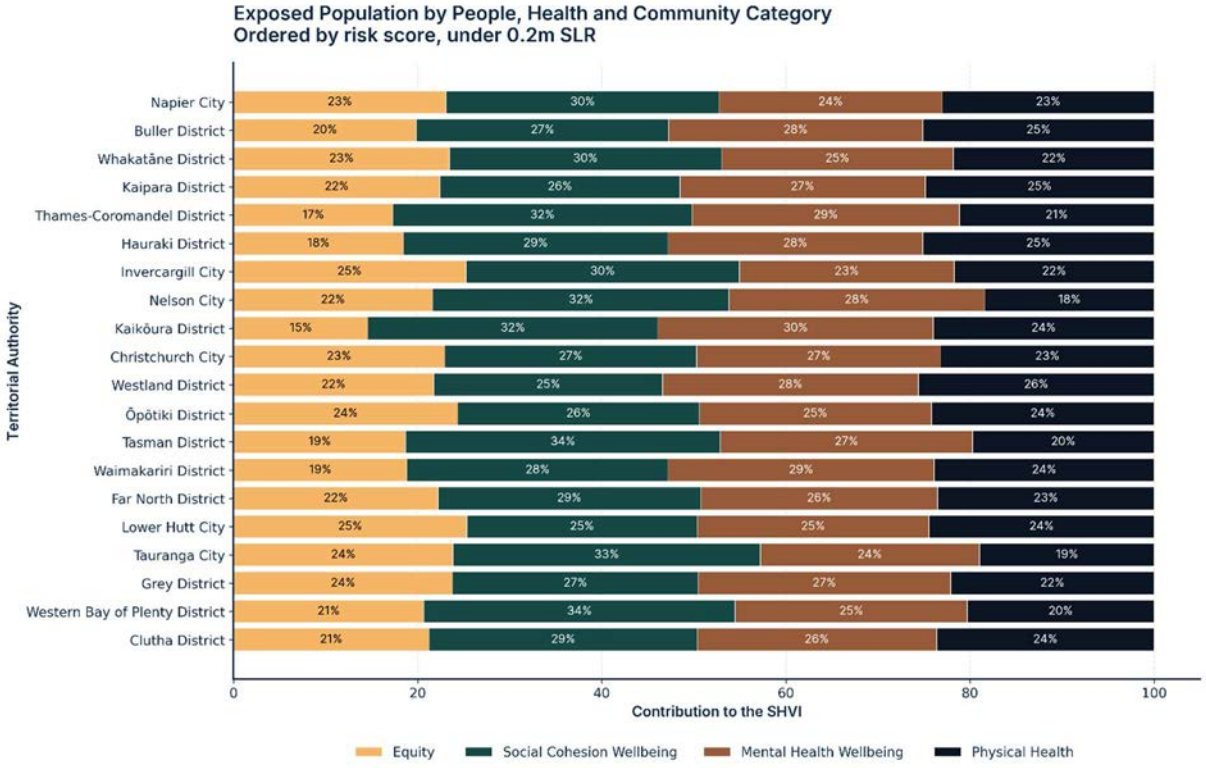

Figure 3-5 This figure demonstrates the relative contribution of the people, health and community categories to the outcomes and sensitivities of the populations with heightened social vulnerability from exposure to 1% AEP coastal flooding (quintiles 4 and 5) under 0.2m SLR contribution to the SHVI). The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

3.1.5 Direct Exposure - By TA (0.5m SLR)

Under 0.5m SLR, Napier City remains the TA with the highest total percentage of their usually resident population at risk of direct exposure to coastal flooding under present-day conditions (31.5% of their total population, approximately 20,201 people in total) (Figure 3-6). They are followed by Buller District (22.6% of their total population, approximately 1,393 people), Hauraki District (11.5% of their total population, approximately 2,438 people), Thames-Coromandel District (9.8% of their total population, approximately 3,129 people), and Whakatāne District (8.8% of their total population, approximately 3,253 people).

In terms of social vulnerability, Napier City continues to have the population with the highest potential social vulnerability, as a proportion of their total population, under 0.5m SLR (Figure 3-6). It has a risk score of 23.8% (Table 3-1). More specifically, 75.6% of their exposed population are classified as potentially having heightened social vulnerability. This calculation is based on the sum of quintile 4 and 5 in Figure 3-6. Following Napier, Buller District has the population with the next highest potential social vulnerability, as a proportion of their total population (risk score of 20.4%). Of their exposed residents specifically, 90.4% are classified as potentially having heightened social vulnerability. The next highest ranked TAs with the largest proportion of exposed residents classified as having heightened social vulnerability as a proportion of their total population are:

- Whakatāne District - 7.4% risk score (84.4% of exposed residents are classified as having heightened social vulnerability)
- Thames-Coromandel District - 6.1% risk score (62.3% of exposed residents are classified as having heightened social vulnerability)
- Kaipara District - 5.9% risk score (94.3% of exposed residents are classified as having heightened social vulnerability)

The risk scores for all top 20 ranked TAs are available in Appendix D.

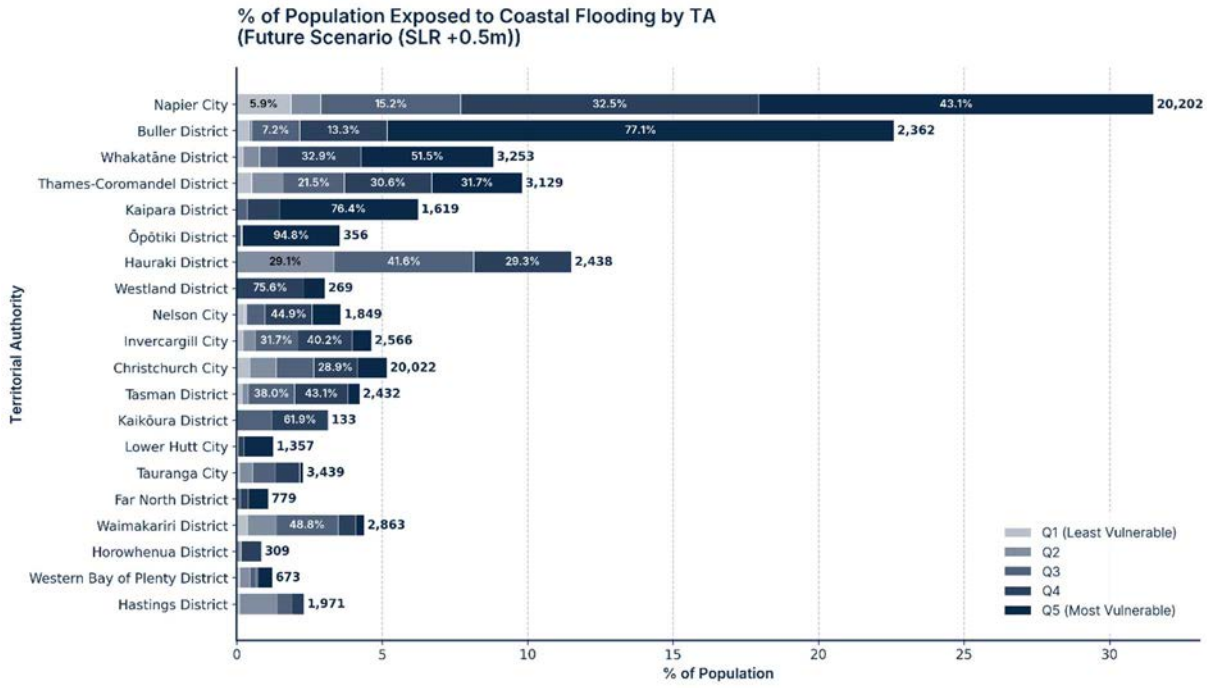

Figure 3-6 This graph shows the total percentage of residents directly exposed to sea-level rise under 0.5m SLR, by TA. For each TA, the quintiles Q4 and Q5 show what percentage of exposed residents are considered to have heightened social vulnerability. The TAs are ranked by risk score i.e. which have the highest proportion of their total population that are both at risk of exposure and potentially have heightened social vulnerability to 1% AEP coastal flooding. The risk scores for the top 20 ranked TAs are available in Appendix D.

Figure 3-7 shows how the four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) contribute to the SHVI, as it relates to exposure to coastal flooding under 0.5m SLR. There are few people, health and community categories that clearly dominate, though again the most notable difference is the lower relative contribution of equity amongst Kaikōura District, and that social cohesion, community and cultural wellbeing tend to contribute the highest share across the TAs. The overall trends by people, health and community category are:

- Physical health ranges from 18% (Nelson City) to 26% (Hauraki District)
- Mental health ranges from 24% (Hastings District, Tauranga City, Invercargill City) to 30% (Kaikōura District)
- Social cohesion, community and cultural wellbeing ranges from 25% (Lower Hutt City) to 34% (Western Bay of Plenty District, Tasman District)
- Equity ranges from 14% (Kaikōura District) to 25% (Ōpōtiki District, Lower Hutt City)

For the five TAs with the highest risk scores:

- Napier City: The social cohesion category continues to contribute the most (28%), while the other three categories contribute relatively equally (25% for mental health, 23% for physical health and equity)
- Buller District: Mental health continues to contribute the largest share (28%), and equity the least (20%)
- Whakatāne District: Social cohesion continues to contribute the most (30%), and physical health the least (22%)
- Thames-Coromandel District: Social cohesion remains the largest category (at 33%), compared to equity (17%)
- Kaipara District: Mental health continues to contribute the largest share (27%), and equity the least (22%)

A further breakdown of the relative contribution of the indicators within each bundle can be found in available in Appendix E.

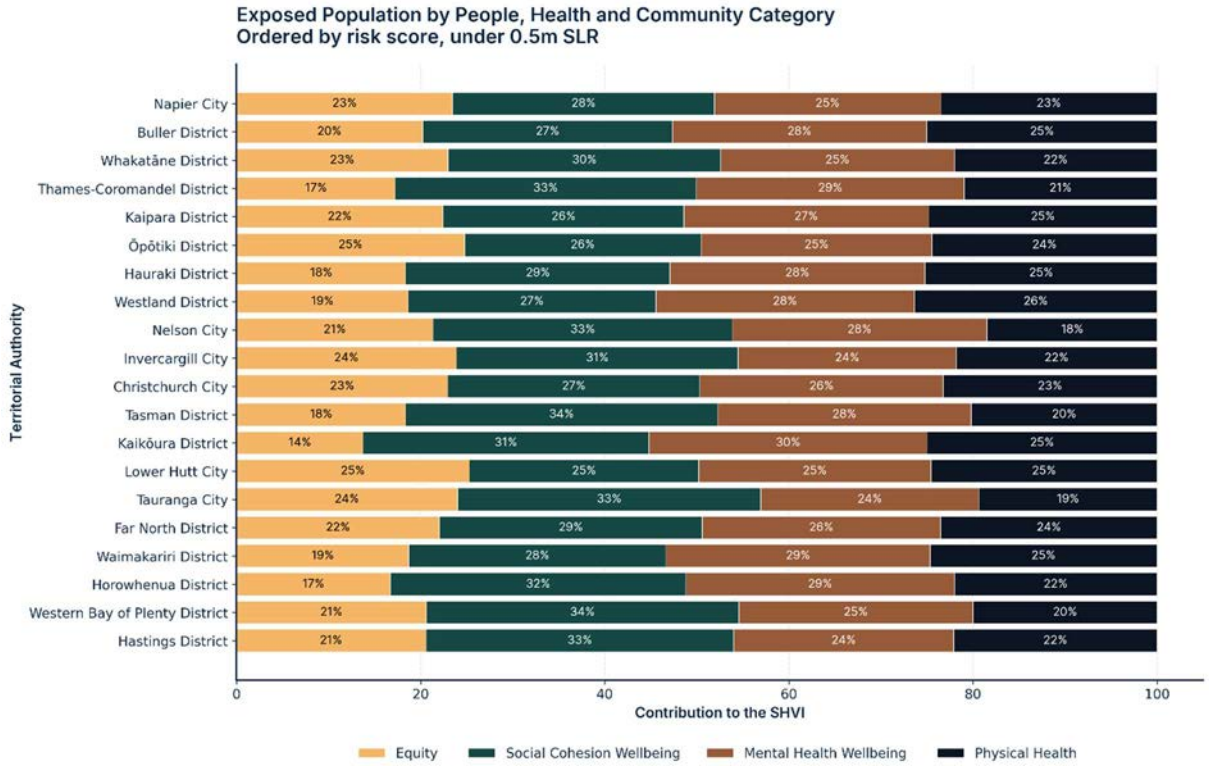

Figure 3-7 This figure demonstrates the relative contribution of the people, health and community categories to the outcomes and sensitivities of the populations with heightened social vulnerability from exposure to 1% AEP coastal flooding (quintiles 4 and 5) under 0.5m SLR (i.e. contribution to the SHVI). The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability as a proportion of their total population).

3.1.6 Direct Exposure - By TA (1.0m SLR)

Under 1.m SLR, Napier City remains the TA with the highest total percentage of their usually resident population at risk of direct exposure to coastal flooding under present-day conditions (46.7% of their total population, approximately 29,934 people in total) (Figure 3-8). This is up from 12.8% under present-day conditions. Napier are again followed by Buller District (31.7% of their total population, approximately 3,312 people; up from 8.2%), Thames-Coromandel District (15.6% of their total population, approximately 4,961 people; up from 5.6%), Whakatāne District (11.9% of their total population, approximately 4,395 people; up from 0.9%), and Ōpōtiki District (7.7% of their total population, approximately 768 people; up from 0.5%).

In terms of social vulnerability, Napier City continues to have the population with the highest potential social vulnerability, as a proportion of their total population under 1.0m SLR (Figure 3-8). It has a risk score of 32.1% (Table 3-1). More specifically, 68.7% of their exposed population are classified as potentially having heightened social vulnerability. This calculation is based on the sum of quintile 4 and 5 in Figure 3-8). This is down from 79.9% as a proportion of exposed residents under present-day conditions. Following Napier, Buller District has the population with the next highest potential social vulnerability, as a proportion of their total population (risk score of 28.1%). Of their exposed residents specifically, 88.7% are classified as potentially having heightened social vulnerability (down from 95.6% under present-day conditions). The next highest ranked TAs with the largest proportion of exposed residents classified as potentially having heightened social vulnerability as a proportion of their total population are:

- Thames-Coromandel District - 9.9% risk score (63.7% of exposed residents are classified as having heightened social vulnerability; up from 72.3%)

- Whakatāne District - 9% risk score (75.5% of exposed residents are classified as having heightened social vulnerability; up from 34.9%)
- Ōpōtiki District - 7.5% risk score (97.8% of exposed residents are classified as having heightened social vulnerability; up from 82.2%)

The risk scores for all top 20 ranked TAs are available in Appendix D.

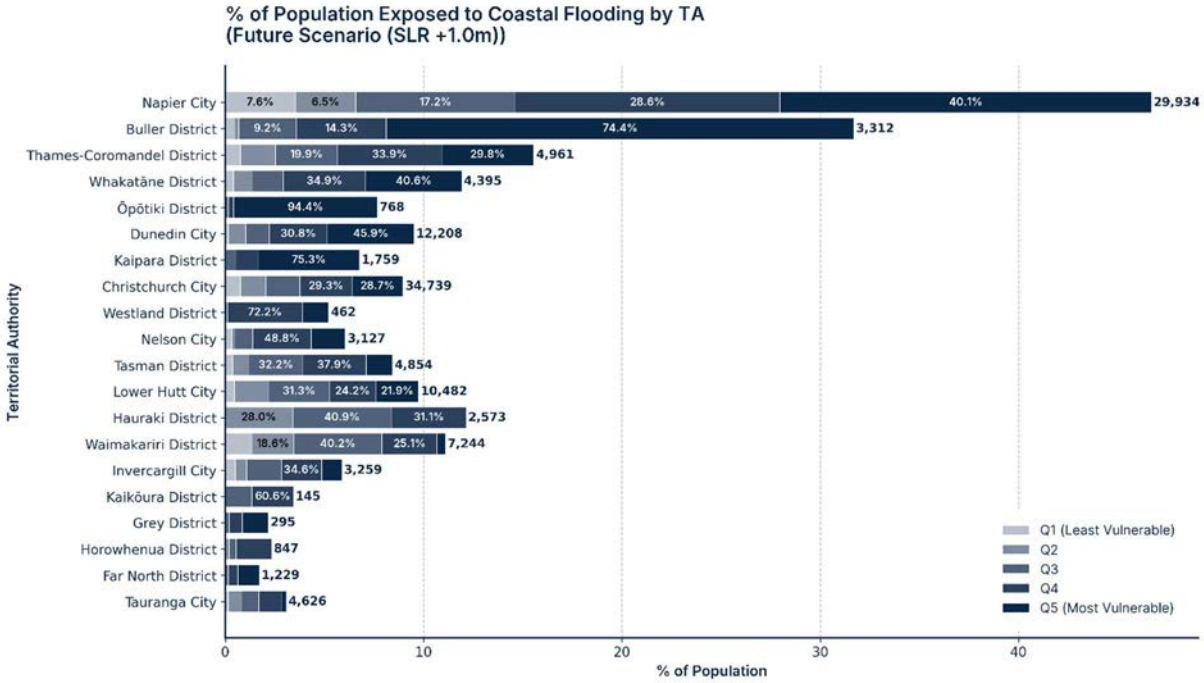

Figure 3-8 This graph shows the total percentage of residents directly exposed to sea-level rise under 1.0m SLR, by TA. For each TA, the quintiles Q4 and Q5 show what percentage of exposed residents are considered to have heightened social vulnerability. The TAs are ranked by risk score i.e. which have the highest proportion of their total population that are both at risk of exposure and have heightened social vulnerability to 1% AEP coastal flooding. The risk scores for the top 20 ranked TAs are available in Appendix D.

Figure 3-9 shows how the four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) contribute to the SHVI, as it relates to exposure to coastal flooding under 1.0m SLR. There are few people, health and community categories that clearly dominate, though again the most notable difference is the lower relative contribution of equity amongst Kaikōura District, and that social cohesion, community and cultural wellbeing tend to contribute the highest share across the TAs, and equity the least. The overall trends by people, health and community category are:

- Physical health ranges from 17% (Lower Hutt City City) to 26% (Westland District)
- Mental health ranges from 23% (Lower Hutt City City) to 30% (Kaikōura District)
- Social cohesion, community and cultural wellbeing ranges from 25% (Grey District) to 34% (Lower Hutt City)
- Equity ranges from 13% (Kaikōura District) to 26% (Lower Hutt City).

For the five TAs with the highest risk scores:

- **Napier City:** The social cohesion category continues to contribute the most (30%), while the other three categories contribute relatively equally (25% for mental health, 23% for physical health and equity)
- **Buller District**: Remains unchanged, with mental health contributing the largest share (28%), and equity the least (20%)
- **Thames-Coromandel District**: Social cohesion remains the largest category (at 33%), compared to equity (17%)
- **Whakatāne District:** Social cohesion continues to contribute the most (30%), and physical health the least (22%)
- **Ōpōtiki District**: All four categories contribute relatively equally, with social cohesion the highest (26%) and physical health and equity the lowest at 24% each.

A further breakdown of the relative contribution of the indicators within each bundle can be found in Appendix E.

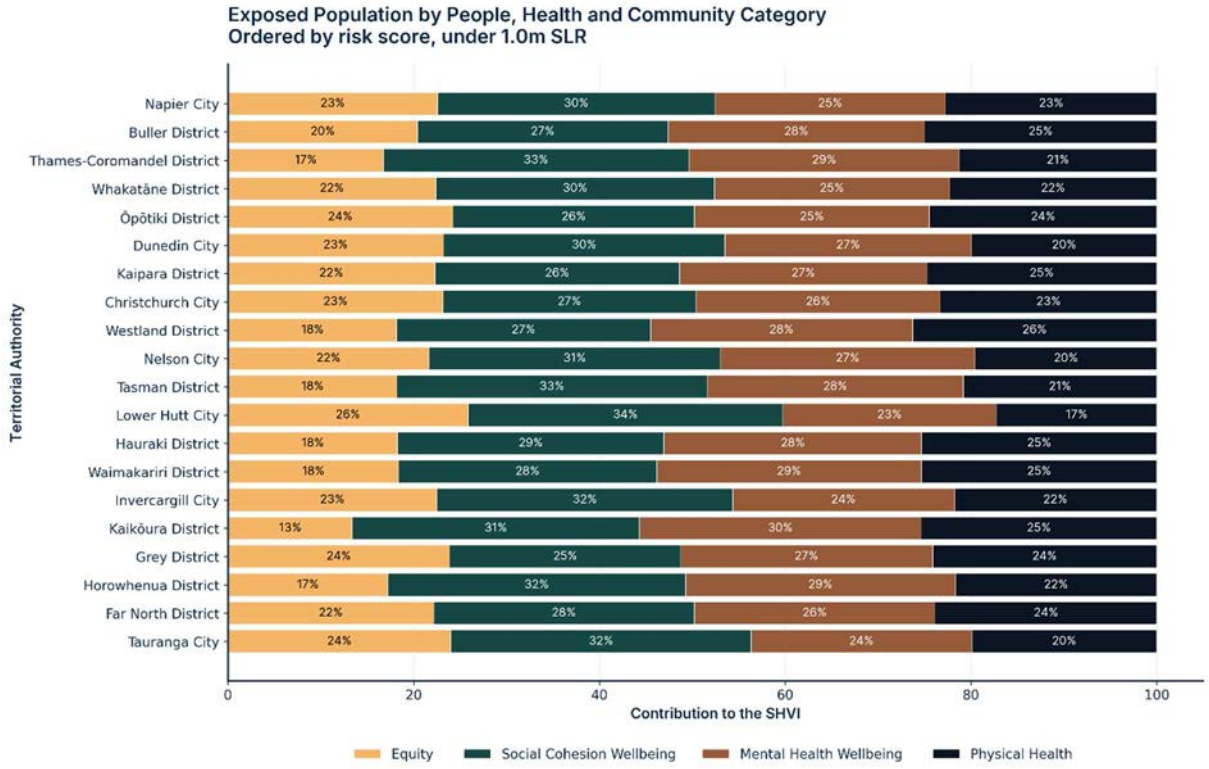

Figure 3-9 This figure demonstrates the relative contribution of the people, health and community categories to the outcomes and sensitivities of the populations with having heightened social vulnerability from exposure to 1% AEP coastal flooding (quintiles 4 and 5) under 1.0m SLR (i.e. contribution to the SHVI). The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

3.1.7 Social Vulnerability Trends for Exposure

As sea levels rise, the number of people across Aotearoa New Zealand who will be potentially exposed to 1% AEP coastal flooding will increase. At present 0.6% of the population (more than 28,900 people) could be directly exposed. At 0.2m SLR this increases to 1.1% of residents (approximately 52,700 people), increasing again to 1.6% (approximately 80,130 people) at 0.5m SLR, to 3.1% (approximately 150,900 people) at 1.0m SLR, and 5.4% (approximately 264,900 people) at 2.0m SLR.

Just over half of those potentially exposed are classified as having potentially higher social vulnerability (quintiles 4 and 5) due to factors that may make them more sensitive to harm. Of the residents who are potentially exposed to a 1% AEP coastal flood under present-day conditions (0.0m SLR), approximately 16,700 (57.7%) have higher potential social vulnerability. For future increments of sea-level rise, these figures increase to 28,850 people (54.7% of those exposed) under 0.2m SLR; 46,600 people (58.1% of those exposed) under 0.5m SLR; 87,800 people (58.2% of those exposed) under 1.0m SLR; 145,250 people (54.8% of those exposed) under 2.0m SLR.

Napier City and Buller District consistently have the highest proportion of their total population at risk of direct exposure to coastal flooding, under present-day conditions and across the 0.2m SLR, 0.5m SLR, and 1.0m SLR scenarios (Table 3-1). The difference between their proportion of exposed residents compared to other TAs increases significantly under 0.5m and 1.0m of SLR. For example, under 0.5m SLR, Napier City and Buller District's exposed populations are 31.5% and 22.6% of their total population respectively, compared to the next highest TA, Hauraki District (11.5%). Under 1.0m SLR, Napier City and Buller District's exposed populations are 46.7% and 31.7% of their total population respectively, compared to the next highest TA, Thames-Coromandel District (15.6%)

Territorial authorities are not impacted equally with regard to vulnerability associated with exposure to coastal flooding. Of all directly exposed TAs, Napier City and Buller District are consistently ranked as having the highest and second highest risk scores across present day, 0.2m SLR, 0.5m SLR, and 1.0m SLR scenarios. That is to say, they have the highest proportion of their total population that are both exposed and potentially have heightened social vulnerability. Therefore, they may have the highest community-level burden of harm arising from exposure to coastal flooding. Their risk scores are also consistently higher relative to other TAs, and this gap increases significantly under 0.5m SLR and 1.0m SLR. For example, under 1.0m SLR, Napier City and Buller District's respective scores of 32.1% and 28.1% are followed by the next highest, Thames-Coromandel District, at 9.9%. This indicates that Napier City and Buller District are consistently at much greater risk of community vulnerability arising from exposure to 1% AEP coastal flooding.

Other TAs with relatively consistent high risk scores are Thames-Coromandel District, Whakatāne District, and Kaipara District. Under 1.0m SLR, Dunedin City is a significant mover, joining the 10 TAs with the highest social vulnerability, with a risk score of 7.3%, and Christchurch City rejoins at 5.2%. Ōpōtiki District also rises noticeably by joining the top 10 at 0.5m SLR (3.4%) and increasing to 7.5% at 1.0m SLR.

The sensitivities contributing to, and the outcomes associated with, social vulnerability from exposure are diverse, and not limited to simply physical health impacts. Amongst those populations exposed to coastal flooding, none of the four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) clearly dominated. Overall, the mental health and social cohesion, community and cultural wellbeing categories tended to make up the greater share of factors associated with vulnerability, and systemic inequities (equity category) the lesser share. This shows that adaptation responses focused solely on physical health and/or mental health impacts and drivers are unlikely to be effective.

Table 3-1 This table shows the TAs ranked by risk score i.e. which have the highest proportion of their total population that are both at risk of exposure and potentially have heightened social vulnerability to 1% AEP coastal flooding (i.e. categorised as Q4 or Q5). The risk score is presented as a percentage in brackets next to each TA's name. Rankings are shown under present day (0.0m SLR), 0.2m SLR, 0.5m SLR, and 1.0m SLR to be able to demonstrate any changes over time. The arrows indicate a shift in the ranking of a TA relative to other TAs, not necessarily an increase or decrease in their risk score over time.

Exposure Risk Score Rankings by Territorial Authority

Legend | ↑ New entry or increased ranking position | ↓ Decreased ranking position

Present Day	0.2m SLR	0.5m SLR	1.0m SLR
Napier City (10.2%)	Napier City (13.6%)	Napier City (23.8%)	Napier City (32.1%)
Buller District (7.8%)	Buller District (12.7%)	Buller District (20.4%)	Buller District (28.1%)
Kaipara District (5.1%)	Whakatāne District (6%) ↑	Whakatāne District (7.4%)	Thames-Coromandel District (9.9%) ↑
Thames-Coromandel District (4.1%)	Kaipara District (5.4%) ↓	Thames-Coromandel District (6.1%) ↑	Whakatāne District (9%) ↓
Kaikōura District (1.5%)	Thames-Coromandel District (4.9%) ↓	Kaipara District (5.9%) ↓	Ōpōtiki District (7.5%) ↑
Westland District (0.9%)	Hauraki District (3.1%) ↑	Ōpōtiki District (3.4%) ↑	Dunedin City (7.3%) ↑
Christchurch City (0.9%)	Invercargill City (2.2%) ↑	Hauraki District (3.4%) ↓	Kaipara District (6.2%) ↓
Hauraki District (0.7%)	Nelson City (2.2%) ↑	Westland District (3%) ↑	Christchurch City (5.2%) ↑
Far North District (0.6%)	Kaikōura District (1.6%) ↓	Nelson City (2.6%) ↓	Westland District (5.1%) ↓
Tasman District (0.4%)	Christchurch City (1.2%) ↓	Invercargill City (2.5%) ↓	Nelson City (4.7%) ↓

3.2 Indirect Exposure - Isolation

Isolation arises when residents lose access to the services that support daily life, even if their properties are not directly flooded. In this report, isolation is defined as the loss of access to community centres and essential services. We operationalise this definition by representing community access through three nationally consistent amenities: fire stations, hospitals, and primary schools. If residents lose access to all three, they are considered isolated, on the basis that they are also effectively cut off from other essential services and activities. Residents directly flooded are also counted as isolated, because inundation necessarily severs access to these amenities. As a result, isolation results are always larger than, and inclusive of, direct exposure results.

3.2.1 Isolation - Overall Isolation

Under present-day conditions (0.0m SLR), more than 142,200 New Zealanders (approximately 2.8% of residents) are potentially isolated during a 1% AEP coastal flood (Figure 3-10). This number increases with sea-level rise: more than 183,200 at 0.2m SLR (3.7%), 237,900 at 0.5m SLR (4.8%), and 368,000 at 1.0m

SLR (7.4%). At 2.0m SLR, approximately 528,400, New Zealanders (10.7% of residents) may experience isolation.

Of those potentially isolated by a 1% AEP coastal flood under present-day conditions (0.0m SLR), approximately 68,100 (47.9%) are classified in the higher-vulnerability quintiles (4 and 5). Across future sea-level rise increments, roughly half of the isolated population falls into these higher-vulnerability groups:

- 0.2m SLR: 88,900 (48.6%)
- 0.5m SLR: 122,600 (51.6%)
- 1.0m SLR: 188,200 (51.1%)
- 2.0m SLR: 266,100 (50.3%)

This analysis captures loss of access (physical isolation); in practice, community burden may be amplified where services remain physically reachable but cannot operate due to cascading infrastructure failures (functional isolation), as shown in recent studies [16], [20].

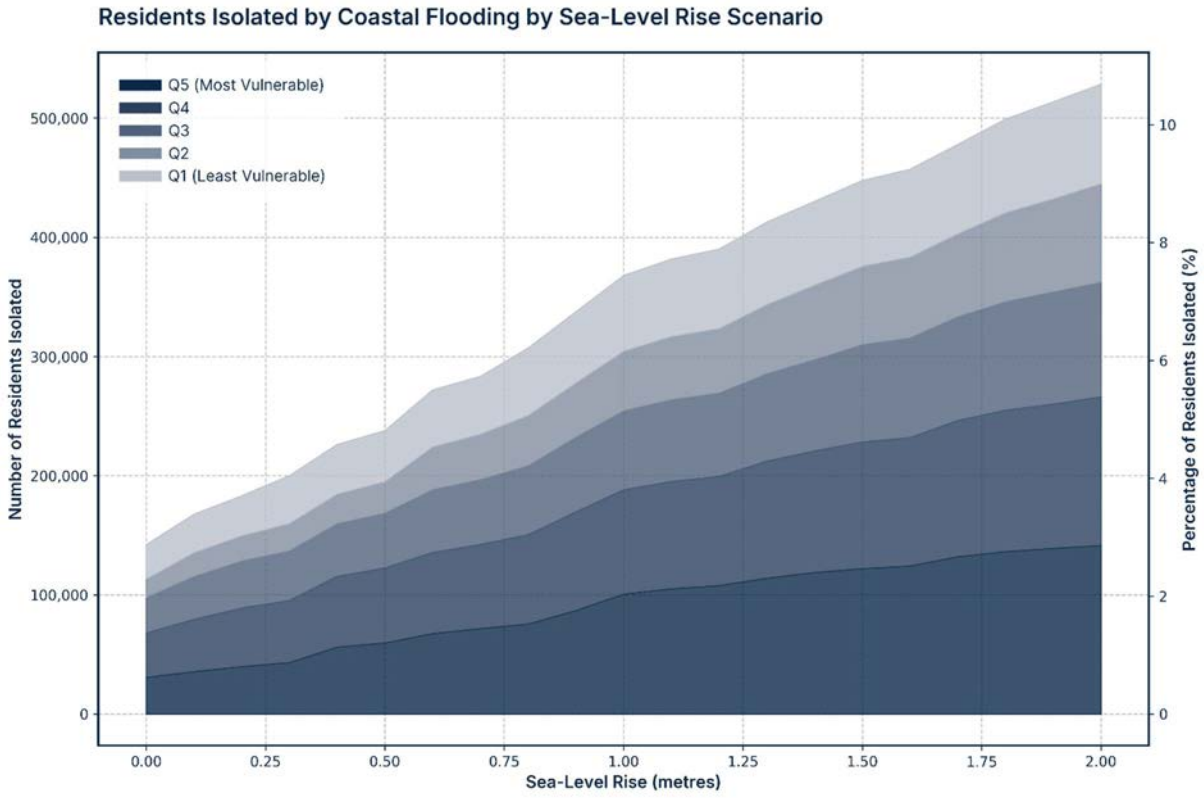

Figure 3-10 This graph shows the total percentage of residents potentially isolated due to a 1% AEP coastal flood with different increments of sea-level rise. Of those potentially isolated, the different lines show what proportion of all exposed residents are classified within each quintile, with quintiles 4 and 5 being high and highest vulnerability, respectively.

3.2.2 Isolation - By Territorial Authority

The distribution of residents potentially isolated by a 1% AEP coastal flooding is not uniform across Aotearoa New Zealand. Some territorial authorities have greater numbers of potentially affected residents, and a higher percentage of those residents may be more likely to experience negative impacts as a result of any isolation. The following section describes the distribution across the TAs of those isolated and the

proportion classified as having heightened social vulnerability (quintiles 4 and 5 of SHVI) for the present day (0.0cm), 0.2m, 0.5m, and 1.0m sea-level rise.

The TAs are ranked by their risk score, which is a function of both the proportion of their total population who is potentially isolated due to coastal flooding, and the proportion of those isolated who are classified as potentially having heightened social vulnerability (i.e. classified into quantiles 4 and 5 of higher and highest vulnerability). As described previously, this is done to avoid the dominance of larger TAs with high numbers of people isolated, that represent only a small proportion of the TA's total population. It also avoids the opposite problem where a small number of people are isolated, but of those few people, all of them are likely to experience heightened social vulnerability.

3.2.3 Isolation - By TA (Present Day)

Thames-Coromandel District has the highest total percentage of their usually resident population potentially at risk of isolation due to 1% AEP coastal flooding under present-day conditions (49% of their total population, approximately 15,623 people in total) (Figure 3-11). They are followed by Kaipara District (25.5% of their total population, approximately 6,634 people), Napier City (19.1% of their total population, approximately 12,230 people), Buller District (18.3% of their total population, approximately 1,914 people), and Far North District (15.9% of their total population, approximately 11,359 people).

When considering social vulnerability, Thames-Coromandel District also has the population with the highest potential social vulnerability as a proportion of their total population under present-day conditions (0.0m SLR) (Figure 3-11). It has a risk score of 28.2% (

Table 3-2). Approximately 57.6% of their isolated residents are classified as potentially having heightened social vulnerability. This calculation is based on the sum of quintile 4 and 5 on Figure 3-11. Buller District has the population with the next highest potential social vulnerability as a proportion of their total population (risk score of 17.1%). Of their isolated residents specifically, 93.4% are classified as potentially having heightened social vulnerability. The next highest ranked TAs with the highest proportion of isolated residents classified as having heightened social vulnerability, as a proportion of their total population are:

- Napier City - 15.3% risk score (80% of their isolated residents are classified as having heightened social vulnerability)
- Far North District - 14.4% risk score (90.2% of their isolated residents are classified as having heightened social vulnerability)
- Kaipara District - 14% risk score (54.9% of their isolated residents are classified as having heightened social vulnerability)

The risk scores for all top 20 ranked TAs are available in Appendix D.

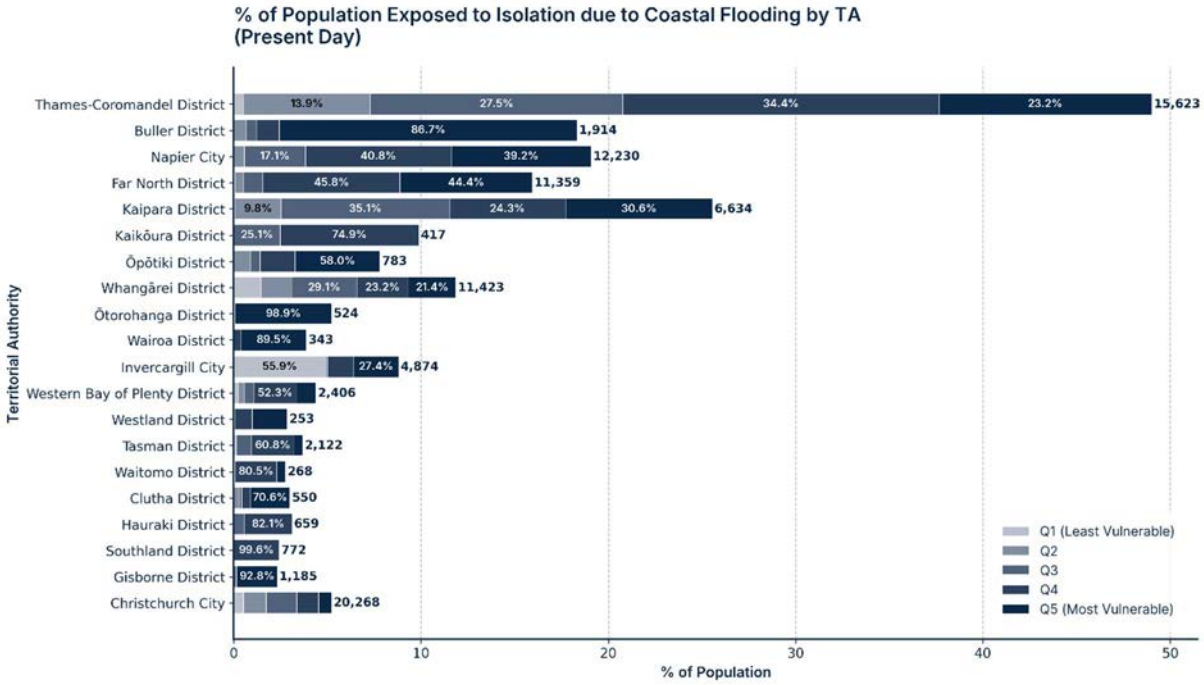

Figure 3-11 This graph shows the total percentage of residents isolated due to sea-level rise under present-day conditions, by TA. For each TA, the quintiles Q4 and Q5 show what percentage of isolated residents are considered to have heightened social vulnerability. The TAs are ranked by risk score i.e. which have the highest proportion of their total population that are both at risk of isolation and potentially have heightened social vulnerability to 1% AEP coastal flooding. The risk scores for the top 20 ranked TAs are available in Appendix D.

Figure 3-12 demonstrates how all four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) contribute to the SHVI, as it relates to isolation under present-day conditions. Although the relative percentage contributions vary somewhat across the top 20 TAs and contributions are not equal relative to one another, there are few people, health and community categories that clearly dominate. The exceptions are Invercargill City and Waitomo District, where the physical health risk category scores highly and the equity category relatively low. The overall trends by people, health and community category are:

- Physical health varies from 20% (Whangārei) to 34% (Invercargill City)
- Mental health varies from 24% (Napier City and Invercargill City) to 32% (Waitomo District)
- Social cohesion, community and cultural wellbeing ranges from 25% (Buller, Westland and Clutha Districts) to 32% (Whangārei District)
- Equity ranges from 10% (Waitomo District) to 26% (Napier City).

Of the five TAs with the highest risk scores:

- Thames-Coromandel District: Mental health contributes the largest share (30%), while equity contributes 17%.
- Buller District: Similarly, mental health contributes the largest share (28%), and equity the smallest (21%)
- Napier City: Equity and social cohesion have a slightly greater share (26%), compared to mental and physical health (both 24%)
- Far North District: Social cohesion has the largest share (29%) and equity the least (21%)

- **Kaipara District**: Social cohesion and mental health have the largest contributions (28%), compared with physical health (24%) and equity (20%).

A further breakdown of the relative contribution of the indicators within each bundle can be found in Appendix E.

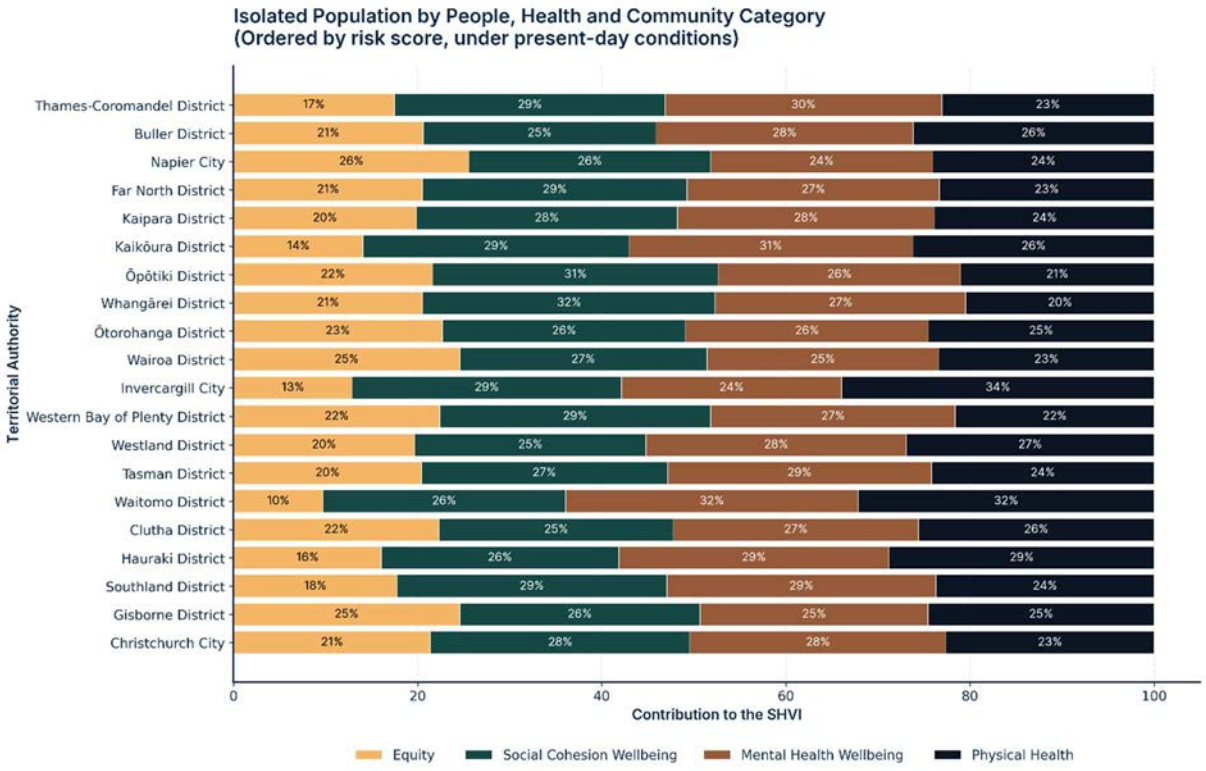

Figure 3-12 This figure demonstrates the relative contribution of the people, health and community categories to the outcomes and sensitivities of the populations with heightened social vulnerability due to isolation to 1% AEP coastal flooding (quintiles 4 and 5) under present-day conditions (i.e. contribution to the SHVI). The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

3.2.4 Isolation - By TA (0.2m SLR)

At 0.2m of sea-level rise **Thames-Coromandel District** remains the TA with the highest percentage of their usually resident population potentially isolated by a 1% AEP coastal flood (20,855 people or 65.4% of the population) (Figure 3-13). **Kaipara District** has the next highest percentage with 25.7% of their total population, approximately 6,687 people potentially isolated. Next is **Buller District** with 25% of their total population, or approximately 2,612, then **Napier City** (24.9% of their total population, approximately 15,966 people), **Far North District** (16.5% of their total population, approximately 11,733 people).

*With respect to social vulnerability, **Thames-Coromandel District** also has the population with the highest potential social vulnerability as a proportion of their total population, with 0.2m sea-level rise (Figure 3-13). It has a risk score of 35.3% (*

Table 3-2). Approximately 54% of their isolated residents are classified as potentially having heightened social vulnerability. This calculation is based on the sum of quintile 4 and 5 on Figure 3-13. **Buller District** has

the population with the next highest potential social vulnerability as a proportion of their total population (risk score of 23.7%). Of their isolated residents specifically, 94.7% are classified as being potentially highly vulnerable. The next highest ranked TAs with the highest proportion of isolated residents classified as having heightened social vulnerability, as a proportion of their total population are:

- Napier City - 17.8% risk score (71.4% of their isolated residents are classified as having heightened social vulnerability)
- Far North District - 14.9% risk score (90.2% of their isolated residents are classified as having heightened social vulnerability)
- Kaipara District - 14.2% risk score (55.1% of their isolated residents are classified as having heightened social vulnerability)

The risk scores for all top 20 ranked TAs are available in Appendix D.

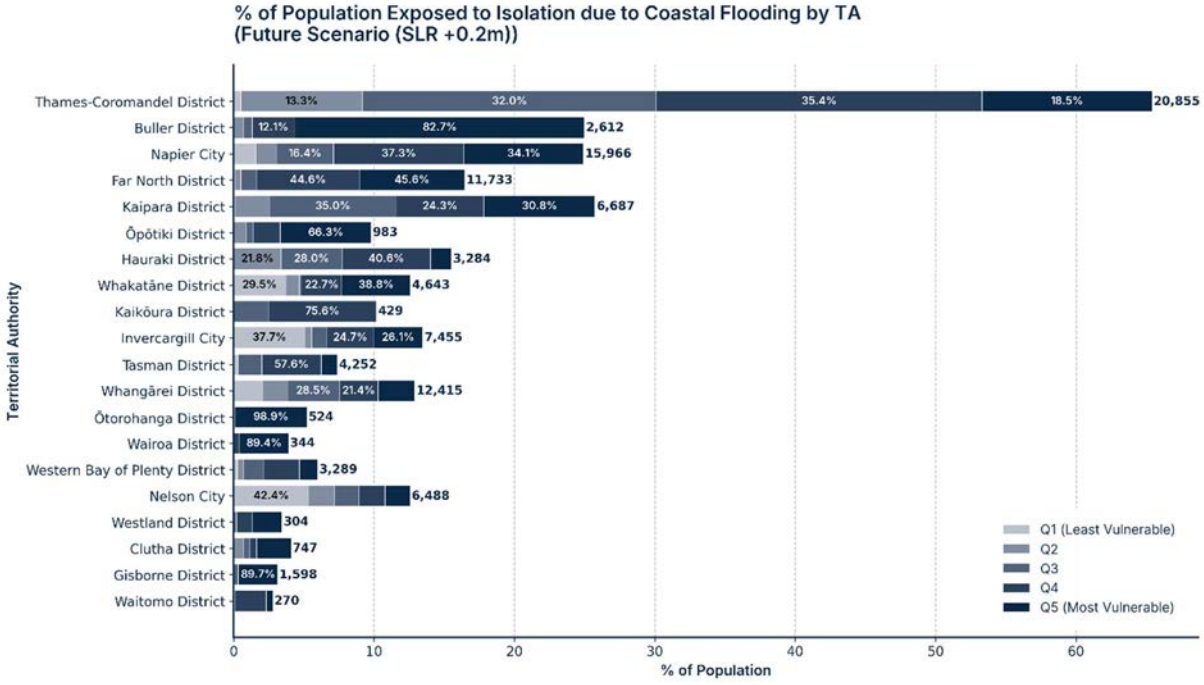

Figure 3-13 This graph shows the total percentage of residents isolated due to sea-level rise under 0.2m SLR, by TA. For each TA, the quintiles Q4 and Q5 show what percentage of isolated residents are considered to have heightened social vulnerability. The TAs are ranked by risk score i.e. which have the highest proportion of their total population that are both at risk of isolation and have heightened social vulnerability to 1% AEP coastal flooding. The risk scores for the top 20 ranked TAs are available in Appendix D.

Figure 3-14 demonstrates how all four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) contribute to the SHVI, as it relates to isolation under 0.2m SLR. Although the relative percentage contributions vary somewhat across the TAs and contributions are not equal relative to one another, there are no people, health and community categories that clearly dominate, with the exception of Waitomo District. For Waitomo, the physical and mental health people, health and community categories have a combined contribution of 64%, while equity is only 10%. The overall trends by people, health and community category are:

- **Physical health** varies from 19% (Nelson City) to 32% (Waitomo District)
- **Mental health** varies from 24% (Invercargill City) to 32% (Waitomo District)
- **Social cohesion, community and cultural wellbeing** ranges from 25% (Buller and Westland District) to 32% (Nelson City and Whangārei District)
- **Equity** ranges from 10% (Waitomo District) to 25% (Wairoa District).

For the five TAs with the highest risk scores:

- **Thames-Coromandel District**: Mental health and social cohesion are 30% each, while equity is 17%.
- **Buller District**: Mental health has the largest share (28%), while equity has the smallest (21%)
- **Napier City**: Social cohesion and mental health have a slight greater share (28% and 25% respectively), compared to equity (24%) and physical health (23%)
- **Far North District:** Social cohesion contributes the most (29%) and equity the least (21%)
- **Kaipara District**: Social cohesion and mental health (28%) have the largest share and equity the least (20%)

A further breakdown of the relative contribution of the indicators within each bundle can be found in Appendix E.

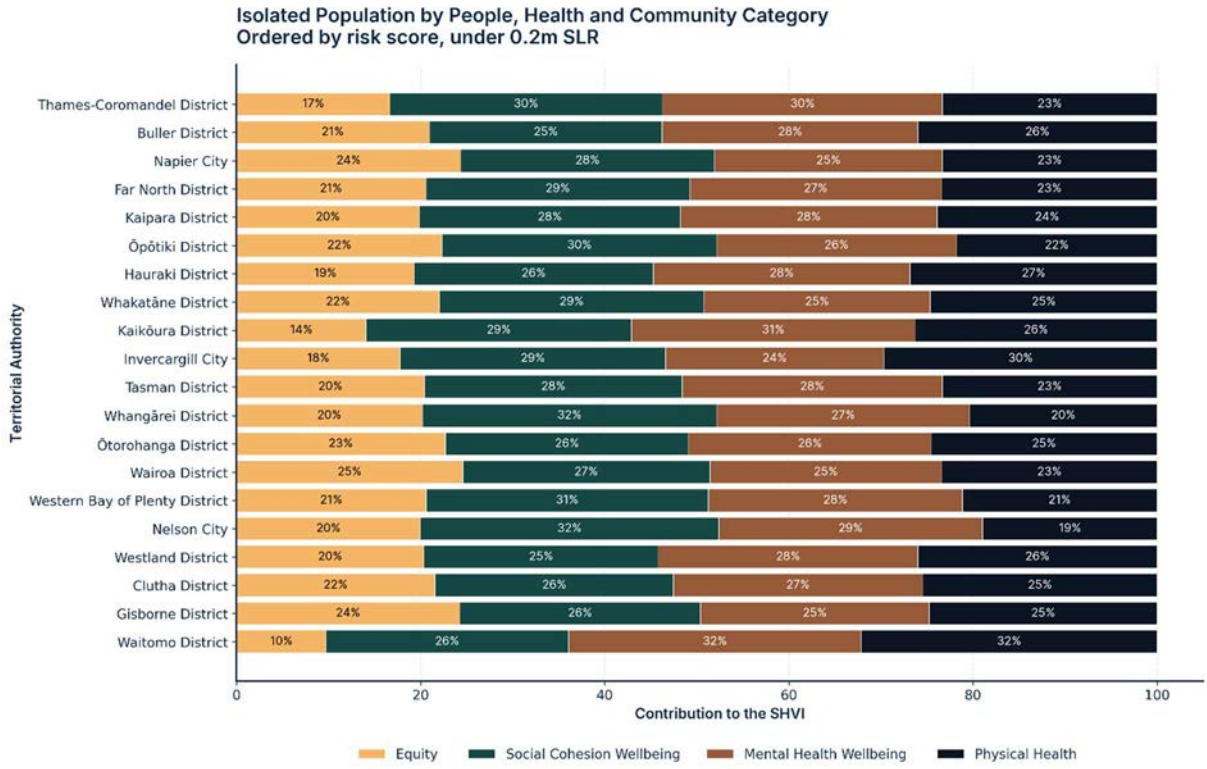

Figure 3-14 This figure demonstrates the relative contribution of the people, health and community categories to the outcomes and sensitivities of the populations with heightened social vulnerability due to isolation to 1% AEP coastal flooding (quintiles 4 and 5) under 0.2m SLR (i.e. contribution to the SHVI). The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

3.2.5 Isolation - By TA (0.5m SLR)

At 0.5m of sea-level rise Thames-Coromandel District remains the TA with the highest percentage of their usually resident population potentially isolated by a 1% AEP coastal flood (24,828 people or 77.9% of the population) (Figure 3-15). Napier City has the next highest percentage of their total population isolated (41.1% or approximately 26,339 people). Next is Buller District, with 34.5% of their total population potentially isolated, or approximately 3,609. Followed by Kaipara District (26.1% of their total population, approximately 6,779 people), Ōpōtiki District (17.7% of their total population around 1,775 people), and Far North District (16.8% of their total population, approximately 11,987 people).

When the focus shifts to social vulnerability, Thames-Coromandel District still has the population with the highest potential social vulnerability as a proportion of their total population with 0.5m sea-level rise (Figure 3-15). It has a risk score of 47.1% (

Table 3-2). Approximately 60.5 % of their isolated residents are classified as potentially having heightened social vulnerability. This calculation is based on the sum of quintile 4 and 5 on Figure 3-15. Buller District still has the population with the next highest potential social vulnerability as a proportion of their total population (risk score of 33.2%). Of their isolated residents specifically, 96.2% are classified as being potentially highly vulnerable. The next highest ranked TAs with the highest proportion of isolated residents classified as having heightened social vulnerability, as a proportion of their total population are:

- Napier City - 32.1% risk score (78.2% of their isolated residents are classified as having heightened social vulnerability)
- Ōpōtiki District - 16.3% risk score (92.1% of their isolated residents are classified as having heightened social vulnerability)
- Far North District - 15.2% risk score (90.5% of their isolated residents are classified as having heightened social vulnerability)

The risk scores for all top 20 ranked TAs are available in Appendix D.

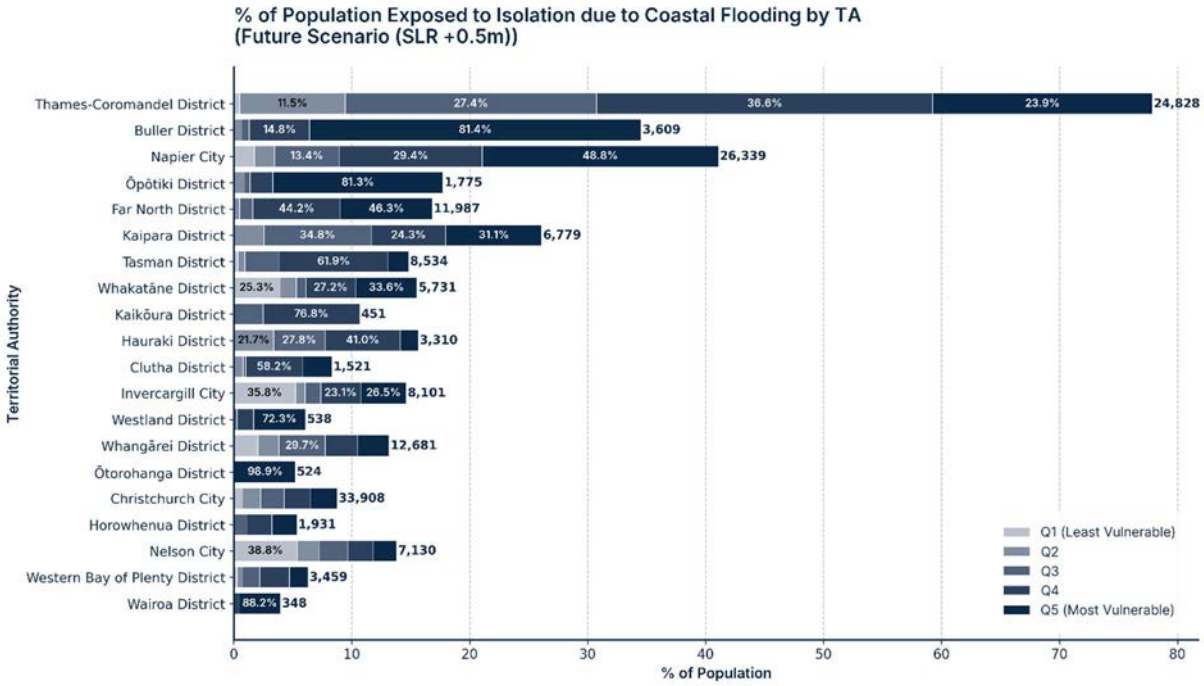

Figure 3-15 This graph shows the total percentage of residents isolated due to sea-level rise under 0.5m SLR, by TA. For each TA, the quintiles Q4 and Q5 show what percentage of isolated residents are considered to have heightened social vulnerability. The TAs are ranked by risk score i.e. which have the highest proportion of their total population that are both at risk of isolation and potentially have heightened

social vulnerability to 1% AEP coastal flooding. The risk scores for the top 20 ranked TAs are available in Appendix D.

Figure 3-16 shows how the four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) contribute to the SHVI, as it relates to isolation under 0.5m of sea-level rise. As under previous scenarios, none of the people, health and community categories clearly dominate, with the exception of Kaikōura District. For Kaikōura, the social cohesion (29%) and mental health (31%) people, health and community categories are larger compared to the equity category (14%). The overall trends by people, health and community category are:

- Physical health varies from 19% (Nelson City) to 29% (Invercargill City)
- Mental health varies from 24% (Invercargill City) to 31% (Kaikōura District)
- Social cohesion, community and cultural wellbeing ranges from 25% (Buller and Clutha Districts) to 32% (Nelson City and Whangārei District)
- Equity ranges from 14% (Kaikōura District) to 25% (Wairoa District).

For the five TAs with the highest risk scores:

- Thames-Coromandel District: Mental health and social cohesion continue at 30% each, while equity is 18%.
- Buller District: Mental health continues to have the largest share (28%), and equity the smallest (21%)
- Napier City: Mental health (25%) and social cohesion (27%) have a slightly greater share, compared to equity and physical health (both 24%)
- Ōpōtiki District: Social cohesion (28%) has the largest contribution compared with physical health and equity (both on 23%)
- Far North District: Social cohesion continues to contribute the most (29%) and equity the least (21%)

A further breakdown of the relative contribution of the indicators within each bundle can be found in Appendix E.

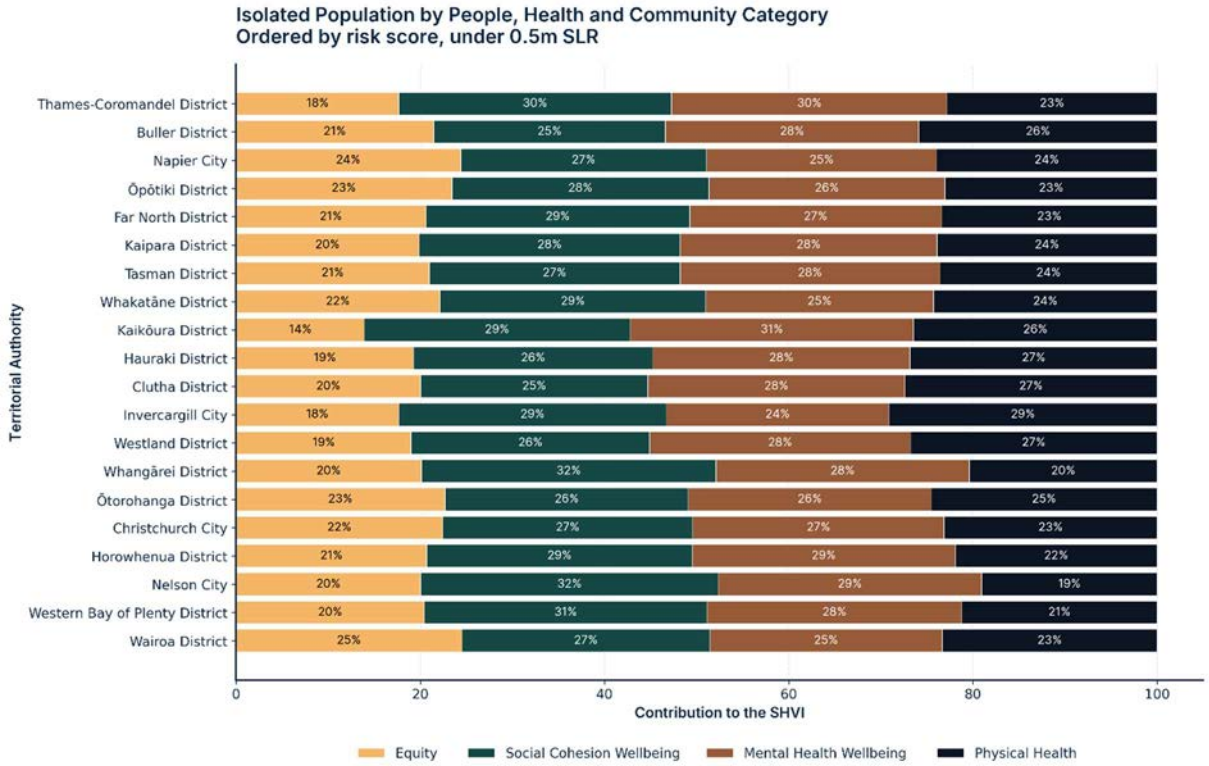

Figure 3-16 This figure demonstrates the relative contribution of the people, health and community categories to the outcomes and sensitivities of the populations with heightened social vulnerability due to isolation to 1% AEP coastal flooding (quintiles 4 and 5) under 0.5m SLR (i.e. contribution to the SHVI). The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

3.2.6 Isolation - By TA (1.0m SLR)

At 1.0m of sea-level rise, Thames-Coromandel District remains the TA with the highest percentage of their usually resident population potentially isolated by a 1% AEP coastal flood (78.3% of the population, approximately 24,965 people) (Figure 3-17). Hauraki District becomes the TA with the second highest percentage of their population potentially isolated by a 1% AEP coastal flood (62.4%, approximately 13,217 people). Hauraki is followed by Napier City (51.9%, approximately 33,264 people), Buller District (40.3%, approximately 4,211 people), and Kaipara District (41.1%, approximately 10,674 people).

With respect to social vulnerability, Hauraki District becomes the TA with the population with the highest potential social vulnerability as a proportion of their total population at 1.0m sea-level rise (Figure 3-17). It has a risk score of 51.9% (

Table 3-2). Approximately 83.2% of their isolated residents are classified as potentially having heightened social vulnerability. This calculation is based on the sum of quintile 4 and 5 in Figure 3-17. Thames-Coromandel District has the population with the next highest potential social vulnerability as a proportion of their total population (risk score of 47.4%). Approximately 60.5 % of their isolated residents are classified as being potentially highly vulnerable.

The next highest ranked TAs with the highest proportion of isolated residents classified as having heightened social vulnerability, as a proportion of their total population are:

- Buller District - 38.4% risk score (95.4% are classified as having heightened social vulnerability).

- Napier City - 35.1% risk score (67.6% of their isolated residents are classified as having heightened social vulnerability)
- Kaipara District - 29.4% risk score (71.5% of their isolated residents are classified as having heightened social vulnerability)

The risk scores for all top 20 ranked TAs are available in Appendix D.

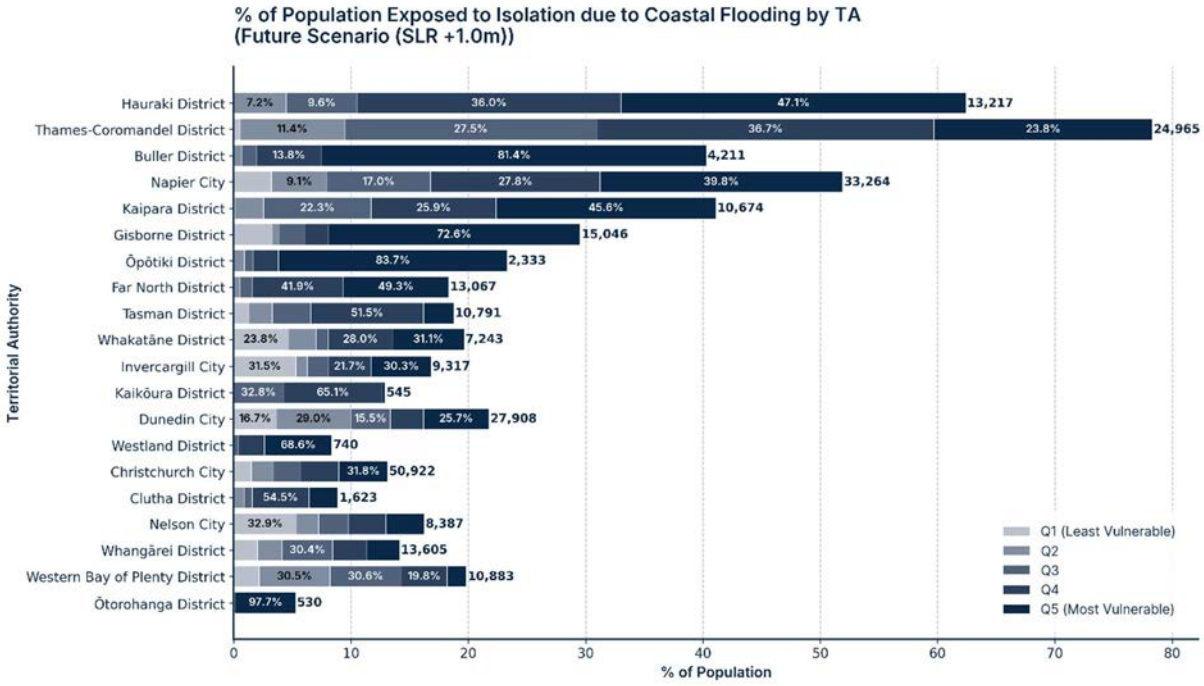

Figure 3-17 This graph shows the total percentage of residents isolated due to sea-level rise under 1.0m SLR, by TA. For each TA, the quintiles Q4 and Q5 show what percentage of isolated residents are considered to have heightened social vulnerability. The TAs are ranked by risk score i.e. which have the highest proportion of their total population that are both at risk of isolation and potentially have heightened social vulnerability to 1% AEP coastal flooding. The risk scores for the top 20 ranked TAs are available in Appendix D.

Figure 3-18 shows how the four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) contribute to the SHVI, as it relates to isolation under 1.0m of sea-level rise. As under previous scenarios, none of the people, health and community categories clearly dominate, with the exception of Kaikōura District. For Kaikōura, the mental health (32%), physical health (28%) and social cohesion (27%) people, health and community categories are larger compared to the equity category (13%). The overall trends by people, health and community category are:

- Physical health ranges from 18% (Dunedin City) to 29% (Invercargill City)
- Mental health ranges from 23% (Gisborne District) to 32% (Kaikōura District)
- Social cohesion, community and cultural wellbeing ranges from 25% (Buller and Clutha Districts) to 32% (Whangārei District)
- Equity ranges from 13% (Kaikōura District) to 26% (Dunedin City).

For the five TAs with the highest risk scores:

- **Hauraki District:** Mental health has the largest contribution (28%) while equity has the lowest (21%)
- **Thames-Coromandel District**: Mental health and social cohesion continue at 30% each, while equity remains at 18%.
- **Buller District**: Mental health continues to have the largest share (27%), and equity the smallest (22%)
- **Napier City**: Social cohesion (28%) has a slightly greater share, compared to equity and physical health (both 23%)
- **Kaipara District**: Social cohesion (28%) has the largest contribution, compared with equity (21%)

A further breakdown of the relative contribution of the indicators within each bundle can be found in Appendix E.

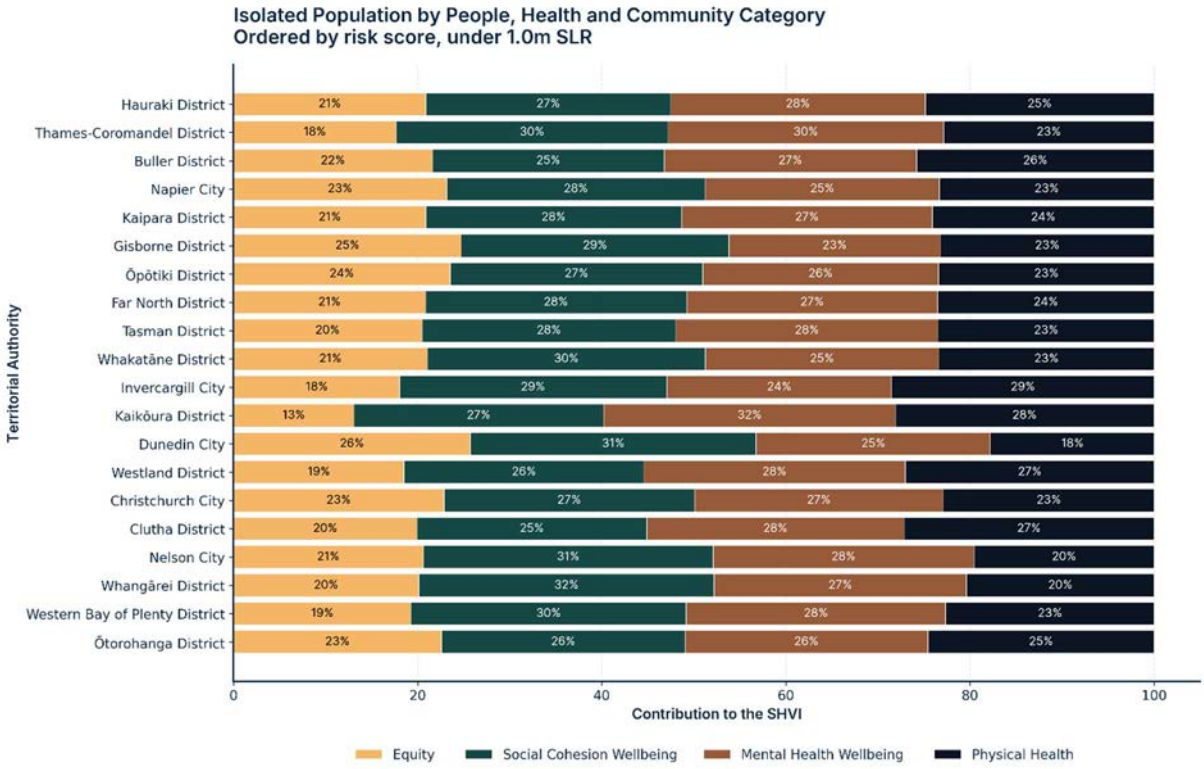

Figure 3-18 This figure demonstrates the relative contribution of the people, health and community categories to the outcomes and sensitivities of the populations with heightened social vulnerability due to isolation to 1% AEP coastal flooding (quintiles 4 and 5) under 1.0m SLR (i.e. contribution to the SHVI). The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

3.2.7 Social Vulnerability Trends for Isolation

As sea levels rise, more people across Aotearoa New Zealand will be potentially isolated (cut off from the services that enable day to day life) as a result of 1% AEP coastal flooding. At present 2.8% or more than 142,000 residents could be isolated. At 0.2m SLR this increases to 3.7% of the population (183,000 people), increasing again to 4.8% (237,900 people) at 0.5m SLR, to 7.4% (368,000 people) at 1.0m SLR, and 10.7% (528,000 people) at 2.0m SLR.

Around half of those potentially isolated at the national scale are classified as having potentially higher social vulnerability (quintiles 4 and 5) due to factors that may make them more sensitive to harm. Of the residents who are potentially isolated by a 1% AEP coastal flood under present-day conditions (0.0m SLR), approximately 68,100 (47.9%) have higher potential social vulnerability. For future increments of sea-level rise, these figures increase to 88,900 people (48.6% of those isolated) under 0.2m SLR; 122,600 people (51.6% of those isolated) under 0.5m SLR; 188,200 people (51.1% of those isolated) under 1.0m SLR; 266,100 people (50.3% of those isolated) under 2.0m SLR.

Thames-Coromandel District has the highest proportion of their total population at risk of isolation due to coastal flooding, under present-day conditions and across the 0.2m SLR, 0.5m SLR, and 1.0m SLR increments. Under present-day conditions, 49% of their total population are at risk of isolation. This increases to 65.4% at 0.2m SLR, then to 77.9% at 0.5m SLR, and a smaller increase to 78.3% at 1.0m SLR. For present-day conditions and 0.2m of SLR the percentage of Thames-Coromandel District's population isolated is more than double that of any other TA.

Other trends include:

- **Kaipara and Buller District and Napier City** are consistently in the top four TAs with the highest percentage of potentially isolated populations for present day, 0.2m and 0.5m SLR. For 1.0m SLR they remain in the top 5, displaced by Hauraki District
    - Napier City: present day - 19.1% (12,230 people), 0.2m - 24.9% (15,966 people), 0.5m - 41.1% (26,339 people), 1.0m - 51.9% (33,264 people)
    - Buller District: present day - 18.3% (1,914 people), 0.2m - 25% (2,612 people), 0.5m - 34.5% (3,609 people), 1.0m - 40.3% (4,211 people)
    - Kaipara District: present day - 25.5% (6,634 people), 0.2m - 25.7% (6,687 people), 0.5m - 26.1% (6,779 people), 1.0m - 41.1% (10,674 people).
- For both **Napier City and Buller District** the percentage of the population potentially isolated by coastal flooding more than doubles from present day to 1.0m SLR
- **Hauraki District** becomes the TA with the second highest percentage of their population (62.4%, approximately 13,217 people) potentially isolated by a 1% AEP coastal flood at 1.0m of SLR.

Thames-Coromandel District, Buller District, and Napier City *consistently have the populations with the highest potential social vulnerability as a proportion of their total population. These TAs have the top 3-4 risk scores out of all TAs as SLR occurs over time (*

Table 3-2). That is to say, they have the highest proportion of their total population that are both isolated and potentially have heightened social vulnerability. Therefore, they may have the highest community-level burden of harm arising from isolation due to coastal flooding. **Kaipara District** is consistently in the top 6, while **Hauraki District** has the highest risk score (51.9%) with 1.0m SLR. Key trends include:

- **Thames-Coromandel District** residents are particularly affected by isolation associated with 1% AEP coastal flooding, with a SHVI of at least 10% higher than any other TA for present conditions (0.0cm SLR), 0.2m and 0.5m SLR. The risk score increases over SLR increments with a difference of 7.1% between present day and 0.2m SLR, then 11.8% between 0.2m and 0.5m. However, there is only a small change (0.3%) between 0.5m and 1.0m.
- **Buller District and Napier City's** risk scores more than double as sea levels rise from present day (0.0m) to 1.0m. The largest increase in SHVI (a change of from 17.8% to 32.1%) for Napier is between 0.2m and 0.5m, while Buller has a more consistent increase over the SLR increments.
- **Hauraki District** experiences a significant increase (from 7.9% to 51.9%) in SHVI between 0.5m and 1.0m SLR, rising to the top of the table. This is the single largest change of all the TAs.
- **All risk scores of the top ten TAs** increase over time as sea levels rise.

The sensitivities contributing to, and the outcomes associated with, social vulnerability resulting from isolation are diverse and not limited to simply physical health impacts. In general, for populations potentially

isolated due to 1% AEP coastal flooding, none of the four people, health and community categories (physical health, mental health, equity, and social cohesion, community and cultural wellbeing) clearly dominated. Similar to direct exposure, the mental health and social cohesion, community and cultural wellbeing categories tended to make up the greater share of factors associated with vulnerability, and systemic inequities (equity category) the lesser share. Once again, this shows that adaptation responses focused solely on physical health and/or mental health impacts and drivers are unlikely to be effective.

Table 3-2 This table shows the TAs ranked by risk score i.e. which have the highest proportion of their total population that are both at risk of isolation and potentially have heightened social vulnerability to 1% AEP coastal flooding (i.e. categorised as Q4 or Q5). The risk score is presented as a percentage in brackets next to each TA's name. Rankings are shown under present day (0.0m SLR), 0.2m SLR, 0.5m SLR, and 1.0m SLR to be able to demonstrate any changes over time. The arrows indicate a shift in the ranking of a TA relative to other TAs, not necessarily an increase or decrease in their risk score over time.

Isolation Risk Score Rankings by Territorial Authority

Legend | ↑ New entry or significant change | ↓ Decreased ranking position

Present Day	0.2m SLR	0.5m SLR	1.0m SLR
Thames-Coromandel District (28.2%)	Thames-Coromandel District (35.3%)	Thames-Coromandel District (47.1%)	Hauraki District (51.9%) ↑
Buller District (17.1%)	Buller District (23.7%)	Buller District (33.2%)	Thames-Coromandel District (47.4%) ↓
Napier City (15.3%)	Napier City (17.8%)	Napier City (32.1%)	Buller District (38.4%) ↓
Far North District (14.4%)	Far North District (14.9%)	Ōpōtiki District (16.3%) ↑	Napier City (35.1%) ↓
Kaipara District (14%)	Kaipara District (14.2%)	Far North District (15.2%) ↓	Kaipara District (29.4%) ↑
Kaikōura District (7.4%)	Ōpōtiki District (8.4%) ↑	Kaipara District (14.5%) ↓	Gisborne District (23.5%) ↑
Ōpōtiki District (6.4%)	Hauraki District (7.8%) ↑	Tasman District (11%) ↑	Ōpōtiki District (21.7%) ↓
Whangārei District (5.3%)	Whakatāne District (7.7%) ↑	Whakatāne District (9.4%)	Far North District (16.7%) ↓
Ōtorohanga District (5.2%)	Kaikōura District (7.7%) ↓	Kaikōura District (8.2%)	Tasman District (12.2%) ↓
Wairoa District (3.9%)	Invercargill City (6.8%) ↑	Hauraki District (7.9%) ↓	Whakatāne District (11.6%) ↓

3.3 Ability of Emergency Management System to Respond

In this assessment, we have included indicators that seek to understand which groups may experience heightened social vulnerability if they become isolated from their wider community as a result of coastal flooding. This includes isolation from emergency management system services, such as evacuation centres, emergency assistance services (e.g. food, temporary accommodation services), as well as the ability to be reached by first responders. For example, those with physiological risk factors are likely to be

disproportionately affected if they become isolated from emergency services. As another example, those without enough food or water to cope with a shortage are likely to be particularly stressed if they are unable to access food assistance services.

Additional insights into the capacity of the emergency management system and its ability to respond are needed to supplement the vulnerability assessment undertaken here. The National Infrastructure Exposure & Property Isolation Assessment [19] that complements this report provides an assessment of how coastal flooding may affect core asset types that form part of the emergency management system – fire stations, hospitals, marae, and primary schools (the latter of which can serve as evacuation centres). This includes their exposure to coastal flooding, and whether residential properties become cut off from these critical assets due to impacts on the transport network.

Further consideration should also be given to understanding the preparedness and capacity of governance systems to plan for, manage, and adapt emergency responses and undertake longer-term adaptation planning to respond to increasing coastal flood risk over time. This is likely to require additional indicators specifically tailored to emergency response capacity which, for example, could draw on assessment criteria adopted in the Civil Defence and Emergency Management (CDEM) Capability Assessment Tool [30].

3.4 Social Infrastructure and Community Services

Similarly to emergency management system capacity, we have considered coastal flood risk to social infrastructure and community services from the perspective of who may experience heightened social vulnerability if they are unable to access these services. For example, children may be particularly affected if they are unable to access school due to isolation, disrupting their sense of routine and limiting their ability to connect with their social networks.

The National Infrastructure Exposure & Property Isolation Assessment [19] provides additional insights into how social infrastructure and community services may become compromised due to exposure to coastal flooding, or cut off from residents. However, it focuses on a sub-set of these with available national data (marae, primary schools, hospitals), and therefore assessment of a much wider range of social infrastructure and services at the regional or local level offers the potential for greater context-specific insights. Other important social infrastructure and community services which would be useful for inclusion in assessments of exposure and isolation at local or regional levels include primary healthcare services, high schools, tertiary education facilities, childcare facilities, social housing, aged care facilities, and sports and recreation facilities, for example.

3.5 Limitations and Considerations

Limitations of the approach employed in this report fall into two broad categories: data and methodological limitations. They both represent current limits of practice, and highlight why quantitative, indicator-based assessments of social vulnerability should be used to provide high-level insights rather than as the sole basis for decision-making.

3.5.1 Data Limitations

Data availability and currency: Data used in this report were from available national datasets, which restricts the indicators we can use. This means that the bundles of indicators may not include all the metrics deemed useful in the social vulnerability literature, because the information is either not collected or available at the required scale in Aotearoa New Zealand. For example, we have used proxies such as older age and measures of poor housing quality as indicators of poorer health outcomes, as health data can be difficult to access at the local level. Further, there are important populations who have not been explicitly included in this assessment due to limitations of data availability at the required scale, and public availability. This includes local-level spatial data about people experiencing homelessness, tourists, and people experiencing domestic violence. While some of these limitations on data availability exist for valid reasons, such as protecting confidentiality, relying primarily on quantifiable and spatially mappable data can risk overlooking populations with potentially heightened social vulnerability in planning and decision-making.

More detailed and nuanced indicators are available for some councils at various scales, but these are not universally collected. For example, some councils collect local information with a greater breadth of social indicators through the Quality of Life Survey [7], but we have not used these because they are not nationally consistent and would confuse any hot spot analysis. The use of 2023 census data, while the most recent available for this study, may not fully reflect current or emerging demographic patterns. One-off national scale surveys also provide useful potential indicators, but they are snapshots in time and may date rapidly as the social context changes. We have not included indicators from one-off surveys because they may not be conducted in the future which will affect the reproducibility of our method. Future studies should prioritise using the most up-to-date data available but be mindful of the need for indicators that will be periodically updated. An additional challenge going forward is likely to be the replacement of the census from 2030 with new data collection methods that rely on using existing routinely collected datasets and a smaller annual survey [31].

Hazard data layers: The hazard datasets used are the most complete and nationally consistent available, but they lack local context. For example, they do not account for existing protective measures (e.g. seawalls), which may lead to an overestimation of inundation in some areas. However, excluding these structures also highlights the importance of their maintenance and the potential consequences of their failure. In addition, the coastal flooding layers provide only extent data, not depth. This means we can identify where exposure occurs, but not the severity of flooding. As a result, we adopt a conservative assumption that any property or road intersecting the flood extent is treated as compromised.

Event frequency: Our focus on 1% annual exceedance probability (AEP) events provides insight into severe coastal floods, but this should not be interpreted as meaning they are unlikely to occur. A 1% AEP flood has roughly a one in four chance of occurring within a 30-year period, so while low-probability in any given year, such events are not rare over the timeframes relevant for households, infrastructure, and planning. At the same time, this focus does not capture the cumulative impacts of more frequent, lower-intensity events. Moreover, the 1% return period does not reflect potential changes in event frequency as the climate warms. Altered storm patterns and intensities could make what is currently a 1% AEP event occur more often in the future. Event frequency is also relevant when comparing exposure and isolation: communities are generally more tolerant of short-term isolation than of direct inundation. Assessing isolation against more frequent benchmarks, such as Mean High Water Spring (MHWS), would highlight where regular service disruption could impose significant burdens on residents.

Spatial resolution of the data sets: Both hazard and social data have a fixed spatial scale. For example, the census data is not available at the individual household level (for justifiable confidentiality reasons) which means that we employ a dasymetric model that distributes people to households. This adds a layer of assumptions to the data which may not reflect the on-the-ground reality.

Assumptions about location of people: This analysis uses census data on the usually resident population, which reflects where people live rather than where they may be located at the time of a flood. This approach is appropriate for a climate risk assessment, since it focuses on long-term exposure and vulnerability at the household level. However, it means the analysis primarily captures the disruption, burden, and potential trauma associated with impacts to people's homes, rather than to other important places such as workplaces, schools, or amenities. As such, the wider consequences of coastal flooding for daily mobility and activity spaces are not fully represented here.

Assumptions about isolation of people: For the purposes of this assessment, people are considered at risk of isolation if no publicly accessible driving route exists between their residential property and the three representative community facilities (fire stations, hospitals, and primary schools) as a result of coastal flooding. In other words, residents are classified as isolated only if access to all three facilities is lost; if even one remains reachable, they are not considered isolated. These facilities are used as representative community hubs that are typically colocated with other essential services. This approach provides a consistent national measure, but it is conservative: residents may still lose access to many other important services and amenities even if one of the three facilities remains accessible.

3.5.2 Methodological Limitations

Deficit approach to vulnerability: Many of the indicators used in social vulnerability analysis focus on sensitivity rather than adaptive capacity, which results in a negative framing of how people experience and

respond to exposure to a hazard. Adaptive capacity can be underestimated or poorly represented, leading to an overestimation of vulnerability. In reality, people and communities who fall within categories of being 'more vulnerable' may nonetheless have skills, knowledge and networks that are a source of resilience compared to others. Of course, while adaptive capacity does need to be recognised, we need to remain cognisant of the structural and/or physical factors that shape the way people experience hazards and change.

Temporal Snapshot: This analysis provides a snapshot based on current data and models, the existing location of assets, and static demographics with no population change, despite the 100-year timeframes. Given the dynamic nature of climate risks and societal changes (including population and land use projections), regular updates will be necessary to maintain the relevance and accuracy of the findings. Methodological improvements in risk and vulnerability assessments will bring future advances that better account for the dynamic nature of vulnerability over time.

Siloing forms of wellbeing: Splitting social vulnerability into different forms of wellbeing, while useful to some degree, also risks ignoring the highly interconnected and holistic nature of wellbeing. For example, dividing aspects of wellbeing into distinct categories can downplay the ways in which physical and mental health directly affect one another, or how individuals' inequitable experiences of harm ultimately affect community wellbeing overall. Recognising and finding alternative ways to capture the complex, interconnected relationships that influence wellbeing will be important for gaining a more holistic understanding of vulnerability.

Statistical Aggregation Choices: As described in Section 2, methodological decisions such as the use of principal component analysis (PCA) for bundles with ≥4 indicators, equal weighting across bundles and categories, and the use of quintiles (4–5) to represent high vulnerability influence how results are expressed. These choices are consistent with other vulnerability indices. Alternative approaches, such as expert-derived weightings, data-driven weights across all levels, or different cut-offs (e.g. tertiles or deciles), could be applied in other contexts. Future refinements may explore the sensitivity of results to these methodological decisions.

Vulnerability is not limited to specific groups: While the social indicators included in this assessment are informed by evidence about which groups are likely to be more sensitive to hazards, the findings should not be misinterpreted to say that communities can be divided into 'vulnerable' and 'not vulnerable' categories. Binary conceptualisations of vulnerability miss how disasters affect entire communities, creating ripple effects that extend far beyond initially impacted areas. While it is essential to recognise the ways in which some groups are more sensitive to harm due to social, political, and economic factors, when the focus is too narrowly on pre-identified groups, it risks creating a false representation of security for everyone else. The reality is that new vulnerabilities may be created across communities as the climate and societal conditions change.

These limitations do not undermine the findings presented in this report but rather provide important context for interpretation and application. They strongly highlight the need for ongoing research, refinement of understandings of vulnerability, and on-going monitoring. They also strongly highlight the importance of not relying solely on indicators to inform understandings of who may experience heightened social vulnerability to coastal flooding, and where they are located.

The dynamic nature of this field emphasises the importance of viewing this report as part of an ongoing process of risk assessment and adaptation planning, rather than a final statement. Regular updates, reassessments, and ground truthing of findings will be essential to ensure that decision-makers have the most current and accurate information to guide their strategies for climate resilience.

3.6 Implications and Future Analysis

Our analysis provides several important implications for adaptation planning and future risk analysis.

Adaptation implications

- Communities are already exposed or isolated by 1% AEP coastal flooding under present-day conditions (0.0m SLR). Adaptation actions are therefore needed in the short term for certain locations.

- Several communities are disproportionately at risk, with a significant portion of the exposed or isolated population falling into higher vulnerability groups. Adaptation strategies must account for this and be designed to avoid worsening their circumstances.

- Adaptation to coastal flooding will be required for substantial portions of some communities, which will add complexity to local adaptation planning processes.

- Adaptation must consider the diversity of reasons for vulnerability, rather than focusing narrowly on physical health as a source of vulnerability or as the sole type of negative outcomes that people will face. In short, adaptation actions that fail to engage with the breadth of likely needs are unlikely to be effective.

- To avoid maladaptation, coastal flooding should be considered alongside other hazards (e.g. river flooding), recognising the potential for compounding or cascading effects as well as identifying co-benefits from action.

Future analysis

Climate change risk is a dynamic and rapidly evolving field, and new hazard models are continually being developed, risks are changing due to climate change, and demographics are in flux. This underscores the need for ongoing research and reassessment.

Future analysis should focus on:

- Regular updates: Risk assessments must be refreshed as new hazard models, demographic data, and infrastructure information become available. This ensures risk trajectories can be monitored and acted upon before they reach intolerable levels.

- Aggregation of Local Assessments: Future work would benefit from aggregating locally-specific district and regional assessments into a national picture, rather than relying solely on nation-wide datasets. This approach could provide more nuanced, locally-relevant insights while maintaining a comprehensive national overview. This requires consistent approaches to risk assessment around the country. Aggregating local assessments would likely improve the feasibility of using hydrodynamic (instead of bathtub) flood models and incorporating protective structures.
- Expanded Hazard Analysis: While this assessment has focussed on coastal flooding, incorporating a wider range of hazard types, return periods and any data updates would offer a more comprehensive understanding of risk. Incorporating a range of return periods would help capture the impacts of more frequent, lower-intensity events that can have significant cumulative effects on communities and infrastructure.
- Dynamic Population Projections: Incorporating projections of population dynamics in coastal areas could offer valuable insights for long-term planning, acknowledging potential shifts in exposure due to migration or retreat. At present exciting population data is projected forwards into the future, which is unlikely to be accurate. Integration of changing population and assets will be challenging but increase the plausibility of future risk and vulnerability.
- A Systems Approach to Risk:
- Further consideration of cascading risk and the intersectionality of different forms of vulnerability would also enhance the assessment process.

Overall, this report provides a summary of the best available information with regard to the social vulnerability risk from direct exposure to and isolation from a 1% AEP coastal flood. The findings can inform the National Climate Change Risk Assessment (NCCRA), the next National Adaptation Plan (NAP), and the

National Adaptation Plan Progress Assessment (NAPPA), supporting both immediate and long-term adaptation decisions.

04

Glossary

4. Glossary

Term	Definition
Adaptive Capacity	The ability of systems, institutions, humans, and other organisms to adjust to potential or actual climate impacts, take advantage of opportunities, or respond to consequences. This includes access to resources, information, skills, and social networks that enable adaptation actions.
AEP	Annual Exceedance Probability. The probability that an event of a certain size will occur in a given year. Note that a 1% AEP event has approximately a 1-in-4 chance of occurring within a 30-year period.
Dasymetric modelling	A spatial analysis technique that redistributes aggregate population data (available at census boundaries like Statistical Area 1) to more precise locations based on spatial information about where people actually live based on the location of residential property.
Direct Risk	Risk that arises when an element of value is directly exposed and vulnerable to a specific hazard or change.
Exposure	The state or condition of being subjected to or encountering a risk source, which can occur in a binary manner where one is either exposed or not, or in a continuous manner where the level or intensity of exposure varies.
Hazard	A type of risk source generated from a natural or human-induced event or trend that has the potential to cause consequences.
Indirect Risk	Risk that emerges not from direct exposure to a hazard, but as a secondary consequence when directly affected elements impact other connected elements, systems, or services.
Isolation	The state of property temporarily or permanently losing access to essential services (e.g. schools, hospitals, fire stations) due to hazard/change impacts on the transportation network or other essential infrastructure e.g. power supply.
NAP	National Adaptation Plan
NAPPA	National Adaptation Plan Progress Assessment
NCCRA	National Climate Change Risk Assessment
New Zealand Deprivation Index (NZDep)	An area-based index of socioeconomic deprivation based on census information, with 1 representing the least deprived areas and 10 representing the most deprived areas. It includes measures of income, unemployment, education, internet access, home ownership, overcrowding, support, and housing quality.
Populations Experiencing Heightened	Population groups with characteristics that are traditionally assumed to represent a higher sensitivity to events and/or a lower adaptive capacity or ability to cope with and respond to events. It is important to note that

Social Vulnerability	sensitivity to events and low adaptive capacity are not limited to populations traditionally considered to be 'vulnerable', as all areas of society are impacted by events in some way, and vulnerability is a fluid, dynamic state rather than an innate trait.
Resilience	The capacity of social, economic, and environmental systems to absorb disturbances and reorganise while maintaining essential function, identity, and structure, as well as the capacity for adaptation and transformation.
Resilient	A state where a system can withstand, recover from, and adapt to climate hazards and stresses while maintaining its essential functions and structure. A resilient system has sufficiently reduced vulnerability and enhanced adaptive capacity to manage climate risks at levels deemed acceptable by stakeholders.
Risk	The potential for and severity of consequences on things we value in the presence of uncertainty. Risk exists when there is uncertainty about how something we care about might be affected, recognising that different individuals and communities may have diverse priorities and objectives.
Risk Assessment	Systematic process to comprehend the nature of risk, express and evaluate risk, with the available knowledge
Risk Score	The risk score used in this assessment represents the proportion of a TA's total population that are both exposed (or isolated) and may experience heightened social vulnerability. It is presented as a percentage. More specifically, the risk score is a function of both the proportion of a TA's total population that is potentially exposed (or isolated) due to coastal flooding, and the proportion of those exposed (or isolated) who are classified as potentially experiencing heightened social vulnerability (i.e. classified into quantiles 4 and 5 of higher and highest vulnerability). This measure gives insights into which territorial authorities (TA) may have the highest community-level burden of harm arising from exposure or isolation due to coastal flooding.
Risk Source	An action, sub-activity, component, system, or event which alone or in combination with other elements has the potential to give rise to some specified consequences (typically undesirable consequences)
Scenario	A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change, prices) and relationships. Note that scenarios are neither predictions nor forecasts, but rather are used to provide a view of the implications of developments and actions.
Sensitivity	The degree to which a system is affected, either adversely or beneficially, by a hazard or climate-related stimuli.
Sensitivity to Harm	The characteristics and structural influences (including social, political, and economic factors) that may make people or communities more susceptible to harm when exposed or isolated due to a hazard (e.g. health status, housing quality, dependence on climate-sensitive livelihoods, existing experiences of marginalisation).

SHVI	Specific Hazard Vulnerability Index
Social Vulnerability	The likelihood of an individual or social group being affected by (i.e. susceptible to) the adverse impacts of hazards and changes, as influenced by their social, economic, political, and/or cultural positioning within society. Social vulnerability consists of two main components: sensitivity to harm and adaptive capacities. These components are influenced by factors such as socioeconomic status, age, disability, discrimination, social capital, and access to resources.
Vulnerability	A system's susceptibility to negative consequences, encompassing both sensitivity to harm and lack of capacity to cope and adapt.

05

Data Generated

5. Data Generated

Two CSV files containing the results at a national level and at a territorial level have been provided along with the report. This includes the following:

raw_data_nz.csv
This file contains the exposure and isolation results for both the exposed/isolated population and households across all 21 sea-level rise scenarios provided by the hazard model. These results are at a national level and, alongside the overall exposed/isolated total, are also distributed across the five vulnerability quintiles.

raw_data_district.csv
This file contains the exposure and isolation results for both the exposed/isolated population and households across four sea-level rise scenarios (0, 20, 50, and 100 centimetres). These results are at a territorial level, and the results for population are distributed across the five vulnerability quintiles. Further columns are added to show the percentage of the exposed/isolated and total population that are highly vulnerable (contained within the two highest vulnerability quintiles 4-5), which comprises the risk score.

06

References

References

[1] Intergovernmental Panel On Climate Change (IPCC), *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, 1st ed. Cambridge University Press, 2023. doi: 10.1017/9781009325844.

[2] K. Katic, "Social Vulnerability Assessment Tools for Climate Change and DRR Programming: A Guide to Practitioners," United Nations Development Programme, 2017. [Online]. Available: https://www.adaptation-undp.org/sites/default/files/resources/social_vulnerability05102017_0.pdf

[3] S. Barrett, D. Steinbach, and S. Addison, "Assessing vulnerabilities to disaster displacement. A good practice review," International Institute for Environment and Development; UN Office for Disaster Risk Reduction, Working Paper. [Online]. Available: https://www.undrr.org/publication/assessing-vulnerabilities-disaster-displacement-good-practice-review

[4] S. L. Cutter, B. J. Boruff, and W. L. Shirley, "Social Vulnerability to Environmental Hazards," *Social Science Quarterly*, vol. 84, no. 2, pp. 242–261, 2003, doi: 10.1111/1540-6237.8402002.

[5] Centers for Disease Control and Prevention, "Planning for an Emergency: Strategies for Identifying and Engaging At-Risk Groups. A guidance document for Emergency Managers," CDC, First Edition, 2015. [Online]. Available: https://www.cdc.gov/disaster-epidemiology-and-response/media/pdfs/2025/01/atriskguidance_updated.pdf?CDC_AAref_Val=https://www.cdc.gov/nceh/hsb/disaster/atriskguidance.pdf

[6] J. Birkmann *et al.*, "Framing vulnerability, risk and societal responses: the MOVE framework," *Nat. Hazards*, vol. 67, no. 2, pp. 193–211, Jun. 2013, doi: 10.1007/s11069-013-0558-5.

[7] Ipsos, "Rangahau te Korou o te Ora Quality of Life Survey 2024: Topline Report," 2024. [Online]. Available: https://www.qualityoflifeproject.govt.nz/survey-results/

[8] J. Atkinson, C. Salmond, P. Crampton, H. Viggers, and K. Lacey, "NZDep2023 Index of Socioeconomic Deprivation Research Report," University of Otago, Wellington, 31, 2024. [Online]. Available: https://www.otago.ac.nz/wellington/departments/publichealth/research-groups-in-the-department-of-public-health/hirp/socioeconomic-deprivation-indexes-nzdep-and-nzidep-department-of-public-health

[9] EHINZ, "Social vulnerability indicators 2023, June 2025," Environmental Health Intelligence New Zealand, Massey University, Surveillance Report. [Online]. Available: https://www.ehinz.ac.nz/assets/Surveillance-reports/Released_2025/SVI2023-surveillance-report-June2025.pdf

[10] K. Mason *et al.*, "Social vulnerability indicators for flooding in Aotearoa New Zealand: Research report," Environmental Health Indicators Programme, Massey University, 2019. [Online]. Available: https://www.ehinz.ac.nz/assets/Social-Vulnerability-Indicators/Research-report-social-vulnerability-indicators-for-flooding.pdf

[11] K. Mason *et al.*, "Social Vulnerability Indicators for Flooding in Aotearoa New Zealand," *International Journal of Environmental Research and Public Health*, vol. 18, no. 8, p. 3952, 2021, doi: https://doi.org/10.3390/ijerph18083952.

[12] A. J. Nightingale *et al.*, "Beyond Technical Fixes: climate solutions and the great derangement," *Climate and Development*, vol. 12, no. 4, pp. 343–352, Apr. 2020, doi: 10.1080/17565529.2019.1624495.

[13] Department of Internal Affairs Te Tari Taiwhenua, "Vulnerable Communities Exposed to Flood Hazard," Aug. 2022. [Online]. Available: https://www.dia.govt.nz/diawebsite.nsf/Files/Proactive-releases/$file/Vulnerable-Communities-Exposed-to-Flood-Hazard-August-2022.pdf

[14] Climate Change Commission and Urban Intelligence, "Progress report: National Adaptation Plan – Assessing progress on the implementation and effectiveness of the Government's first national adaptation plan," Report, Aug. 2024.

[15] SRA, "Society of Risk Analysis Glossary," 2022. doi: https://www.sra.org/resources.

[16] T. M. Logan, M. J. Anderson, and A. C. Reilly, "Risk of isolation increases the expected burden from sea-level rise," *Nat. Clim. Chang.*, pp. 1–6, Mar. 2023, doi: 10.1038/s41558-023-01642-3.

[17] Ministry for the Environment, "National Climate Change Risk Assessment for New Zealand: Main Report - Arotakenga Tūraru mō te Huringa Āhuarangi o Āotearoa: Pūrongo whakatōpū," Ministry for

the Environment, 2020. [Online]. Available: https://environment.govt.nz/publications/national-climate-change-risk-assessment-for-new-zealand-main-report/

[18] R. Paulik, A. Wild, S. Stephens, R. Welsh, and S. Wadhwa, "National assessment of extreme sea-level driven inundation under rising sea levels," *Front. Environ. Sci. Eng. China*, vol. 10, 2023, doi: 10.3389/fenvs.2022.1045743.

[19] Urban Intelligence, "National Infrastructure Exposure & Property Isolation Assessment," Prepared for He Pou a Rangi Climate Change Commission, Jun. 2024.

[20] M. J. Anderson, L. Brunner, and T. Logan, "Functional Isolation: The compounding burden on community capacity from cascading infrastructure failures and access disruption," *International Journal of Disaster Risk Reduction*, vol. 118, p. 105190, Feb. 2025, doi: 10.1016/j.ijdrr.2025.105190.

[21] EHINZ, "Social vulnerability to the impacts of climate-related hazards in Aotearoa New Zealand," Environmental Health Intelligence New Zealand, Massey University, Wellington, 2024. [Online]. Available: https://www.climatecommission.govt.nz/public/Monitoring-and-reporting/NAPPA-2024/3.a-EHINZ_Social-vulnerability-to-the-impacts-of-climate-related-hazards.pdf

[22] He Pou a Rangi Climate Change Commission, "2026 National Climate Change Risk Assessment." [Online]. Available: https://www.climatecommission.govt.nz/our-work/adaptation/national-climate-change-risk-assessments/2026-national-climate-change-risk-assessment

[23] Stats NZ, "Statistical standard for geographic areas 2023 (updated December 2023)." [Online]. Available: https://www.stats.govt.nz/methods/statistical-standard-for-geographic-areas-2023/

[24] M. Nardo, M. Saisana, A. Saltelli, S. Tarantola, A. Hoffman, and E. Giovannini, "Handbook on constructing composite indicators: Methodology and user guide," OECD, OECD Statistics Working Papers 2005/03, 2005. [Online]. Available: https://www.oecd.org/en/publications/handbook-on-constructing-composite-indicators_533411815016.html

[25] S. Rufat, E. Tate, C. G. Burton, and A. S. Maroof, "Social vulnerability to floods: Review of case studies and implications for measurement," *International Journal of Disaster Risk Reduction*, vol. 14, pp. 470–486, 2015, doi: 10.1016/j.ijdrr.2015.09.013.

[26] E. Tate, "Social vulnerability indices: a comparative assessment using uncertainty and sensitivity analysis," *Natural Hazards*, vol. 63, no. 2, pp. 325–347, Sep. 2012, doi: 10.1007/s11069-012-0152-2.

[27] I. S. Holand, P. Lujala, and J. K. Rød, "Social vulnerability assessment for Norway: A quantitative approach," *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography*, vol. 65, no. 1, pp. 1–17, Mar. 2011, doi: 10.1080/00291951.2010.550167.

[28] J. Atkinson, C. Salmond, and P. Crampton, "NZDep2018 Index of Deprivation User's Manual," University of Otago, 2019. [Online]. Available: https://www.otago.ac.nz/__data/assets/pdf_file/0030/314976/nzdep2018-index-of-deprivation-users-manual-730391.pdf

[29] Victoria University of Wellington, "NZSeaRise: Improved sea-level rise projections for New Zealand to better anticipate and manage impacts." MBIE Endeavour, 2017.

[30] Civil Defence, "CDEM Capability Assessment Tool." [Online]. Available: https://www.civildefence.govt.nz/cdem-sector/monitoring-and-evaluation/cdem-capability-assessment-tool-

[31] S. Reti, "Sharpened focus on quality economic, population stats." [Online]. Available: https://www.beehive.govt.nz/release/sharpened-focus-quality-economic-population-stats#:~:text=From%202030%2C%20New%20Zealand%20will,population%2C%E2%80%9D%20says%20Dr%20Reti.

[32] D. Lowe, K. L. Ebi, and B. Forsberg, "Factors Increasing Vulnerability to Health Effects before, during and after Floods," *International Journal of Environmental Research and Public Health*, vol. 10, no. 12, pp. 7015–7067, 2013, doi: 10.3390/ijerph10127015.

[33] K. Alderman, L. R. Turner, and S. Tong, "Floods and human health: A systematic review," *Environment International*, vol. 47, pp. 37–47, 2012, doi: 10.1016/j.envint.2012.06.003.

[34] L. H. Mallett PhD and P. Etzel MD Ruth A., "Flooding: what is the impact on pregnancy and child health?," *Disasters*, vol. 42, no. 3, pp. 432–458, Jul. 2018, doi: 10.1111/disa.12256.

[35] G. Mor and I. Cardenas, "The immune system in pregnancy: a unique complexity," *American Journal of Reproductive Immunology*, vol. 63, no. 6, pp. 425–433, 2010.

[36] S. Ha, "The Changing Climate and Pregnancy Health," *Current Environmental Health Reports*, vol. 9, no. 2, pp. 263–275, Jun. 2022, doi: 10.1007/s40572-022-00345-9.

[37] E. W. Harville, L. Beitsch, C. K. Uejio, S. Sherchan, and M. Y. Lichtveld, "Assessing the effects of disasters and their aftermath on pregnancy and infant outcomes: A conceptual model," *International Journal of Disaster Risk Reduction*, vol. 62, p. 102415, 2021.

[38] R. Jones, "Climate change and Indigenous Health Promotion," *Global Health Promotion*, vol. 26, no. 3_suppl, pp. 73–81, 2019, doi: 10.1177/1757975919829713.

[39] S. Awatere *et al.*, "He huringa āhuarangi, he huringa ao: A changing climate, a changing world," Manaaki Whenua Landcare Research, Ngā Pae o te Māramatanga, LC3948, 2021. [Online]. Available: https://www.landcareresearch.co.nz/assets/researchpubs/He-huringa-ahuarangi-he-huringa-ao-a-changing-climate-a-changing-world.pdf

[40] Stats NZ, "Quality Statement: Activity limitations - 2023 Census: Information by concept," Stats NZ DataInfo+. [Online]. Available: https://datainfoplus.stats.govt.nz/item/nz.govt.stats/5da0bc5b-49c1-4859-bffb-8257dd053b36

[41] Ministry of Social Development, "Disability language - words matter." [Online]. Available: https://www.msd.govt.nz/about-msd-and-our-work/work-programmes/accessibility/quick-reference-guides/disability-language-words-matter.html

[42] L. Hemingway and M. Priestley, "Natural hazards, human vulnerability and disabling societies: A disaster for disabled people?," *Review of Disability Studies: An International Journal*, vol. 2, no. 3, 2006, [Online]. Available: https://www.rdsjournal.org/index.php/journal/article/view/337

[43] C. J. Gaskin, D. Taylor, S. Kinnear, J. Mann, W. Hillman, and M. Moran, "Factors Associated with the Climate Change Vulnerability and the Adaptive Capacity of People with Disability: A Systematic Review," *Weather, Climate, and Society*, vol. 9, no. 4, pp. 801–814, 2017, doi: 10.1175/WCAS-D-16-0126.1.

[44] J. L. Fanslow, Z. A. Malihi, L. Hashemi, P. J. Gulliver, and T. K. D. McIntosh, "Lifetime Prevalence of Intimate Partner Violence and Disability: Results From a Population-Based Study in New Zealand," *American Journal of Preventive Medicine*, vol. 61, no. 3, pp. 320–328, Sep. 2021, doi: 10.1016/j.amepre.2021.02.022.

[45] A. Gorman-Murray, S. McKinnon, D. Dominey-Howes, C. J. Nash, and R. Bolton, "Listening and learning: giving voice to trans experiences of disasters," *Gender, Place & Culture*, vol. 25, no. 2, pp. 166–187, Feb. 2018, doi: 10.1080/0966369X.2017.1334632.

[46] D. Dominey-Howes, A. Gorman-Murray, and S. McKinnon, "On the disaster experiences of sexual and gender (LGBTI) minorities: insights to support inclusive disaster risk reduction policy and practice," *Australian Journal of Emergency Management*, vol. Monograph No. 3, pp. 60–68, 2018.

[47] K. K. H. Tan, J. M. Schmidt, S. J. Ellis, and J. F. Veale, "Mental health of trans and gender diverse people in Aotearoa/New Zealand: A review of the social determinants of inequities," *New Zealand Journal of Psychology*, vol. 48, no. 2, pp. 64–72, 2019.

[48] Stats NZ, "Quality Statement Rainbow/LGBTIQ+," Stats NZ DataInfo+. [Online]. Available: https://datainfoplus.stats.govt.nz/item/nz.govt.stats/1dd7227f-6199-415a-92fb-5803b2906c4f

[49] S. Fraser, G. S. Leonard, I. Matsuo, and H. Murakami, "Tsunami evacuation: Lessons from the Great East Japan earthquake and tsunami of March 11th 2011," GNS, GNZ Science Report 2012/17, 2012. [Online]. Available: https://mro.massey.ac.nz/server/api/core/bitstreams/8d3da5bb-7f78-4c35-ba00-96eaab413fef/content

[50] D. Blake, D. Johnston, G. Leonard, L. McLaren, and J. Becker, "A Citizen Science Initiative to Understand Community Response to the Kaikōura Earthquake and Tsunami Warning in Petone and Eastbourne, Wellington, Aotearoa/New Zealand," *Bulletin of the Seismological Society of America*, vol. 108, no. 3B, pp. 1807–1817, 2018, doi: 10.1785/0120170292.

[51] A. Li, M. Toll, and R. Bentley, "Mapping social vulnerability indicators to understand the health impacts of climate change: a scoping review," *Lancet Planet Health*, vol. 7, no. 11, pp. e925–e937, 2023, doi: 10.1016/s2542-5196(23)00216-4.

[52] M. Teo, A. Goonetilleke, A. Ahankoob, K. Deilami, and M. Lawie, "Disaster awareness and information seeking behaviour among residents from low socio-economic backgrounds," *International Journal of Disaster Risk Reduction*, vol. 31, pp. 1121–1131, 2018, doi: 10.1016/j.ijdrr.2018.09.008.

[53] World Health Organization, "WHO Housing and health guidelines," World Health Organization, 2018. [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK535293/

[54] Stats NZ, "Housing affordability more challenging for renters than homeowners." [Online]. Available: https://www.stats.govt.nz/news/housing-affordability-more-challenging-for-renters-than-homeowners/#:~:text=Renters%20over%2Drepresented%20in%20poor%20quality%20housing%20l

n,had%20an%20issue%20with%20dampness%20or%20mould%20%20AND%20Stats%20nZ%20https://www.stats.govt.nz/reports/housing-in-aotearoa-new-zealand-2025/

[55] Stats NZ, "Housing in Aotearoa New Zealand: 2025." [Online]. Available: https://www.stats.govt.nz/reports/housing-in-aotearoa-new-zealand-2025/

[56] A. Bentley, "Sticky Rents and The Affordability of Rentals for Housing in New Zealand Ngā Rēti Hāpiapia me te Whaiutu o ngā Whare Noho Rēti i Aotearoa," *New Zealand Population Review*, vol. 47, pp. 145–170, 2021.

[57] Stats NZ, "Housing costs rise, impact felt strongly by renters." [Online]. Available: https://www.stats.govt.nz/news/housing-costs-rise-impact-felt-strongly-by-renters/

[58] M. D. Keall, J. Crane, M. G. Baker, K. Wickens, P. Howden-Chapman, and M. Cunningham, "A measure for quantifying the impact of housing quality on respiratory health: a cross-sectional study," *Environmental Health*, vol. 11, no. 1, p. 33, 2012, doi: 10.1186/1476-069X-11-33.

[59] WHO, "WHO guidelines for indoor air quality : dampness and mould," World Health Organization, Jan. 2009.

[60] P. Howden-Chapman, C. Fyfe, K. Nathan, M. Keall, L. Riggs, and N. Pierse, "The Effects of Housing on Health and Well-Being in Aotearoa New Zealand Ngā Pānga o Ngā Whare Noho ki te Hauora me te Toiora i Aotearoa," *New Zealand Population Review*, vol. 47, pp. 16–32, 2021.

[61] V. A. Naushad *et al.*, "A Systematic Review of the Impact of Disaster on the Mental Health of Medical Responders," *Prehospital and Disaster Medicine*, vol. 34, no. 6, pp. 632–643, 2019, doi: 10.1017/S1049023X19004874.

[62] D. M. Benedek, C. Fullerton, and R. J. Ursano, "First responders: mental health consequences of natural and human-made disasters for public health and public safety workers," *Annual Review of Public Health i*, vol. 28, pp. 55–68, 2007, doi: 10.1146/annurev.publhealth.28.021406.144037.

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Appendices

Appendix A – Data Sources

Table A-1 Data sources.

Name	Indicators	Source	Link/URL	Date Created/ Updated
NZ Properties National District Valuation Roll	N/A	Toitū Te Whenua Land Information New Zealand	https://data.linz.govt.nz/table/113969-nz-properties-national-district-valuation-roll-restricted-access/	
Fire Stations (New Zealand)	N/A	Fire and Emergency NZ	https://www.fireandemergency.nz/find-a-station/	31/01/2024
Hospitals (New Zealand)	N/A	Toitū Te Whenua Land Information New Zealand	https://data.linz.govt.nz/layer/105588-nz-facilities/	29/05/2025
Schools (New Zealand)	N/A	Toitū Te Whenua Land Information New Zealand	https://data.linz.govt.nz/layer/105588-nz-facilities/	29/05/2025
2023 Census - Individuals Part 1 (SA1)	Ethnicity (Māori only), Age (0-14), No English, Older age (65 and older), Disability, Non-European Ethnicity (Māori,	Stats NZ Tatauranga Aotearoa	https://datafinder.stats.govt.nz/layer/120766-2023-census-totals-by-topic-	19/12/2024

	Pacific Peoples, MELAA, Asian)		for-individuals-by-statistical-area-1-part-1/	
2023 Census - Individuals Part 2 (SA1)	New to neighbourhood (Years at Residence under 1 year), People aged 15–64 years without any qualifications, People aged 15- 64 unemployed, People aged 15 years and older not in the labour force, People aged 15-64 receiving a main means tested benefit, Single-person household, LGBTIQ+ adults over 15, Industry - Health Care and Social Assistance, Industry - Public Administration and Safety, Industry - Agriculture, Forestry and Fishing	Stats NZ Tatauranga Aotearoa	https://datafinder.stats.govt.nz/layer/120792-2023-census-totals-by-topic-for-individuals-by-statistical-area-1-part-2/	19/12/2024
2023 Census - Families (SA1)	Single-parent household	Stats NZ Tatauranga Aotearoa	https://datafinder.stats.govt.nz/layer/120760-2023-census-totals-by-topic-for-families-and-extended-families-by-statistical-area-1/	19/12/2024
2023 Census - Households (SA1)	No access to internet, No access to mobile phone, No vehicle, Household crowding index - crowded	Stats NZ Tatauranga Aotearoa	https://datafinder.stats.govt.nz/layer/120765-2023-census-totals-by-topic-for-households-by-statistical-area-1/	19/12/2024
2023 Census - Dwellings (SA1)	Access to basic amenities - Dwellings with no access to a fridge (among total dwellings stated), Access to basic	Stats NZ Tatauranga Aotearoa	https://datafinder.stats.govt.nz/layer/120759-2023-census-totals-by-topic-	19/12/2024

	amenities - Dwellings with no access to electrical supply (among total dwellings stated), Access to basic amenities - Dwellings with no access to tap water that is safe to drink, Dwelling damp [always, sometimes], Dwelling mouldy [always, sometimes]		for-dwellings-by-statistical-area-1/	
2023 Census - Individuals Part 2 (SA2)	Years since arrival in New Zealand (0) (Recently arrived migrants)	Stats NZ Tatauranga Aotearoa	https://datafinder.stats.govt.nz/layer/120898-2023-census-totals-by-topic-for-individuals-by-statistical-area-2-part-2/	19/12/2024
2023 Census - Households (SA2)	Sector of landlord - total households in rented occupied private dwellings (Renters)	Stats NZ Tatauranga Aotearoa	https://datafinder.stats.govt.nz/layer/122391-2023-census-housing-data-by-statistical-area-2/	19/12/2024
2023 Census - Households with Children (Aged 0-18) (SA2)	Households with Children (Aged 0-18)	Stats NZ Tatauranga Aotearoa	https://explore.data.stats.govt.nz/vis?fs[0]=2023%20Census%2C0%7CFamilies%20and%20households%23CAT_FAMILIES_AND_HOUSEHOLDS%23&pg=20&fc=2023%20Census&bp=true&snb=78&df[ds]=ds-nsiws-disseminate&df[id]=CEN23_FHH_019&df[ag]=STATSNZ&df[vs]=1.0&dq=2023.9999%2B99999%2B999999.77%2B131%2B133%2B134%2B136%2B141%2	2023

			B143%2B144%2B146%2B151%2B153%2B154%2B156%2B161%2B163%2B164%2B166%2B211%2B213%2B214%2B216%2B221%2B223%2B224%2B226%2B231%2B233%2B234%2B236%2B242%2B244%2B245%2B247%2B312%2B314%2B315%2B317%2B99.99&ly[rw]=CEN23_GEO_013&ly[cl]=CEN23_HUH_002&to[TIME]=false	
2023 Census - Age (Less than 1 year) (SA2)	Age (Less than 1 year) (proxy for Pregnant population)	Stats NZ Tatauranga Aotearoa	https://explore.data.stats.govt.nz/vis?fs[0]=2023%20Census%2C0%7CPopulation%20structure%23CAT_POPULATION_STRUCTURE%23&fs[1]=Age%2C3%7CTotal%20-%20age%2399%23%7CUnder%2015%20years%231%23%7C0-4%20years%2301%23%7CLess%20than%20one%20year%23000%23&pg=0&fc=Age&snb=7&df[ds]=ds-nsiws-disseminate&df[id]=CEN23_POP_001&df[ag]=STATSNZ&df[vs]=1.0&dq=2013%2B2018%2B2023.9999%2B999999.999.99%2B000.99&ly[rw]=CEN23_GEO_007&ly[cl]=CEN23_YEAR_001%2CCEN23_AGE_001&to[TIME]=false	2023

2023 Census - Households with Equivalised Income $55,000 and Below (SA2)	Households with Equivalised Income $55,000 and Below	Stats NZ Tatauranga Aotearoa	https://explore.data.stats.govt.nz/vis?tm=equivalised%20income&pg=0&hc[2023%20Census]=Income&snb=6&vw=ov&df[ds]=ds-nsiws-disseminate&df[id]=CEN23_FHH_020&df[ag]=STATSNZ&df[vs]=1.0&dq=2023.01%2B9999%2B99999%2B999999.11%2B12%2B13%2B14%2B15%2B16%2B17%2B18%2B19%2B20%2B99%2B777%2B999.9999.999.99&ly[rw]=CEN23_GEO_002&ly[cl]=CEN23_EQH_001&to[TIME]=false	2023
Statistical Area 1 Higher Geographies 2023 (generalised)	N/A	Stats NZ Tatauranga Aotearoa	https://datafinder.stats.govt.nz/layer/111237-statistical-area-1-higher-geographies-2023-generalised/	7/12/2022
Extreme Sea-Level Rise Extent (New Zealand)	N/A	National Institute of Water and Atmospheric Research	https://niwa.co.nz/sites/default/files/Coastal%20flood%20mapping%20methodology%20report%20FINAL_0.pdf	18/05/2023
Road Network	N/A	Open Street Map	https://www.openstreetmap.org/#map=2/-41.2/-6.6	

Social vulnerability indicators for 2023 (SA2)	Households with older adult (65+ years) living alone	Environmental Health Intelligence New Zealand	https://www.ehinz.ac.nz/social-vulnerability/social-vulnerability-indicators-for-2023/#changes-in-vulnerability-over-time	2023

Appendix B Social Vulnerability Indicators

The social vulnerability indicators used to construct the bundles are listed in the table below, with an explanation of why they have been included.

Table A-2 Social vulnerability indicators

Indicator	People, Health and Community Categories	Reason for Inclusion
Age 65 years and older	Physical Health Social cohesion, community and cultural wellbeing	Older people are often more at risk of injury, death, and complications from exposure during inundation and in the aftermath of flooding due to a range of reasons [25], [32], [33]. This includes higher susceptibility to disease, increased likelihood of having existing health conditions, and difficulties with mobility. This can influence their ability to evacuate, but also to access essential goods, services and social networks following an event. Their reliance on others to assist them to evacuate or undertake recovery activities may be higher, particularly the older they are. Older adults who live alone and have limited social networks may be particularly at risk during and following an event, both in terms of their physical and mental wellbeing.
Age 0-14	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing Social cohesion, community and cultural wellbeing	Children aged 14 years and under are generally at greater risk during flooding events due to their smaller stature and increased susceptibility to physical health impacts such as injuries, drowning, hypothermia and infectious diseases when compared with adults [34]. Children may have difficulties evacuating and be reliant on adults to assist. They may also be particularly affected by disruptions to their usual routine or displacement, including if they are unable to connect with their usual social support networks at school or childcare facilities. Children are also at greater risk of family violence following an event when others' stress levels are heightened.
Age - Less than 1 year old (proxy for pregnant women)	Physical Health	Used as a proxy for pregnancy. Pregnant women may experience greater risk during a coastal flood, due to potential difficulty in evacuating in a timely manner without assistance. Pregnant women are also at risk of pregnancy complications, and may have modulated immune system response which increases their risk of infectious disease (e.g.

		waterborne illness due to contact with contaminated water) [35], [36]. They may also already be at heightened risk of domestic violence, which can be exacerbated during times of stress following a flood event [37].
Ethnicity (Non-European)	Equity Social cohesion, community and cultural wellbeing	Those who do not identify as European are already more likely to experience systematic health, social, political, economic inequities arising from discrimination, bias and marginalisation [33], [38]. These inequities are likely to be exacerbated during or following a coastal flooding event as further strains are placed on the systems that already produce inequitable outcomes. Experiences of discrimination, exclusion and racism may also be exacerbated as a result of increased stress levels within affected communities, undermining social cohesion and community wellbeing.
Ethnicity (Māori only)	Social cohesion, community and cultural wellbeing	Within the 'Cultural Wellbeing' and 'Displacement' bundles of the social cohesion, community and cultural wellbeing category, we included an indicator of Māori ethnicity only, rather than all Non-European ethnicities. As tangata whenua, Māori may disproportionately experience negative effects arising from displacement or the reduced ability to undertake cultural practices due to coastal flooding (e.g. ability to access mahinga kai, access to marae) [39].
Disability	Physical Health Equity Social cohesion, community and cultural wellbeing Mental health, identity, autonomy and sense of belonging and wellbeing	It should be noted that the census data this indicator is based on is not designed to identify all disabled people in the population, and is rated by Stats NZ as being of poor quality due to the census response rates [40]. Disabled people are likely to be at greater risk during a coastal hazard event due to their existing experience of inequities - they are disabled because the existing ways in which society is structured creates obstacles and barriers for them [41], [42], [43]. As a result of these barriers, people with limited physical mobility, physical impairments such as vision or hearing loss, or a learning disability are likely to have increased difficulties evacuating (including receiving or following emergency information). As such, disabled people may be more reliant on the assistance of others to evacuate. They may also be more reliant on others to assist them during the recovery phase or require specialised support that may not always be made available in a timely manner. This may increase their levels of stress and potentially reduce their sense of autonomy. Disabled people are also more likely to have higher levels of income inadequacy, meaning they may require greater financial support to recover

		following an event. When stress levels are high in the community, disabled people can experience increased risk of family violence [44], discrimination and marginalisation.
Rainbow/ LGBTIQ+	Equity Social cohesion, community and cultural wellbeing	Rainbow/LGBTQ+ populations may experience heightened vulnerability due to existing experiences of discrimination, harassment and inequities in healthcare and housing access, for example [45], [46], [47]. In instances where Rainbow/LGBTQ+ populations are displaced from their homes due to flooding, they may experience heightened discrimination or worry when seeking alternative accommodation, staying in evacuation centres, and engaging with certain support services (e.g. faith-based organisations). They may also be more reluctant to seek out support services in the first place, due to concerns they will experience negative treatment. It should be noted that this indicator is rated by Stats NZ as being of poor quality, as alternative data sources were not used, meaning their coverage within the census dataset is lower [48].
Households with older adults (65 years and older) living alone	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing Social cohesion, community and cultural wellbeing	Older adults who live alone and have limited social networks may be at heightened risk both during and following a coastal flooding event if they are reliant on assistance to evacuate, undertake recovery activities (e.g. clean-up), or access the goods and services they need to stay well. They may also be at higher risk of social isolation if they have smaller social networks or are unable to access them as a result of a coastal flooding event.
Single-person household	Mental health, identity, autonomy and sense of belonging and wellbeing Social cohesion, community and cultural wellbeing	Single-person households may experience heightened vulnerability to hazards including coastal flooding for a number of reasons. Single-person households tend to be lower income, making recovery potentially more difficult, and possibly reducing their ability to take preventative measures to reduce their risk in the first place. People living alone may also be less able to access support to evacuate if needed, or to recover following an event unless they have strong social networks they can readily access. This can include the ability to physically undertake activities needed to recover, but also to access the social connections and emotional support needed for mental wellbeing.

Households with children (0-14)	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing Social cohesion, community and cultural wellbeing	Households with children can be delayed in evacuating, as parents and caregivers need to assist children. Parents and caregivers are also likely to travel to pick up children from school or childcare facilities, which can put those adults in harm's way [49], [50]. High concentrations of traffic can also clog roads, making evacuation in those areas more difficult. Following an event, if schools or childcare facilities are closed or inaccessible, this can create stress for parents and caregivers to arrange alternative childcare or take time off work. Children may also experience disruption of daily routine which negatively affects their wellbeing.
Single-parent households	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing Equity	Single-parent households may experience heightened risk [4], [25], for similar reasons to households with children. However, these factors may be experienced even more acutely by single-parent households, given there is only one adult to assist in an emergency or following an event. They may also experience greater difficulties arranging alternative childcare if schools or childcare facilities are not operational or accessible. Single-parent households may also have fewer financial resources to cope following an event which can cause significant stress and reduce their ability to afford essential goods and services.
Households with no access to a private vehicle	Physical Health Social cohesion, community and cultural wellbeing Mental health, identity, autonomy and sense of belonging and wellbeing	Households without access to a private vehicle may be at heightened risk if this prevents the evacuation of people who are otherwise unable to evacuate on foot, or are unable to do so in a timely manner (e.g. people with a physical disability). Following an event, not having a vehicle may also limit people's ability to access goods, services, and other support needed to assist their recovery.
No English	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing	Those who have no or limited English may be at greater risk if they have difficulties understanding hazard information and emergency communications [51], [52]. This can increase their response time if they need to evacuate. Language barriers may also mean people who have limited or no English are less aware of the different forms of support available post-flood and may experience greater challenges in accessing that assistance.

	Social cohesion, community and cultural wellbeing	People who do not speak English may also have smaller social networks which they can draw on for help and emotional support, including potentially having limited ability to share their experiences and feelings with.
Years since arrival in New Zealand (0)	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing Social cohesion, community and cultural wellbeing Equity	Migrants who have recently arrived in the country may have less awareness of what to do during coastal flood events and have less local knowledge of where to go and what assistance may (or may not) be available. Some recently arrived migrants may also experience language barriers, or difficulty navigating bureaucratic processes to receive assistance or insurance pay-outs following an event [4]. Those from different cultures might require access to services that are more appropriate to their cultural needs. Recently arrived migrants might also have less in-country social connections and networks they can draw on for support during and following an event. Where there is increased stress in the wider community, recently arrived migrants from different cultures may be subject to racism or other forms of marginalisation.
New to neighbourhood (Years at Residence under 1 year)	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing Social cohesion, community and cultural wellbeing	People who have recently moved to a neighbourhood may have less awareness of the risk posed by coastal flooding, and less local knowledge about where to go during an event. Newly arrived residents may also have weaker social connections within the area that they are able to draw on to seek help or emotional support.
No access to a mobile phone	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing	Households without a mobile phone may have lower awareness that a coastal flooding hazard is present or predicted, as they may have difficulties receiving emergency alerts or being contacted by others to warn them. Those without a mobile phone may also have less ability to contact emergency services or other people to assist them, especially if they also do not have access to working internet or a landline phone. If they need to leave home, those without a mobile phone may also have reduced ability to access internet services, limiting their ability to get up-to-date information.

No access to the internet	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing	Households without internet access may have lower awareness that a coastal flooding hazard is present or predicted, as they may have difficulties accessing information or receiving news alerts. They may also have greater difficulties accessing information about how to prepare for an emergency event, or what support is available following an event. Without internet access, they may face greater barriers navigating recovery processes such as making an insurance claim or applying for emergency assistance.
Household crowding index - crowded	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing Equity	Those living in crowded households are at greater risk of adverse health outcomes [53], which may be exacerbated by coastal flooding. Household crowding is associated with increased risk of mental stress and the spread of infectious diseases, both of which can be exacerbated following a coastal flooding event. Many crowded households are lower-income, which can reduce their ability to pay for emergency supplies, damage to their property, or to replace flood-affected items.
Sector of landlord - total households in rented occupied private dwellings (Renters)	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing Social cohesion, community and cultural wellbeing Equity	Those living in rental properties are likely to be disproportionately affected following a flood event compared to homeowners, given existing housing and socioeconomic inequities. Rental properties are often lower quality than owner-occupied properties [54], [55]. Therefore, tenants may already be subject to existing conditions that negatively impact their physical and mental wellbeing, for example damp, cold indoor conditions. Tenants are also generally reliant on landlords to make repairs to the property, or to undertake preventative measures to protect the property from floods in the first place. They are also at greater risk of displacement or homelessness as a result of a flood event. Those renting are also typically on lower incomes and have lower income adequacy than owner-occupiers [56], [57], meaning they may have less financial resources to be able to cope following a flood (e.g. being able to afford to replace damaged items or dry out damp housing, being able to take time off work to undertake repairs).
Dwelling damp (always or sometimes)	Physical Health	If damp living conditions are worsened by flooding, this can exacerbate existing health inequities. People living in damp housing are at higher risk of experiencing negative health impacts, particularly

	Mental health, identity, autonomy and sense of belonging and wellbeing Equity	respiratory issues [58]. Poor quality housing conditions can also negatively affect mental wellbeing. Those living in poorer quality housing are more likely to be renters or those experiencing severe housing deprivation. These groups are more likely to be on lower incomes, have less housing security, and less autonomy or ability to make changes to their living environments.
Dwelling mouldy (always or sometimes)	Physical Health Mental health, identity, autonomy and sense of belonging and wellbeing Equity	If the presence of mould indoors is worsened by flooding, this can exacerbate existing health inequities. Similar to damp housing, people living in mouldy homes are at higher risk of experiencing negative health impacts such as respiratory illness [58], [59]. Poor quality housing conditions can also negatively affect mental wellbeing. Those living in poorer quality housing are more likely to be renters or those experiencing severe housing deprivation. These groups are more likely to be on lower incomes, have less housing security, and less autonomy or ability to make changes to their living environments.
People living in households with equivalised income below an income threshold ($55,000 an under)	Physical health Mental health, identity, autonomy and sense of belonging and wellbeing Social cohesion, community and cultural wellbeing Equity	Those living on low-incomes are likely to face greater difficulties preparing for, and responding to, hazards such as coastal flooding [25]. They are less likely to be able to afford to pay for emergency preparedness materials, repairs, or to replace lost or damaged items including essentials such as food and medications. They are also less likely to have insurance cover to assist with financial recovery or to pay for alternative accommodation. In this way, experience of hazardous coastal flooding can compound existing inequities. When people experience financial stress and difficulties paying for the things they need, this can have significant negative impacts on their mental wellbeing, physical health and sense of autonomy.
People aged 15-64 receiving a main means tested benefit	Physical health Mental health, identity, autonomy and sense of belonging and wellbeing Social cohesion, community and cultural wellbeing	Adults receiving a main means tested benefit are likely to be on lower incomes. Therefore, they are more likely to experience difficulties paying for the things they need to prepare for and recover from hazardous coastal flooding. In this way, experience of flooding may exacerbate existing socioeconomic, housing and health inequities for those receiving a benefit. They may also experience stress having to deal with navigating the welfare system, which may be exacerbated if they require additional support following an event. Experiences of social stigma in receiving a welfare benefit may also be worsened,

	Equity	negatively affecting mental wellbeing and sense of belonging.
People aged 15-64 unemployed	Physical health Mental health, identity, autonomy and sense of belonging and wellbeing Social cohesion, community and cultural wellbeing Equity	People who are unemployed (i.e. don't have a paid job but could be working) are likely to have lower incomes and therefore less ability to afford emergency preparedness measures such as preventive works or emergency supplies. Those on low incomes are also more likely to have difficulties paying for post-flood repairs, replacing lost items (including food), or taking time off work to deal with any necessary recovery activities. People on low incomes also tend to have poorer mental and physical health outcomes due to factors such as persistent financial stress, difficulties accessing healthcare services, and a higher likelihood of living in lower quality housing [60].
People aged 15 years and older not in the labour force	Physical health Mental health, identity, autonomy and sense of belonging and wellbeing Social cohesion, community and cultural wellbeing Equity	This indicator encompasses a wide range of people including those in education and training, retired people, people undertaking unpaid housework or childcare, and those with long term sickness, injury or disability. People who are not in the labour force (i.e. are of working age but are neither employed or unemployed) may have lower incomes and therefore less ability to afford emergency preparedness measures or post-event recovery activities. Those on low incomes also tend to have poorer physical and mental health outcomes due to factors such as persistent financial stress, difficulties accessing healthcare services, and a higher likelihood of living in lower quality housing.
People aged 15–64 years without any qualifications	Physical health Mental health, identity, autonomy and sense of belonging and wellbeing	People without qualifications may be disproportionally impacted where low educational attainment corresponds with outcomes such as reduced economic opportunities and income. Those with lower literacy may also have greater difficulties understanding emergency communications or navigating processes to access post-event support or insurance [52].
Dwellings with no access to a fridge	Physical health Mental health, identity, autonomy and sense of	Households without access to a fridge are already likely to have difficulties storing food for prolonged periods of time and therefore have lower emergency supply [21]. This may be worsened following a coastal flooding event, particularly if there are food shortages in their area or they become isolated from accessing their usual food

	belonging and wellbeing	sources. Not having sufficient food supplies can increase mental stress and negatively affect nutritional intake.
Dwellings with no access to electrical supply	Physical health Mental health, identity, autonomy and sense of belonging and wellbeing	Households without electrical supply may have reduced access to equipment to help them prepare or cope during or following a hazard e.g. mobile phones, internet, fridges, heaters, dehumidifiers [21]. They may also have greater difficulty boiling potentially contaminated water following a flood. These experiences can increase stress as well as result in adverse health outcomes.
Dwellings with no access to tap water that is safe to drink	Physical health Mental health, identity, autonomy and sense of belonging and wellbeing	Households without access to safe tap water are already more likely to be experiencing water insecurity [21], which may be exacerbated during or following a coastal flood event. This includes if they are isolated from their usual water source (e.g. community drinking water stations), or if alternative water sources become contaminated. Water insecurity can increase mental stress and result in negative health outcomes such as dehydration or waterborne illnesses.
Industry - Health Care and Social Assistance	Physical health Mental health, identity, autonomy and sense of belonging and wellbeing	Employees working in healthcare and social services during a coastal flood event may be more exposed to negative mental and physical health impacts as a result of that work [61], [62]. If they become physically cut off during a flood event, they may be more likely to attempt to traverse hazardous conditions in order to directly assist others or access their workplace to do so. They may also be required to work extensive hours during an emergency, which can have negative mental and physical health implications.
Industry - Public Administration and Safety	Physical health Mental health, identity, autonomy and sense of belonging and wellbeing	Employees working in emergency response (including first responders and those in supporting roles) during a coastal flood event may be at greater risk of injury, death, infections, diseases, and/or negative mental health impacts as a result of that work [62]. If they become physically cut off during a flood event, they may be more likely to persist in attempting to leave their residence in order to directly assist others or access their workplace to do so, putting themselves at risk. They may also be required to work extensive hours during an emergency, which can have negative mental and physical health implications.
Industry - Agriculture, Forestry and Fishing	Mental health, identity, autonomy and sense of	Employees working in primary industries, and particularly in agricultural and fisheries sectors, may experience heightened financial stress where coastal flooding also affects the natural resources or infrastructure that their livelihoods depend on. They may also be more highly exposed to coastal

	belonging and wellbeing	flooding in their line of work, where these workplaces are located in hazard zones

Appendix C Indicator Bundles by People, Health and Community Category

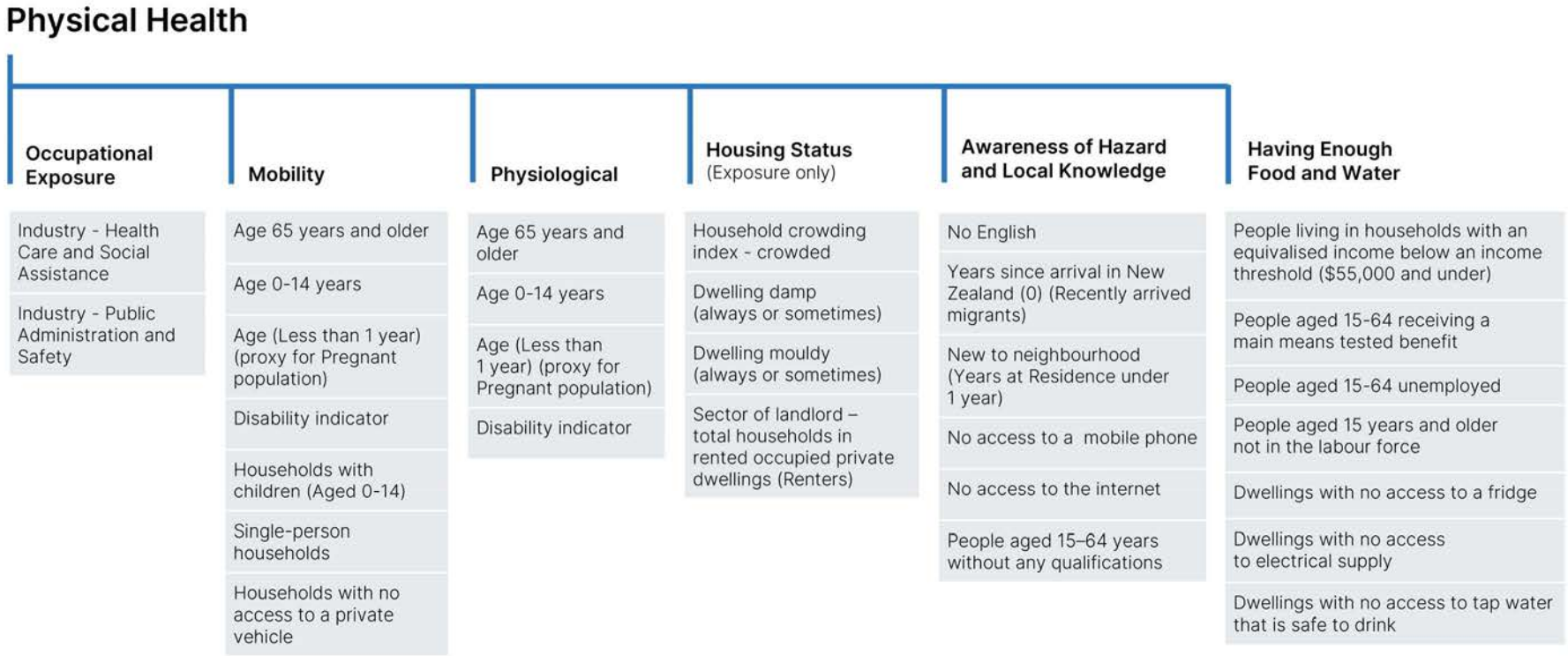

Figure A-1 The indicators that comprise the Physical Health category, arranged into their indicator bundles

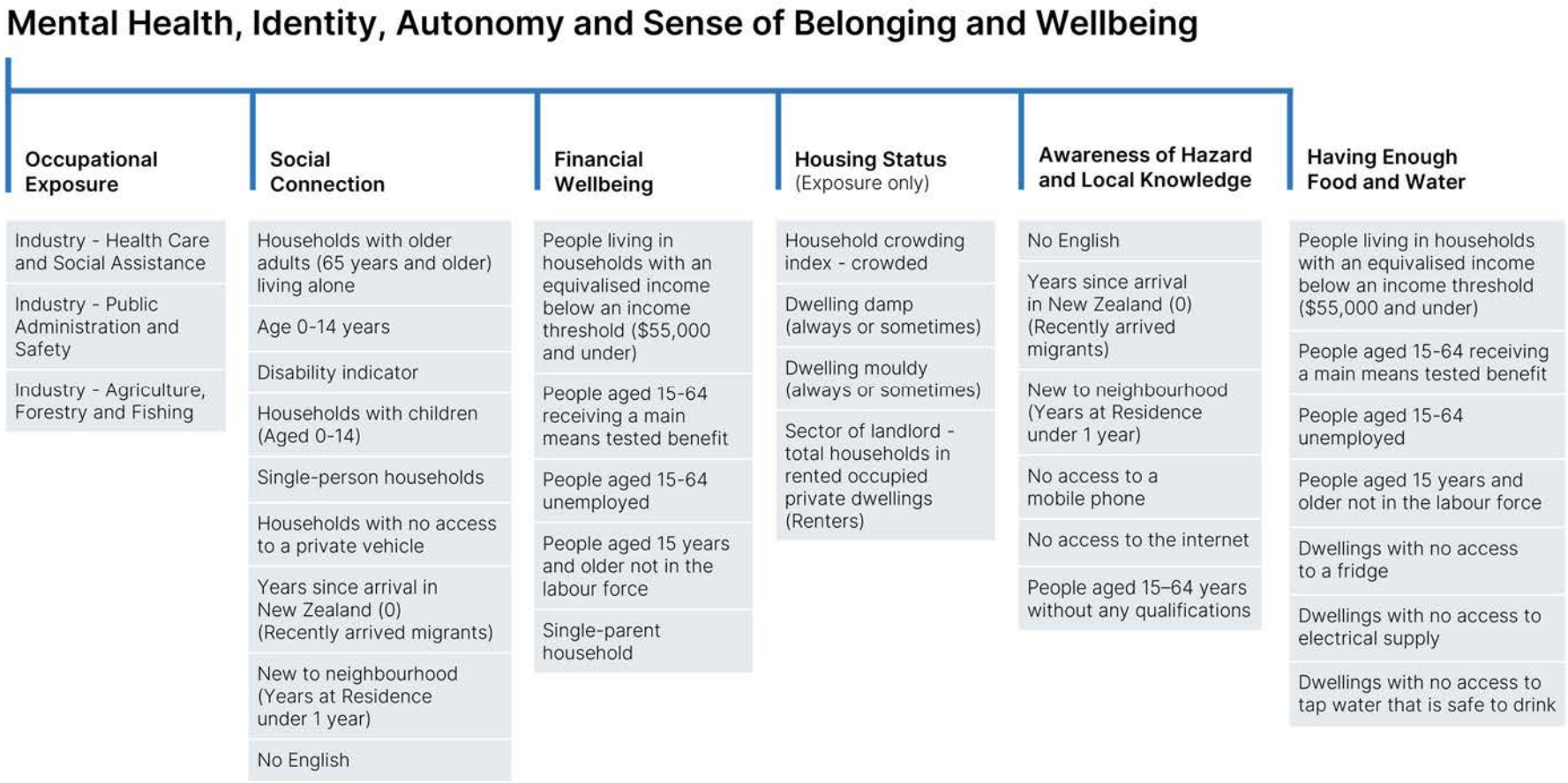

Figure A-2 The indicators that comprise the Mental Health, Identity, Autonomy and Sense of Belonging and Wellbeing category, arranged into their indicator bundles

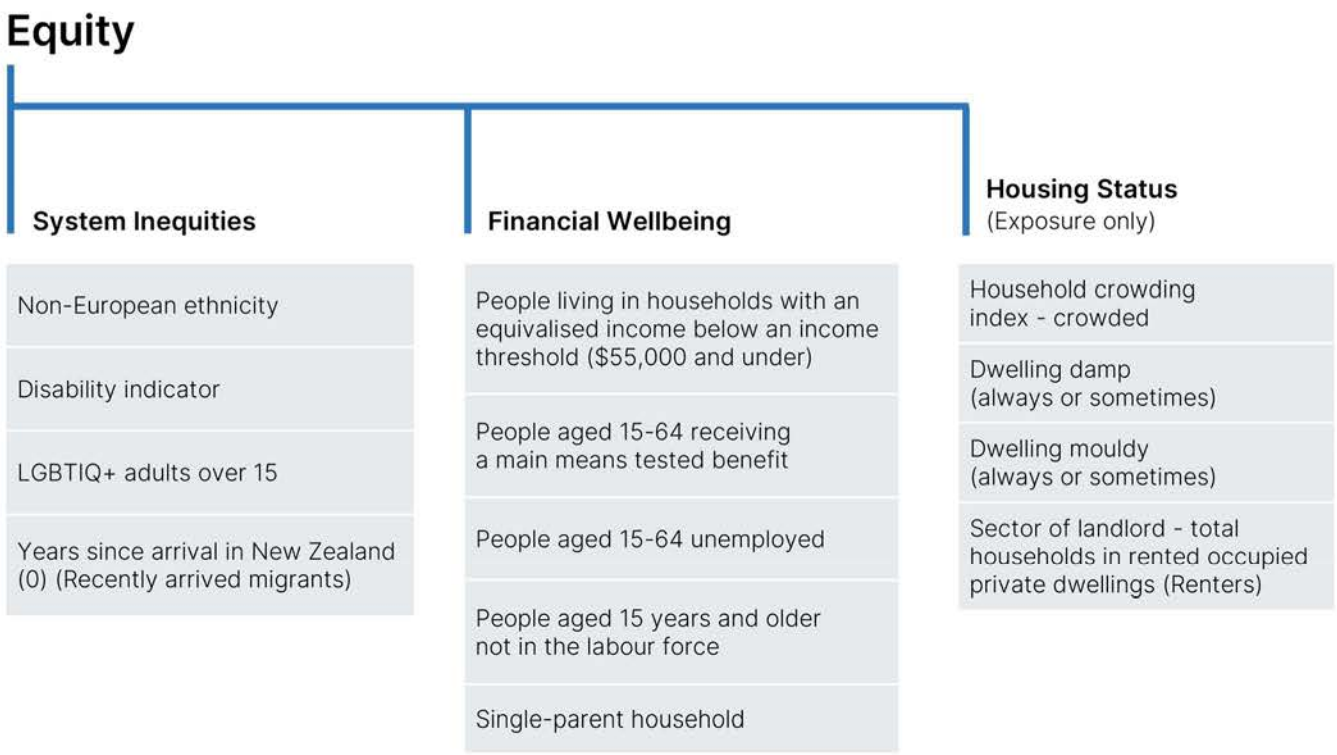

Figure A-3 The indicators that comprise the Equity category, arranged into their indicator bundles

Social Cohesion, Community and Cultural Wellbeing

System Inequities	Social Connection	Displacement		Cultural Wellbeing
Non-European ethnicity	Households with older adults (65 years and older) living alone	Ethnicity – Māori	No English	Ethnicity – Māori
Disability indicator	Age 0-14 years	Households with older adults (65 years and older) living alone	People living in households with an equivalised income below an income threshold ($55,000 and under)	
LGBTIQ+ adults over 15	Disability indicator	Age 65 years and older	People aged 15-64 receiving a main means tested benefit	
Years since arrival in New Zealand (0) (Recently arrived migrants)	Households with children (Aged 0-14)	Age 0-14 years	People aged 15-64 unemployed	
	Single-person households	Single-person households	People aged 15 years and older not in the labour force	
	Households with no access to a private vehicle	LGBTIQ+ adults over 15	Households with no access to a private vehicle	
	Years since arrival in New Zealand (0) (Recently arrived migrants)	Disability indicator	Sector of landlord - total households in rented occupied private dwellings (Renters)	
	New to neighbourhood (Years at Residence under 1 year)	Years since arrival in New Zealand (0) (Recently arrived migrants)		
	No English			

Figure A-4 The indicators that comprise the Social Cohesion, Community and Cultural Wellbeing category, arranged into their indicator bundles

Appendix D Top 20 TAs ranked by Risk Score

Table A-3 Top 20 TAs exposed to coastal flooding, ranked by risk score.

Present Day (0.0m SLR)	Risk Score	0.2m SLR	Risk Score	0.5m SLR	Risk Score	1.0m SLR	Risk Score
Napier City	10.2 %	Napier City	13.6 %	Napier City	23.8%	Napier City	32.1
Buller District	7.8%	Buller District	12.7 %	Buller District	20.4%	Buller District	28.1 %
Kaipara District	5.1%	Whakatāne District	6.0%	Whakatāne District	7.4%	Thames-Coromandel District	9.9%
Thames-Coromandel District	4.1%	Kaipara District	5.4%	Thames-Coromandel District	6.1%	Whakatane District	9.0%
Kaikōura District	1.5%	Thames-Coromandel District	4.9%	Kaipara District	5.9%	Ōpōtiki District	7.5%
Westland District	0.9%	Hauraki District	3.1%	Ōpōtiki District	3.4%	Dunedin City	7.3%
Christchurch City	0.9%	Invercargill City	2.2%	Hauraki District	3.4%	Kaipara District	6.2%
Hauraki District	0.7%	Nelson City	2.2%	Westland District	3.0%	Christchurch City	5.2%
Far North District	0.6%	Kaikōura District	1.6%	Nelson City	2.6%	Westland District	5.1%
Tasman District	0.4%	Christchurch City	1.2%	Invercargill City	2.5%	Nelson City	4.7%
Grey District	0.4%	Westland District	1.2%	Christchurch City	2.5%	Tasman District	4.5%
Ōpōtiki District	0.4%	Ōpōtiki District	1.1%	Tasman District	2.2%	Lower Hutt City	4.5%
Western Bay of Plenty District	0.3%	Tasman District	1.0%	Kaikōura District	1.9%	Hauraki District	3.8%

Whakatāne District	0.3%	Waimakariri District	0.7%	Lower Hutt City	1.2%	Waimakariri District	3.2%
Clutha District	0.2%	Far North District	0.7%	Tauranga City	1.0%	Invercargill City	3.1%
Ōtorohanga District	0.2%	Lower Hutt City	0.7%	Far North District	1.0%	Kaikōura District	2.1%
Southland District	0.2%	Tauranga City	0.6%	Waimakariri District	0.9%	Grey District	2.0%
Tauranga City	0.2%	Grey District	0.4%	Horowhenua District	0.7%	Horowhenua District	1.8%
Horowhenua District	0.1%	Western Bay of Plenty District	0.4%	Western Bay of Plenty District	0.5%	Far North District	1.6%
Gisborne District	0.1%	Clutha District	0.3%	Hastings District	0.4%	Tauranga City	1.4%

Table A-4 Top 20 TAs at risk of isolation due to coastal flooding, ranked by risk score.

Present Day (0.0m SLR)	Risk Score	0.2m SLR	Risk Score	0.5m SLR	Risk Score	1.0m SLR	Risk Score
Thames-Coromandel District	28.2%	Thames-Coromandel District	35.3%	Thames-Coromandel District	47.1%	Hauraki District	51.9%
Buller District	17.1%	Buller District	23.7%	Buller District	33.2%	Thames-Coromandel District	47.4%
Napier City	15.3%	Napier City	17.8%	Napier City	32.1%	Buller District	38.4%
Far North District	14.4%	Far North District	14.9%	Ōpōtiki District	16.3%	Napier City	35.1%
Kaipara District	14.0%	Kaipara District	14.2%	Far North District	15.2%	Kaipara District	29.4%
Kaikōura District	7.4%	Ōpōtiki District	8.4%	Kaipara District	14.5%	Gisborne District	23.5%
Ōpōtiki District	6.4%	Hauraki District	7.8%	Tasman District	11.0%	Ōpōtiki District	21.7%
Whangārei District	5.3%	Whakatāne District	7.7%	Whakatāne District	9.4%	Far North District	16.7%
Ōtorohanga District	5.2%	Kaikōura District	7.7%	Kaikōura District	8.2%	Tasman District	12.2%
Wairoa District	3.9%	Invercargill City	6.8%	Hauraki District	7.9%	Whakatāne District	11.6%
Invercargill City	3.8%	Tasman District	5.4%	Clutha District	7.3%	Invercargill City	8.8%
Western Bay of Plenty District	3.3%	Whangārei District	5.4%	Invercargill City	7.3%	Kaikōura District	8.7%
Westland District	2.8%	Ōtorohanga District	5.2%	Westland District	5.8%	Dunedin City	8.4%
Tasman District	2.7%	Wairoa District	3.9%	Whangārei District	5.4%	Westland District	8.0%

Waitomo District	2.7%	Western Bay of Plenty District	3.9%	Ōtorohanga District	5.2%	Christchurch City	7.4%
Clutha District	2.6%	Nelson City	3.6%	Christchurch City	4.5%	Clutha District	7.3%
Hauraki District	2.6%	Westland District	3.2%	Horowhenua District	4.2%	Nelson City	6.5%
Southland District	2.4%	Clutha District	2.9%	Nelson City	4.2%	Whangārei District	5.7%
Gisborne District	2.2%	Gisborne District	2.8%	Western Bay of Plenty District	4.1%	Western Bay of Plenty District	5.5%
Christchurch City	1.9%	Waitomo District	2.7%	Wairoa District	4.0%	Ōtorohanga District	5.3%

Appendix E Social Vulnerability Indicator Bundles

Exposed Populations - Social Vulnerability Associated with Equity

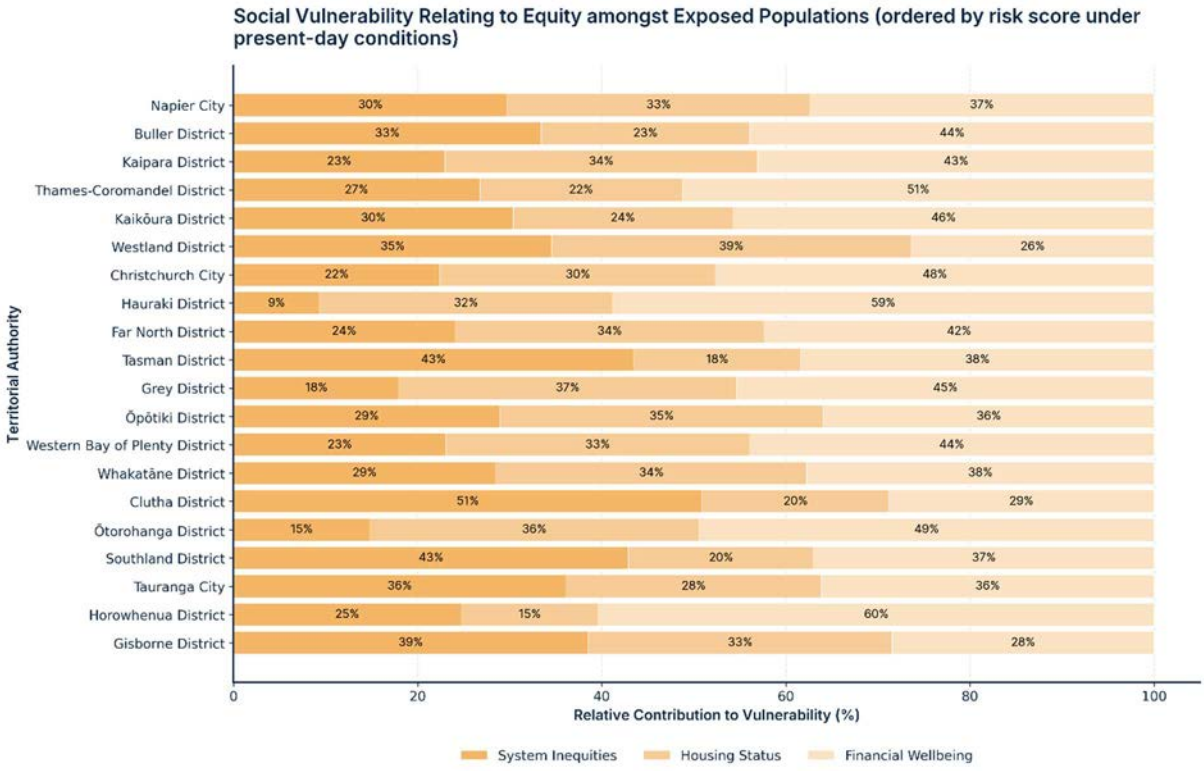

Figure A-5 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing inequitable impacts as a result of exposure to 1% AEP coastal flooding, under present-day conditions. In this instance, those already experiencing systemic, housing, or financial inequities are more likely to experience further inequities as a result of being exposed to coastal flooding. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

Figure A-6 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing inequitable impacts as a result of exposure to 1% AEP coastal flooding, under 0.2m SLR. In this instance, those already experiencing systemic, housing, or financial inequities are more likely to experience further inequities as a result of being exposed to coastal flooding. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

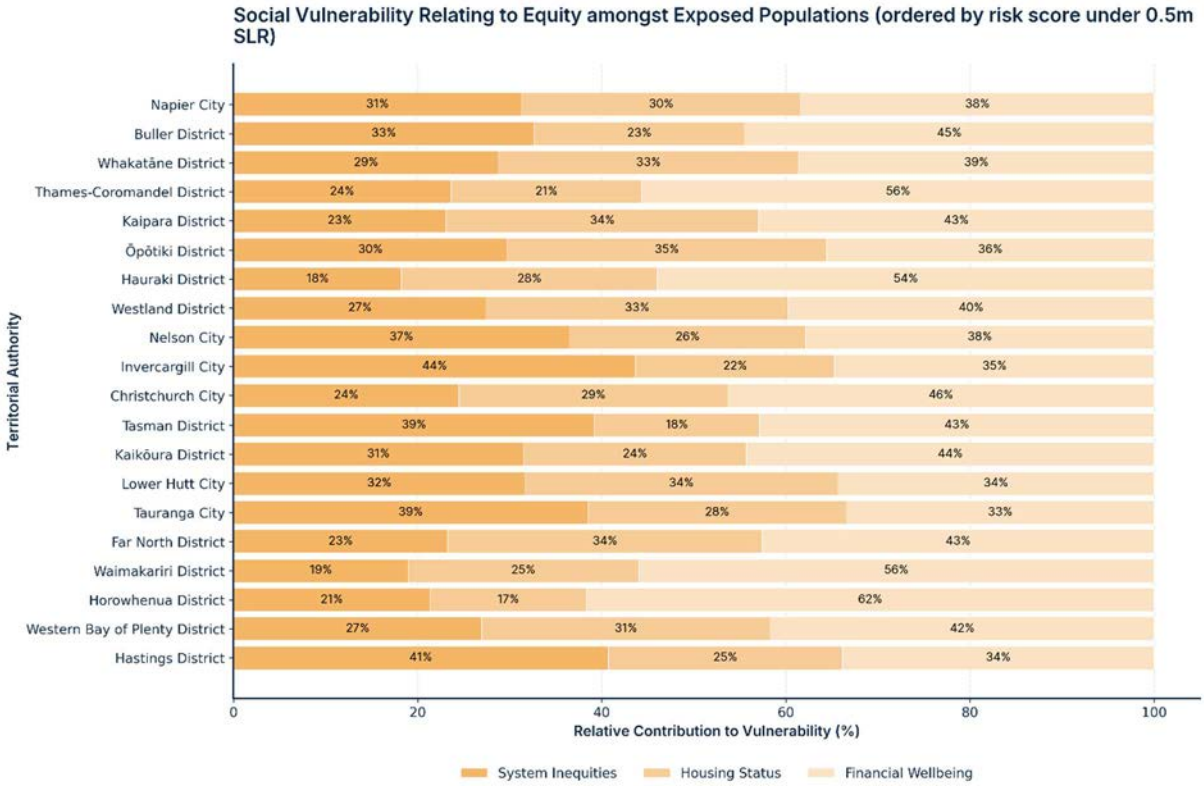

Figure A-7 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing inequitable impacts as a result of exposure to 1% AEP coastal flooding, under 0.5m SLR. In this instance, those already experiencing systemic, housing, or financial inequities are more likely to experience further inequities as a result of being exposed to coastal flooding. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

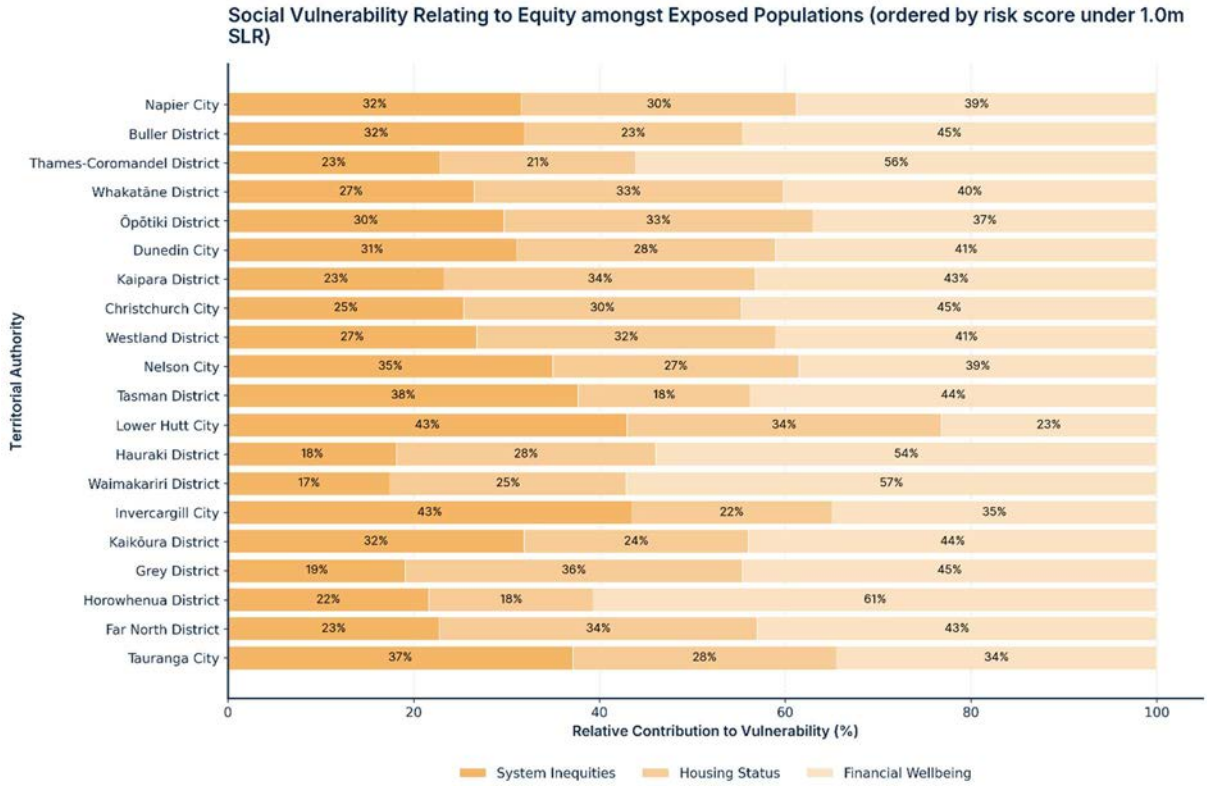

Figure A-8 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing inequitable impacts as a result of exposure to 1% AEP coastal flooding, under 1.0m SLR. In this instance, those already experiencing systemic, housing, or financial inequities are more likely to experience further inequities as a result of being exposed to coastal flooding. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

Exposed Populations - Social Vulnerability Associated with Social Cohesion, Community and Cultural Wellbeing

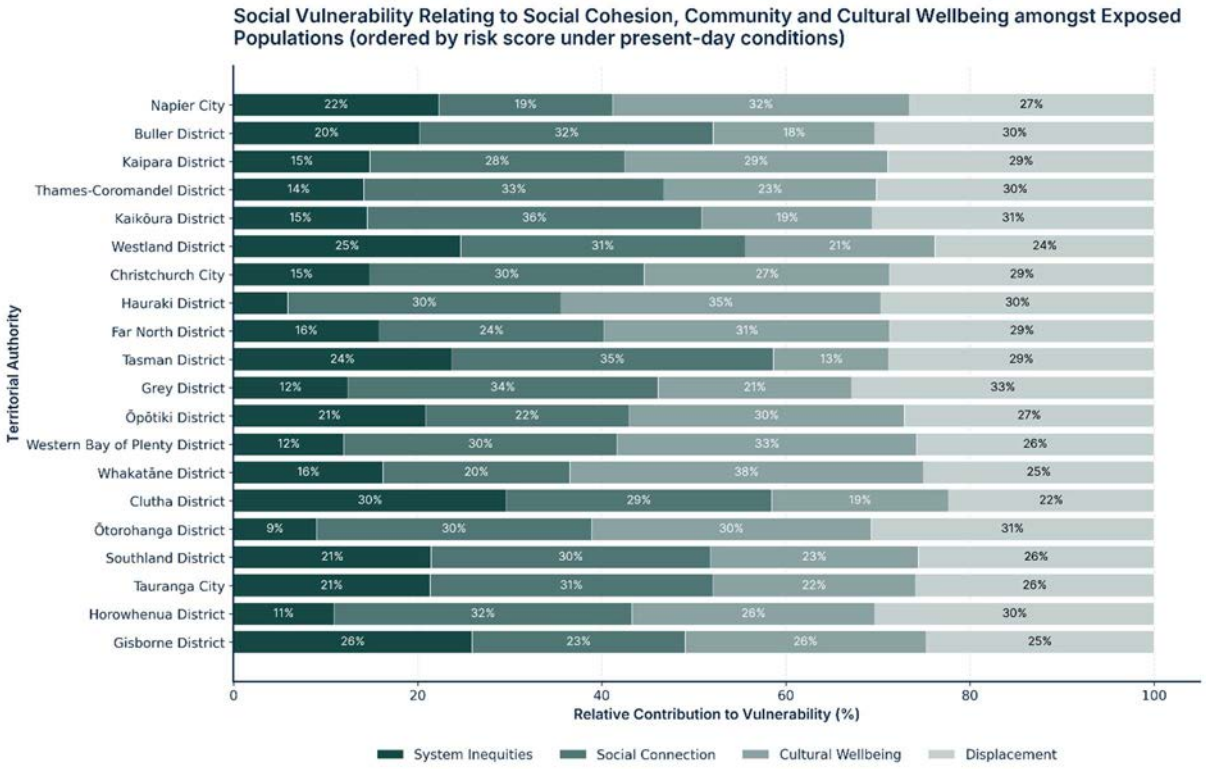

Figure A-9 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative welling outcomes where exposure to 1% AEP coastal flooding undermines social cohesion, community wellbeing, or cultural wellbeing, under present-day conditions. This includes factors associated with people's social connections, experiences of systemic inequities, experiences of displacement, and impacts on cultural wellbeing. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

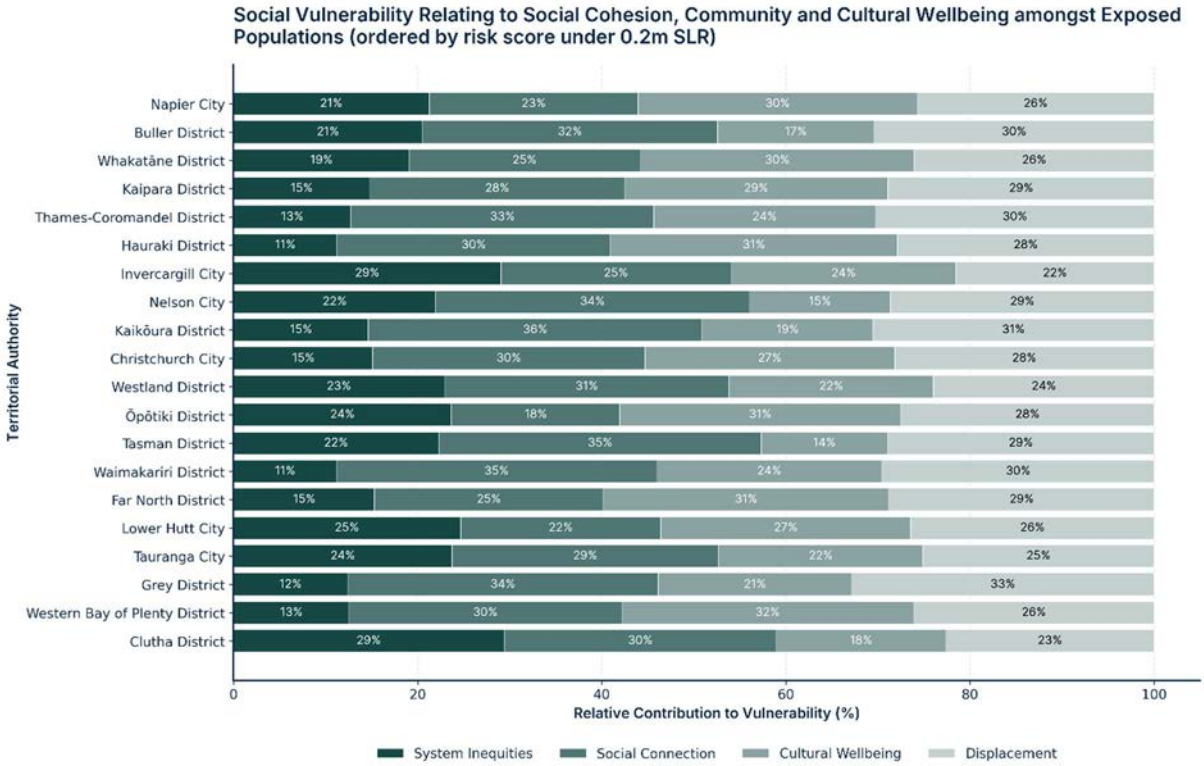

Figure A-10 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative welling outcomes where exposure to 1% AEP coastal flooding undermines social cohesion, community wellbeing, or cultural wellbeing, under 0.2m SLR. This includes factors associated with people's social connections, experiences of systemic inequities, experiences of displacement, and impacts on cultural wellbeing. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

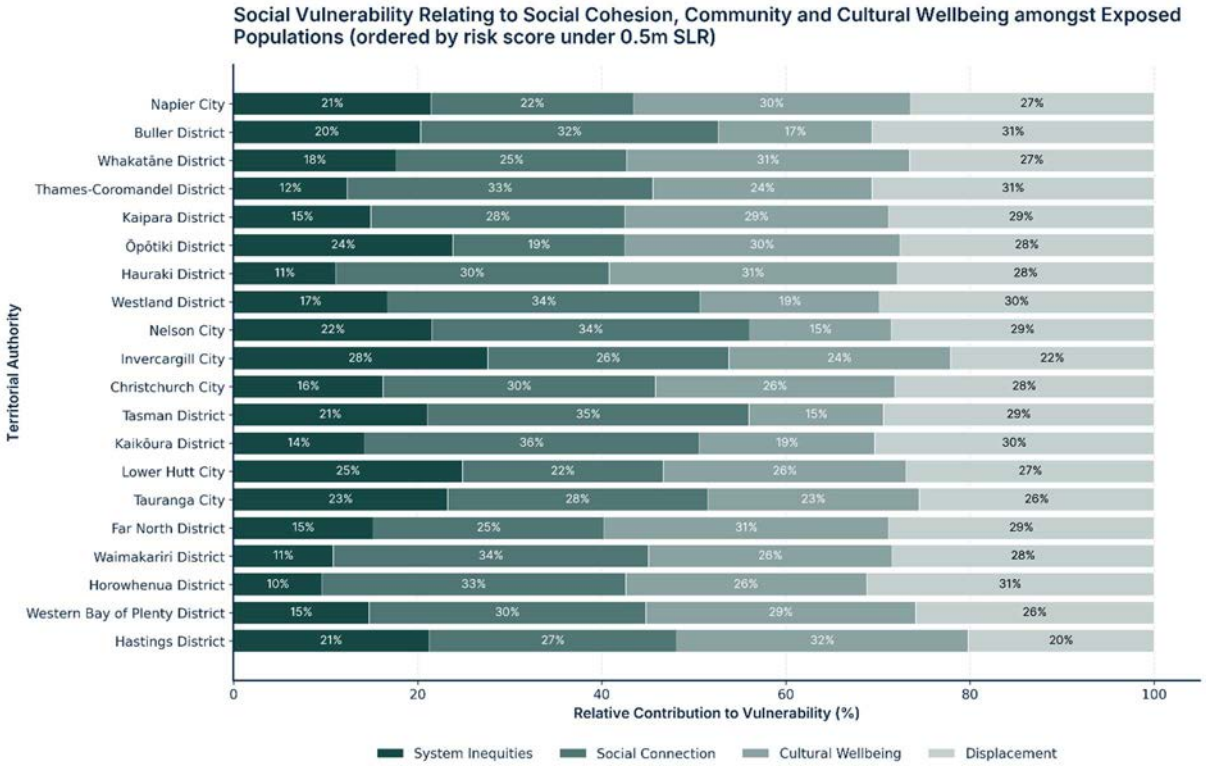

Figure A-11 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative welling outcomes where exposure to 1% AEP coastal flooding undermines social cohesion, community wellbeing, or cultural wellbeing, under 0.5m SLR. This includes factors associated with people's social connections, experiences of systemic inequities, experiences of displacement, and impacts on cultural wellbeing. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

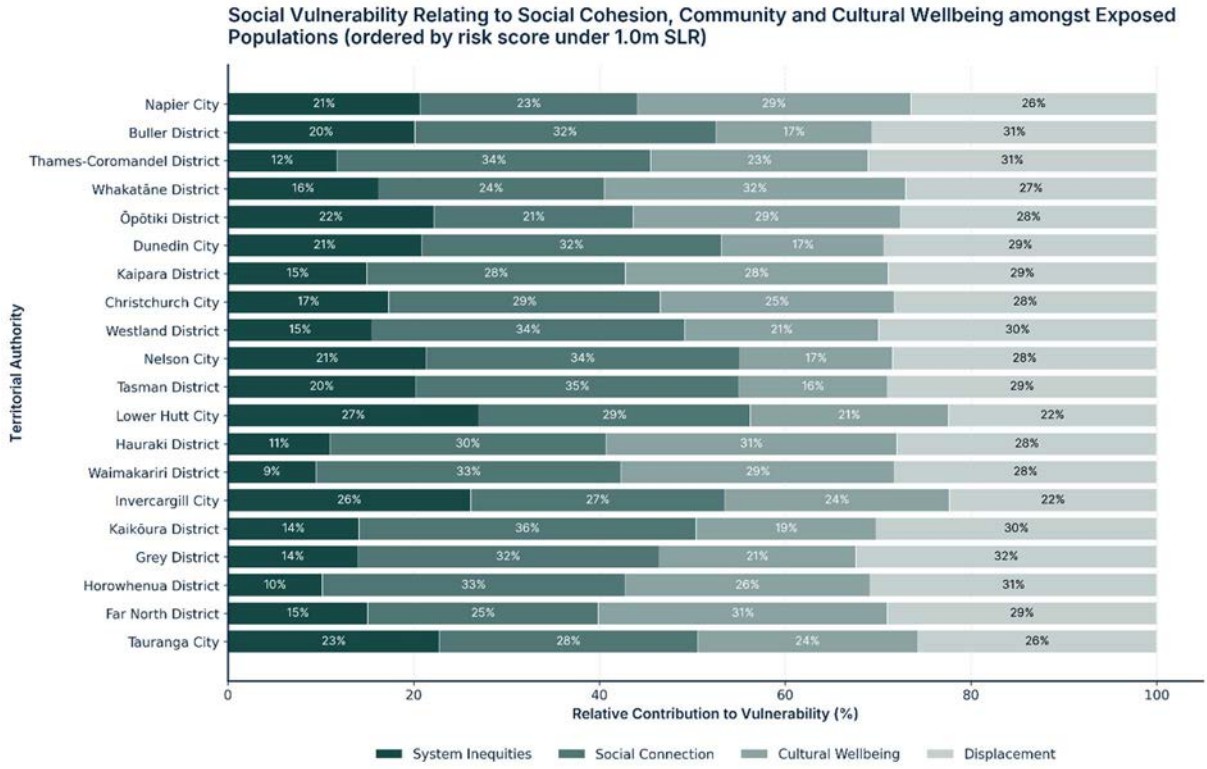

Figure A-12 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative welling outcomes where exposure to 1% AEP coastal flooding undermines social cohesion, community wellbeing, or cultural wellbeing, under 1.0m SLR. This includes factors associated with people's social connections, experiences of systemic inequities, experiences of displacement, and impacts on cultural wellbeing. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

Exposed Populations - Social Vulnerability Associated with Physical Health

Within the physical health impacts category, the mobility and physiological bundles should be considered closely, as they share four of the same indicators (older age, age 0-14, age less than one year as a proxy for pregnancy, and disability). While mobility presents as a relatively small component in some TAs (due to the additional indicators associated with mobility shifting the weighting away from the shared variables), it nonetheless remains a critical component of vulnerability.

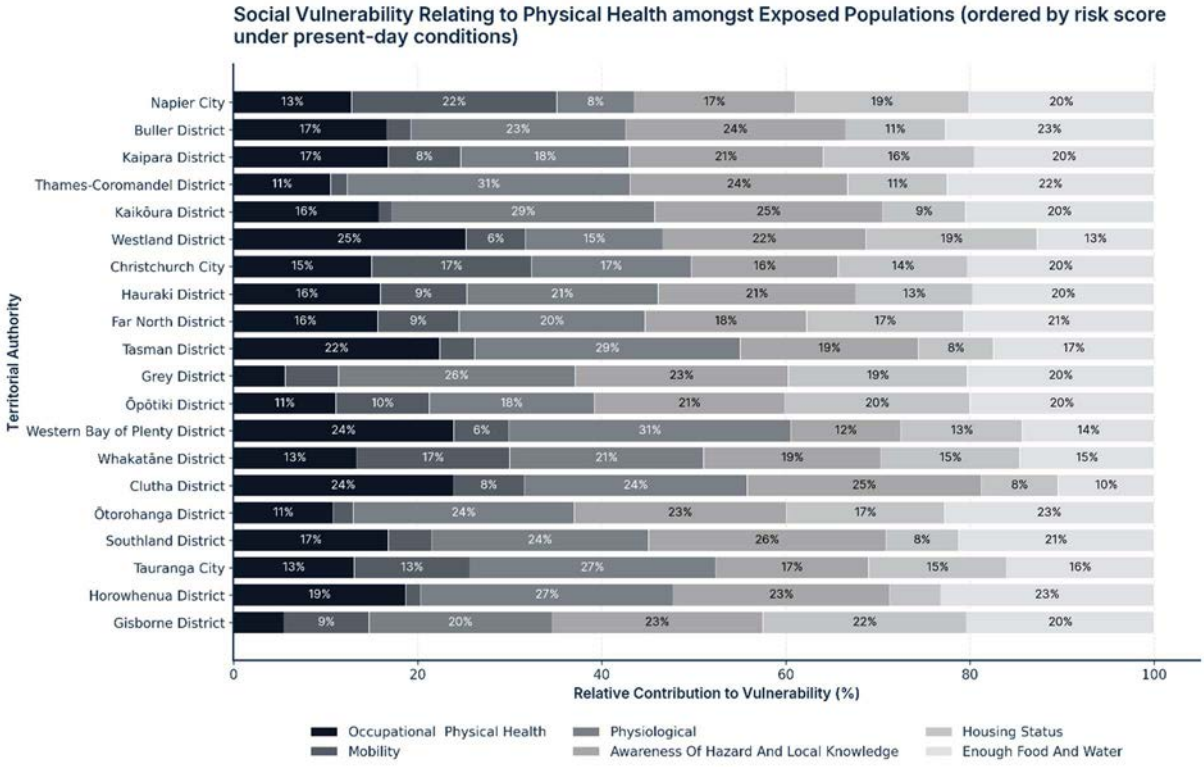

Figure A-13 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative physical health outcomes as a result of being exposed to 1% AEP coastal flooding, under present-day conditions. This includes factors associated with people's occupation, mobility, physiology, awareness of hazard and local knowledge, housing status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

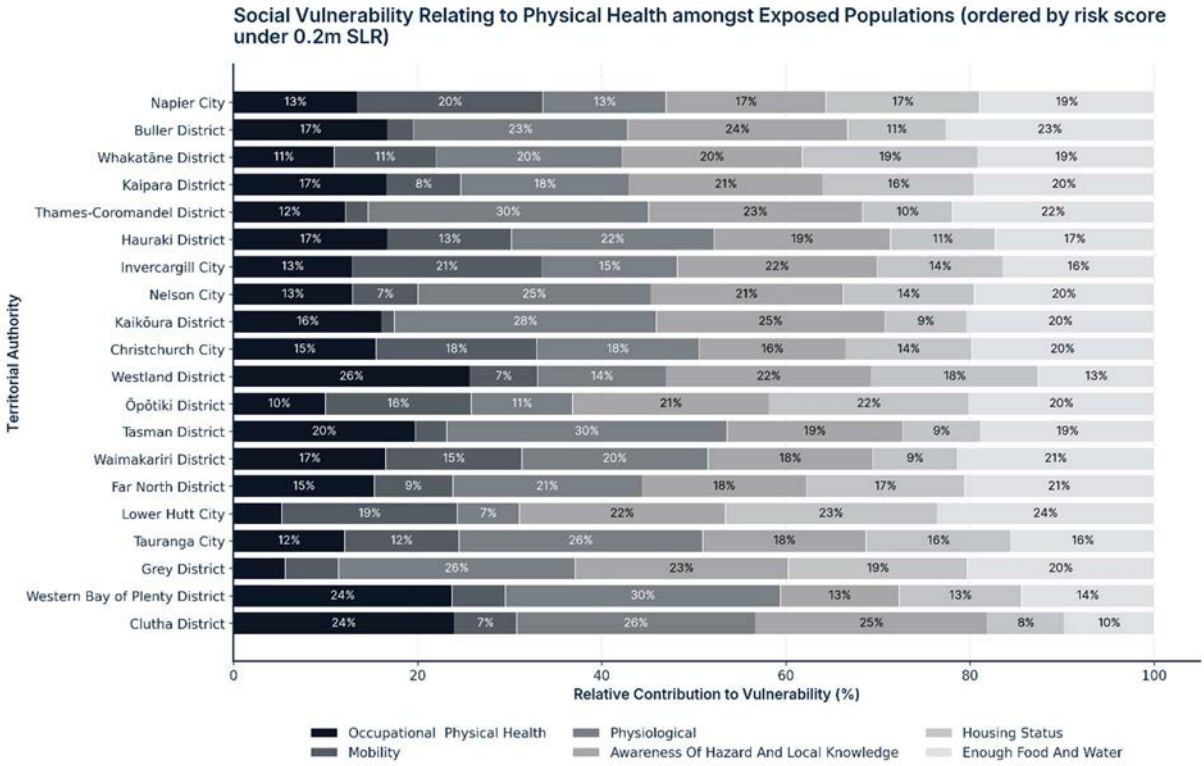

Figure A-14 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative physical health outcomes as a result of being exposed to 1% AEP coastal flooding, under 0.2m SLR. This includes factors associated with people's occupation, mobility, physiology, awareness of hazard and local knowledge, housing status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

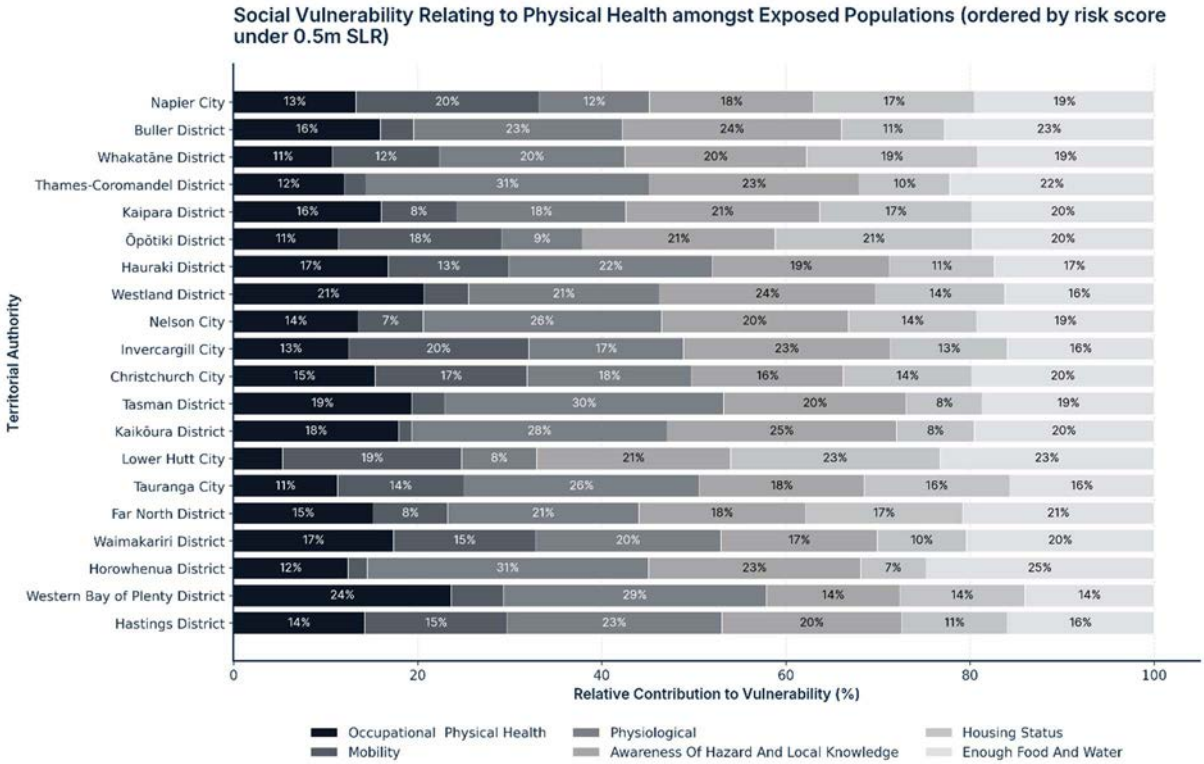

Figure A-15 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative physical health outcomes as a result of being exposed to 1% AEP coastal flooding, under 0.5m SLR. This includes factors associated with people's occupation, mobility, physiology, awareness of hazard and local knowledge, housing status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

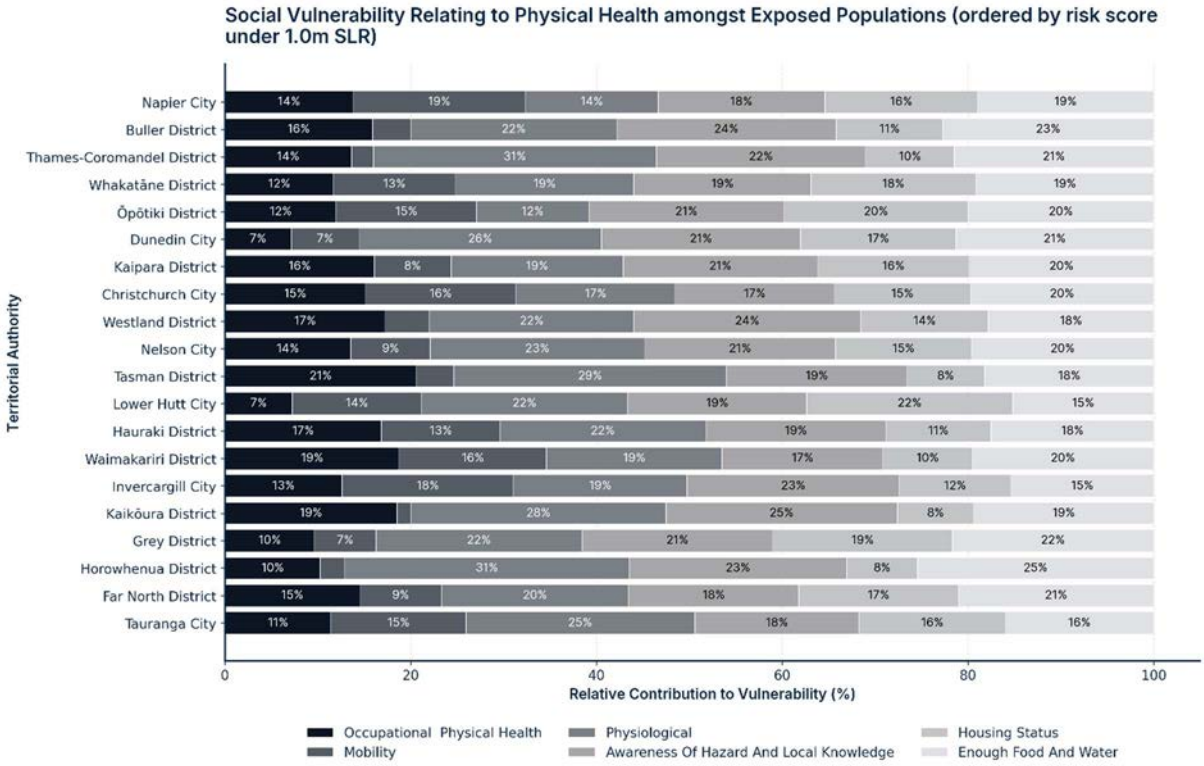

Figure A-16 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative physical health outcomes as a result of being exposed to 1% AEP coastal flooding, under 1.0m SLR. This includes factors associated with people's occupation, mobility, physiology, awareness of hazard and local knowledge, housing status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

Exposed Populations - Social Vulnerability Associated with Mental Health, Identity, Autonomy and Sense of Belonging and Wellbeing

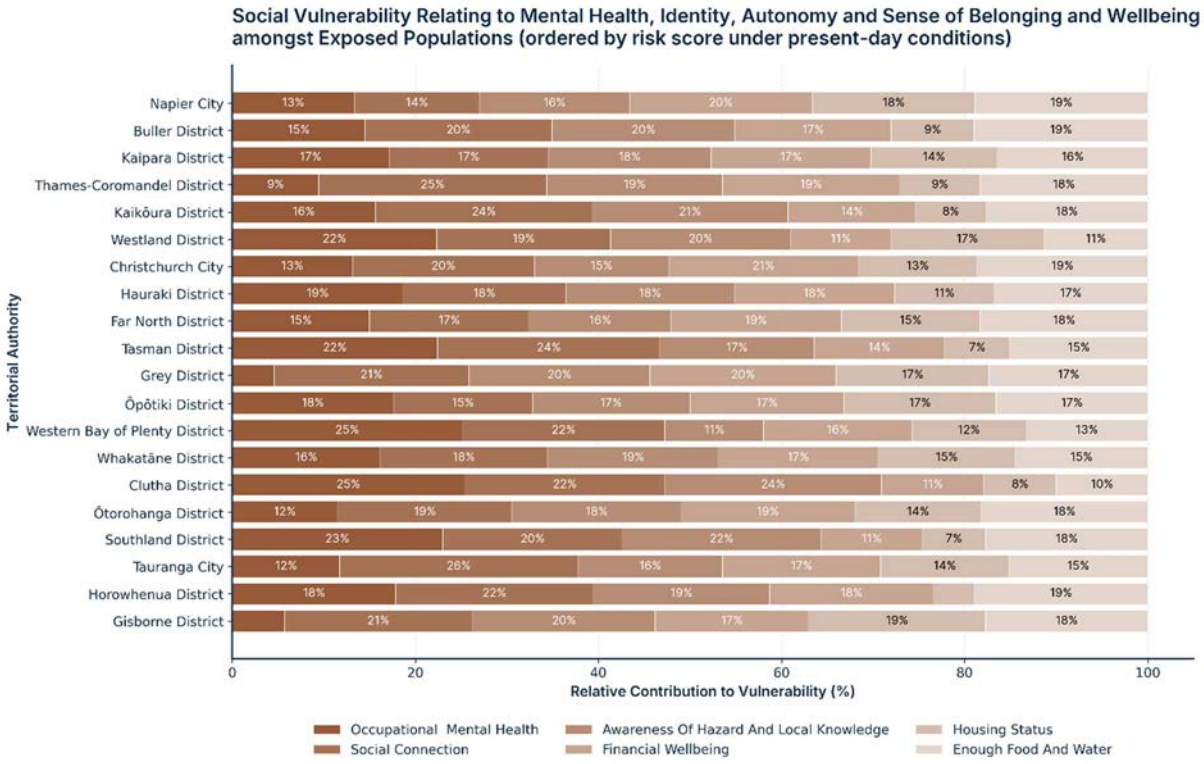

Figure A-17 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative mental health outcomes as a result of being exposed to 1% AEP coastal flooding, under present-day conditions. This includes factors associated with people's occupation, social connections, awareness of hazard and local knowledge, financial status, housing status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

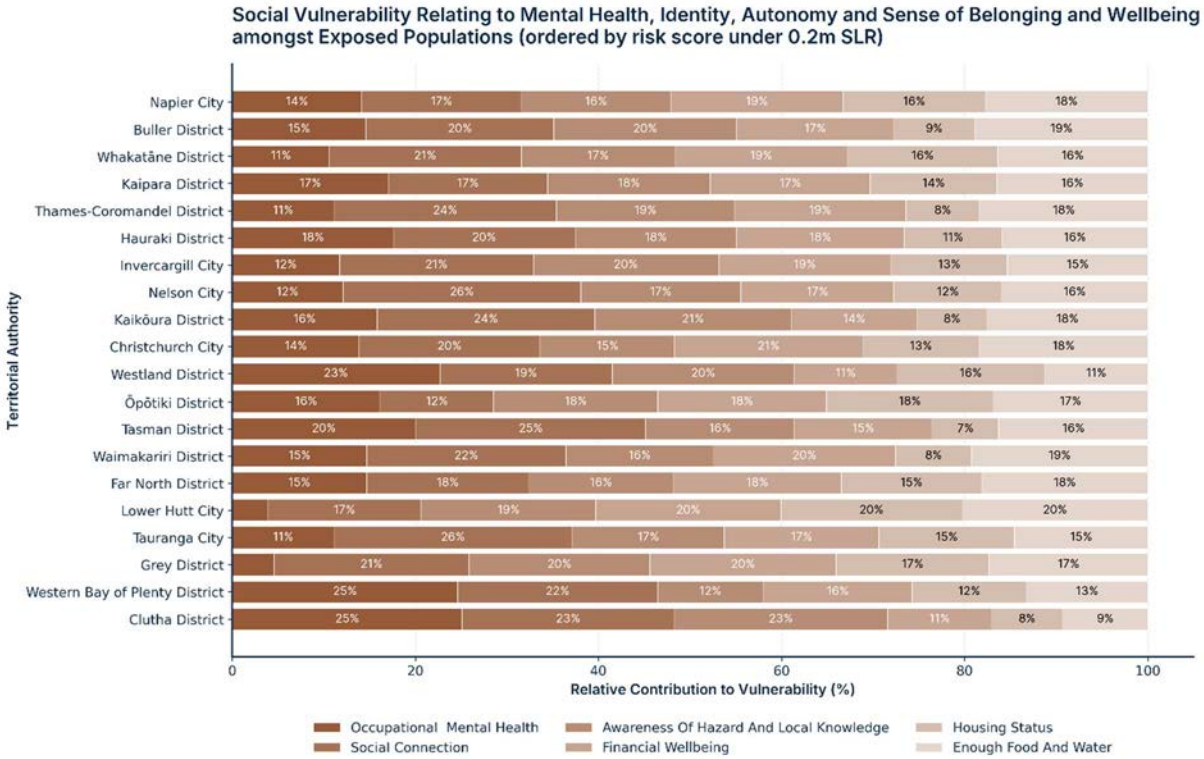

Figure A-18 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative mental health outcomes as a result of being exposed to 1% AEP coastal flooding, under 0.2m SLR. This includes factors associated with people's occupation, social connections, awareness of hazard and local knowledge, financial status, housing status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

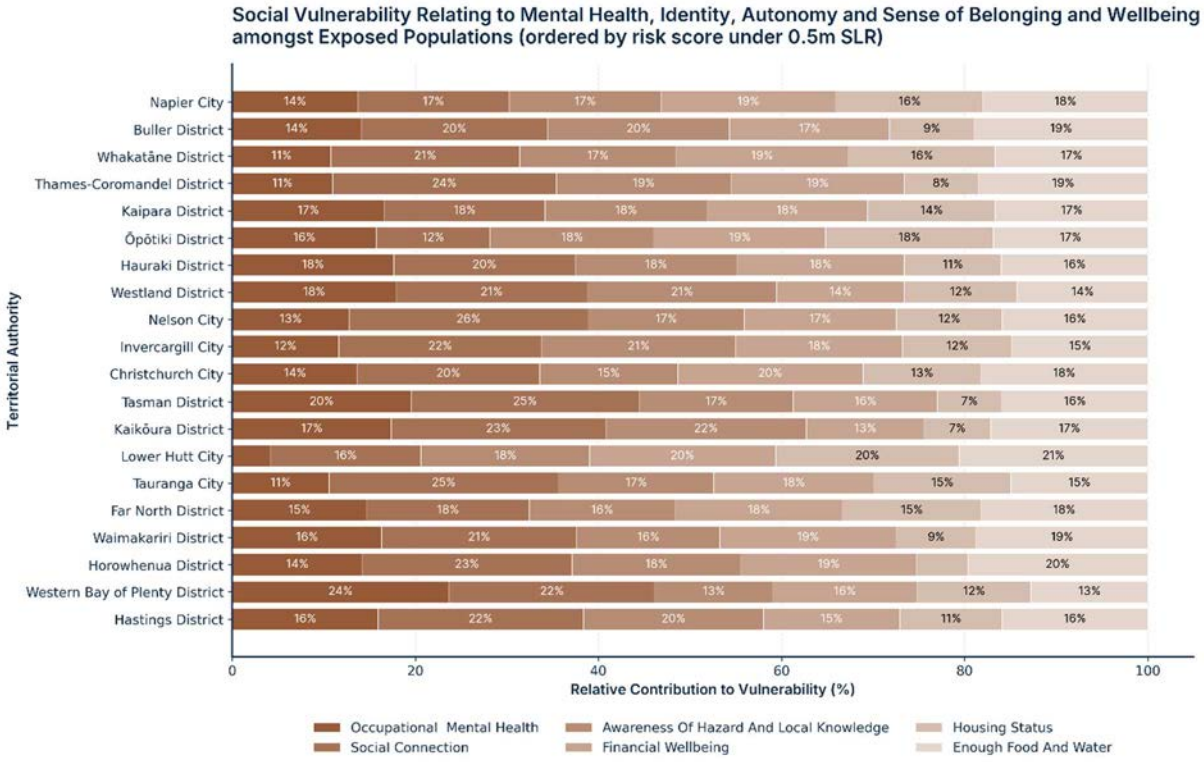

Figure A-19 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative mental health outcomes as a result of being exposed to 1% AEP coastal flooding, under 0.5m SLR. This includes factors associated with people's occupation, social connections, awareness of hazard and local knowledge, financial status, housing status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

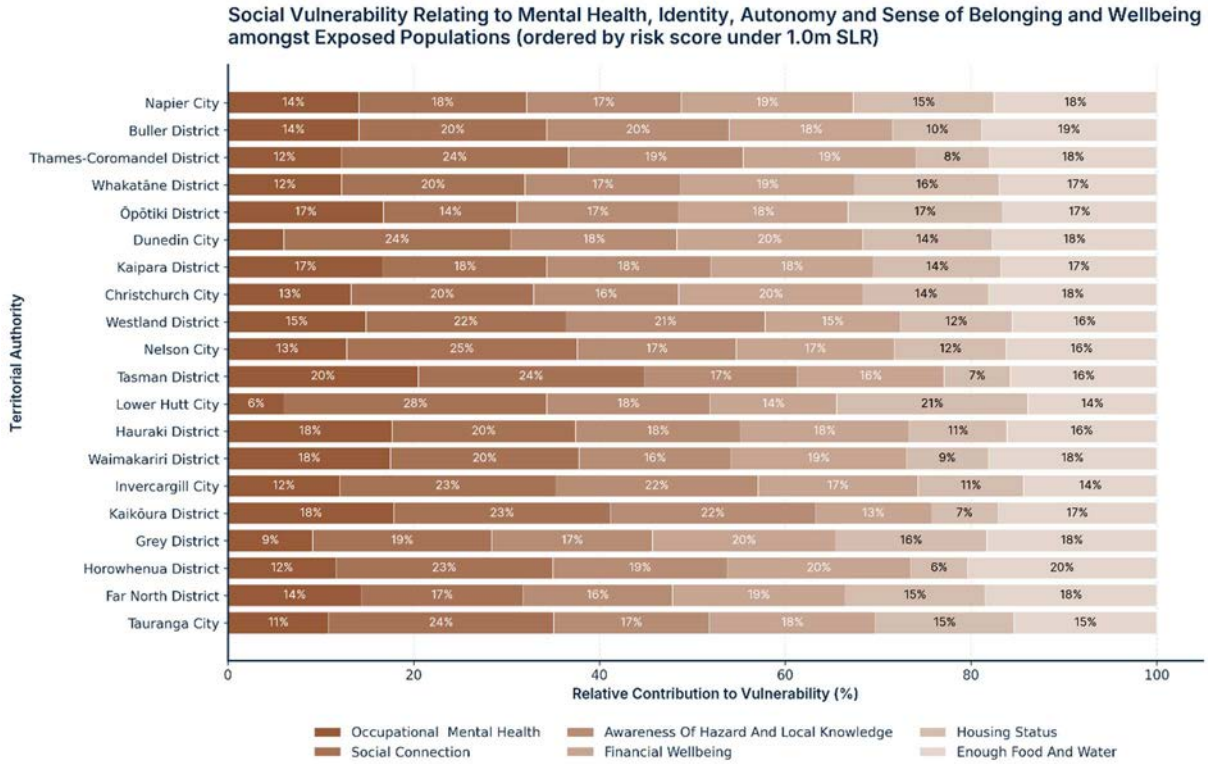

Figure A-20 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative mental health outcomes as a result of being exposed to 1% AEP coastal flooding, under present 1.0m SLR. This includes factors associated with people's occupation, social connections, awareness of hazard and local knowledge, financial status, housing status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to exposure as a proportion of their total population).

Isolated Populations - Social Vulnerability Associated with Equity

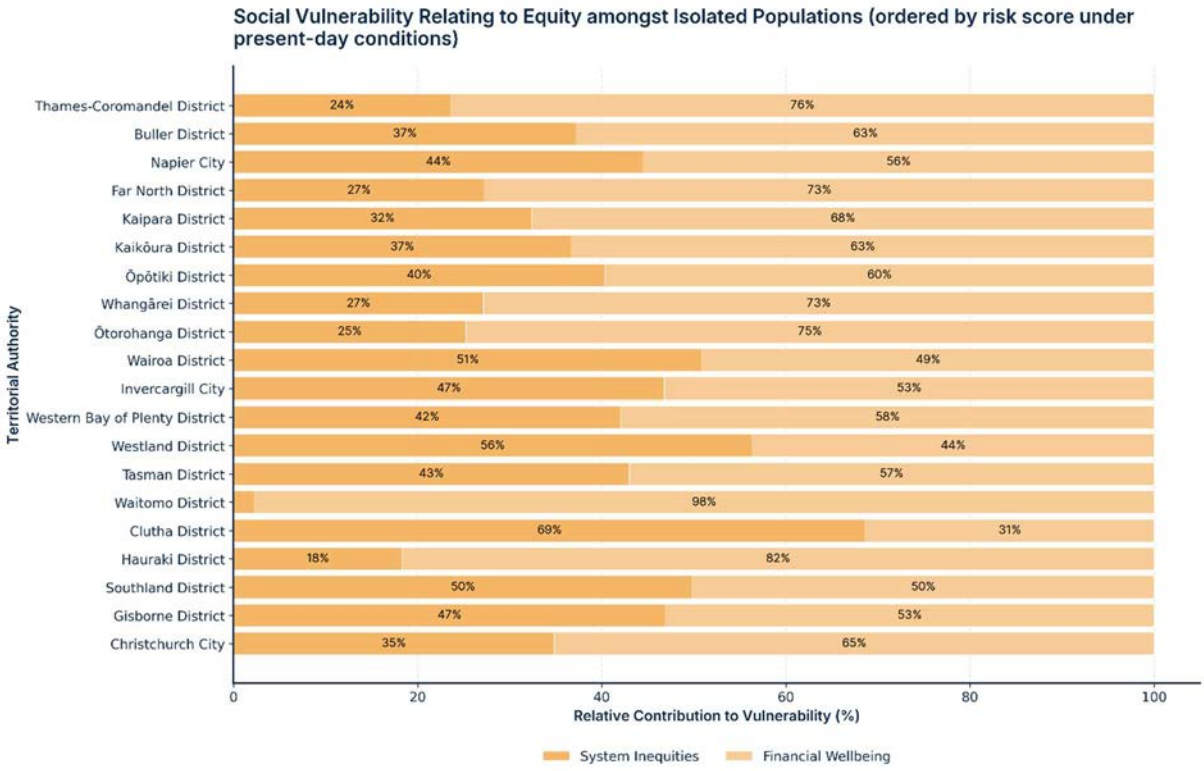

Figure A-21 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing inequitable impacts as a result of isolation due to 1% AEP coastal flooding, under present-day conditions. In this instance, those already experiencing systemic, housing, or financial inequities are more likely to experience further inequities as a result of being isolated due to coastal flooding. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

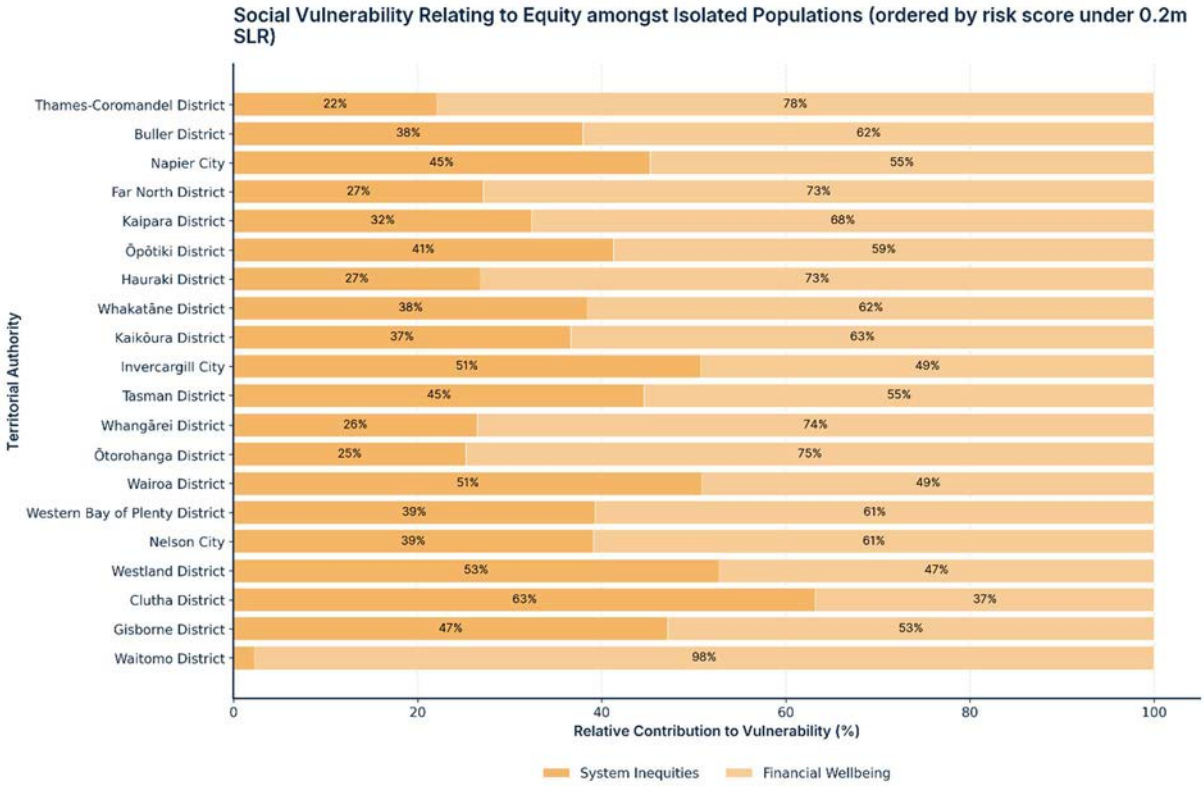

Figure A-22 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing inequitable impacts as a result of isolation due to 1% AEP coastal flooding, under 0.2m SLR. In this instance, those already experiencing systemic, housing, or financial inequities are more likely to experience further inequities as a result of being isolated due to coastal flooding. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

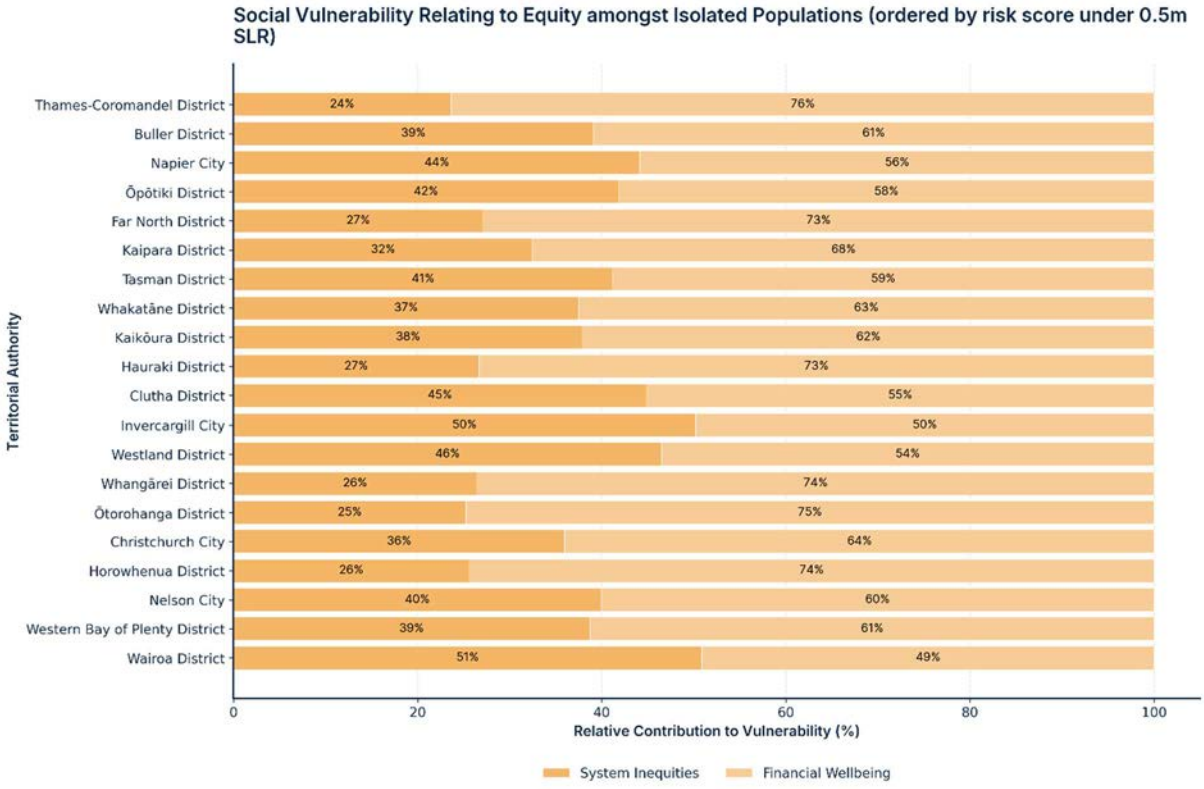

Figure A-23 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing inequitable impacts as a result of isolation due to 1% AEP coastal flooding, under 0.5m SLR. In this instance, those already experiencing systemic, housing, or financial inequities are more likely to experience further inequities as a result of being isolated due to coastal flooding. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

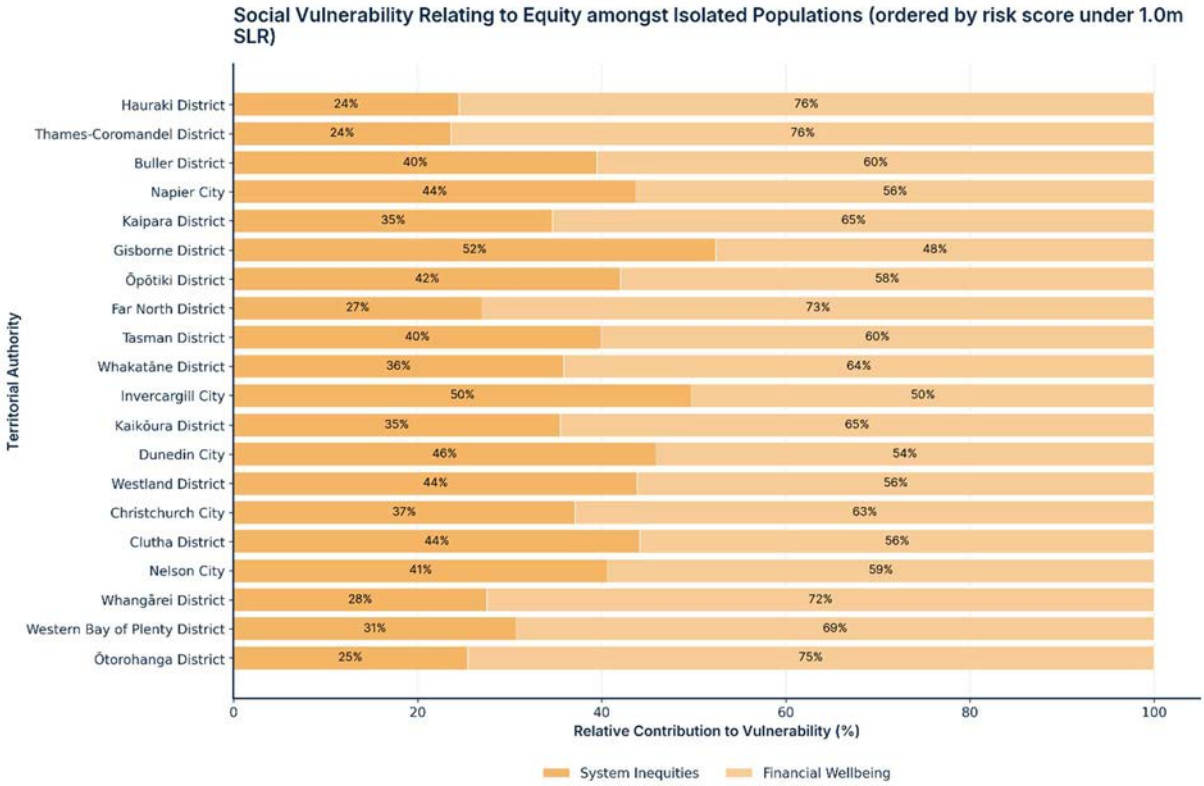

Figure A-24 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing inequitable impacts as a result of isolation due to 1% AEP coastal flooding, under 1.0m SLR. In this instance, those already experiencing systemic, housing, or financial inequities are more likely to experience further inequities as a result of being isolated due to coastal flooding. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

Isolated Populations - Social Vulnerability Associated with Social Cohesion, Community and Cultural Wellbeing

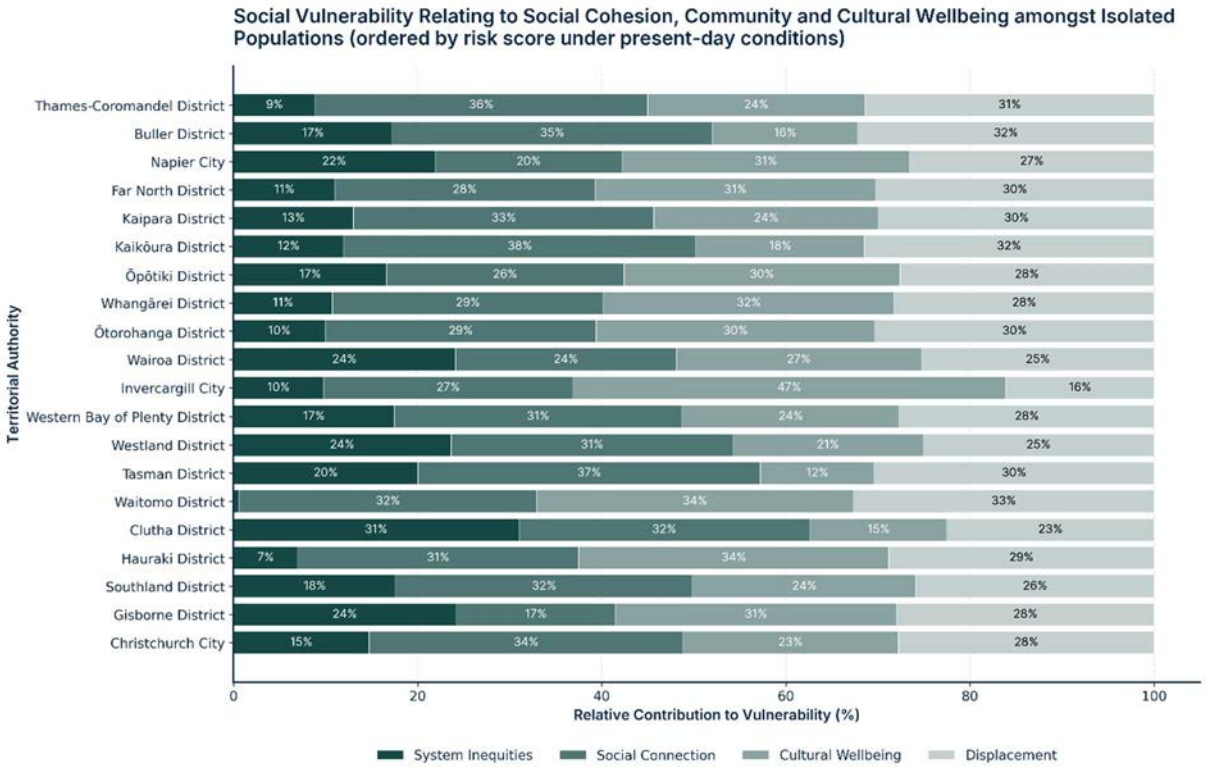

Figure A-25 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative welling outcomes where isolation due to 1% AEP coastal flooding undermines social cohesion, community wellbeing, or cultural wellbeing, under present-day conditions. This includes factors associated with people's social connections, experiences of systemic inequities, experiences of displacement, and impacts on cultural wellbeing. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

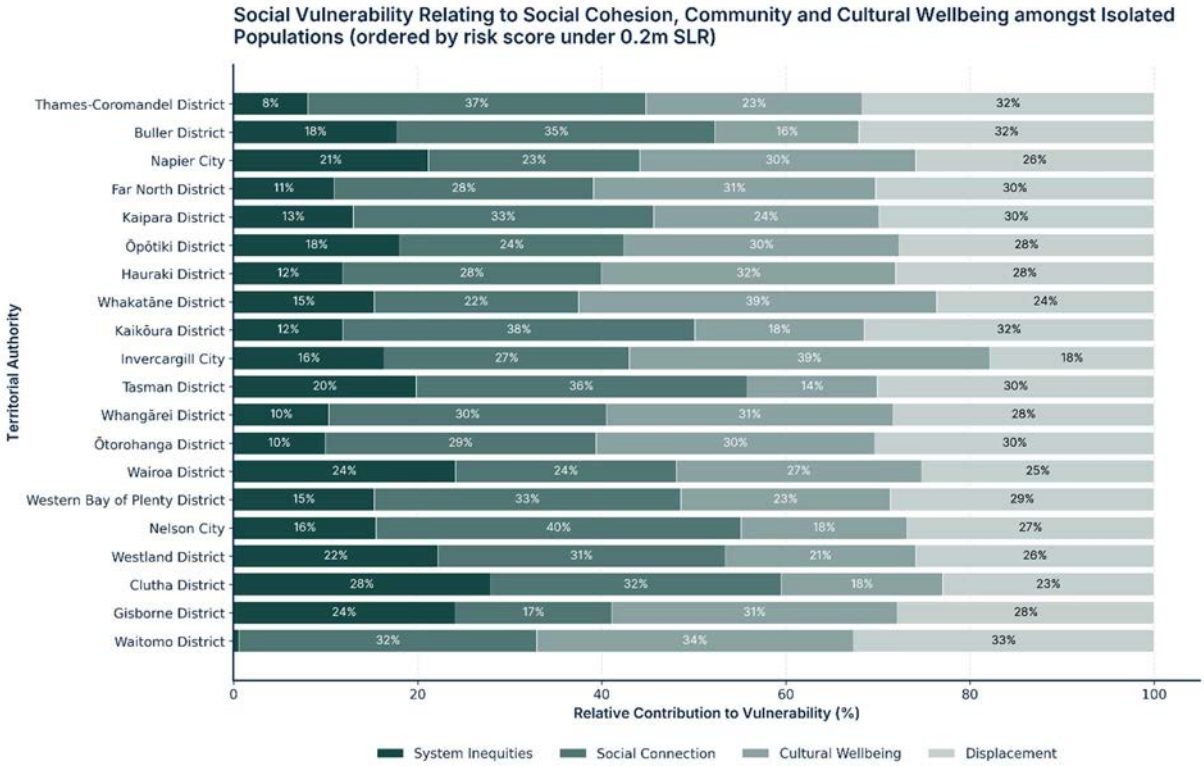

Figure A-26 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative welling outcomes where isolation due to 1% AEP coastal flooding undermines social cohesion, community wellbeing, or cultural wellbeing, under 0.2m SLR. This includes factors associated with people's social connections, experiences of systemic inequities, experiences of displacement, and impacts on cultural wellbeing. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

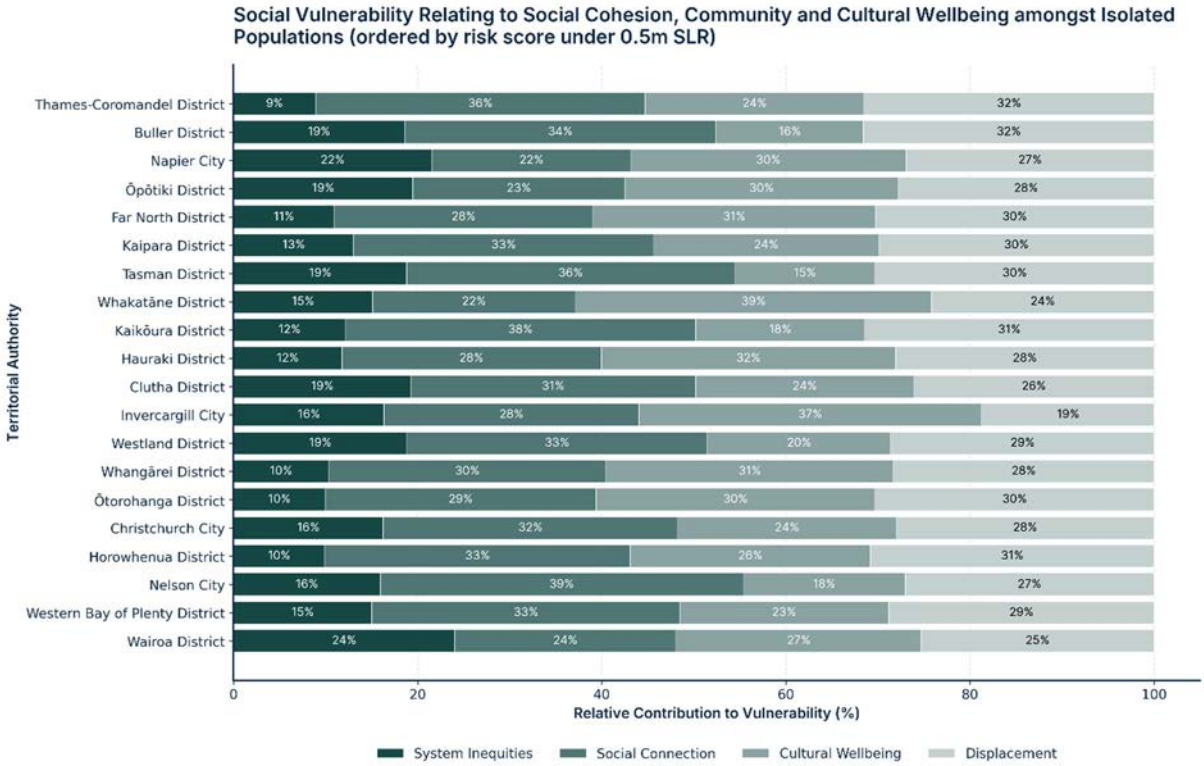

Figure A-27 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative welling outcomes where isolation due to 1% AEP coastal flooding undermines social cohesion, community wellbeing, or cultural wellbeing, under 0.5m SLR. This includes factors associated with people's social connections, experiences of systemic inequities, experiences of displacement, and impacts on cultural wellbeing. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

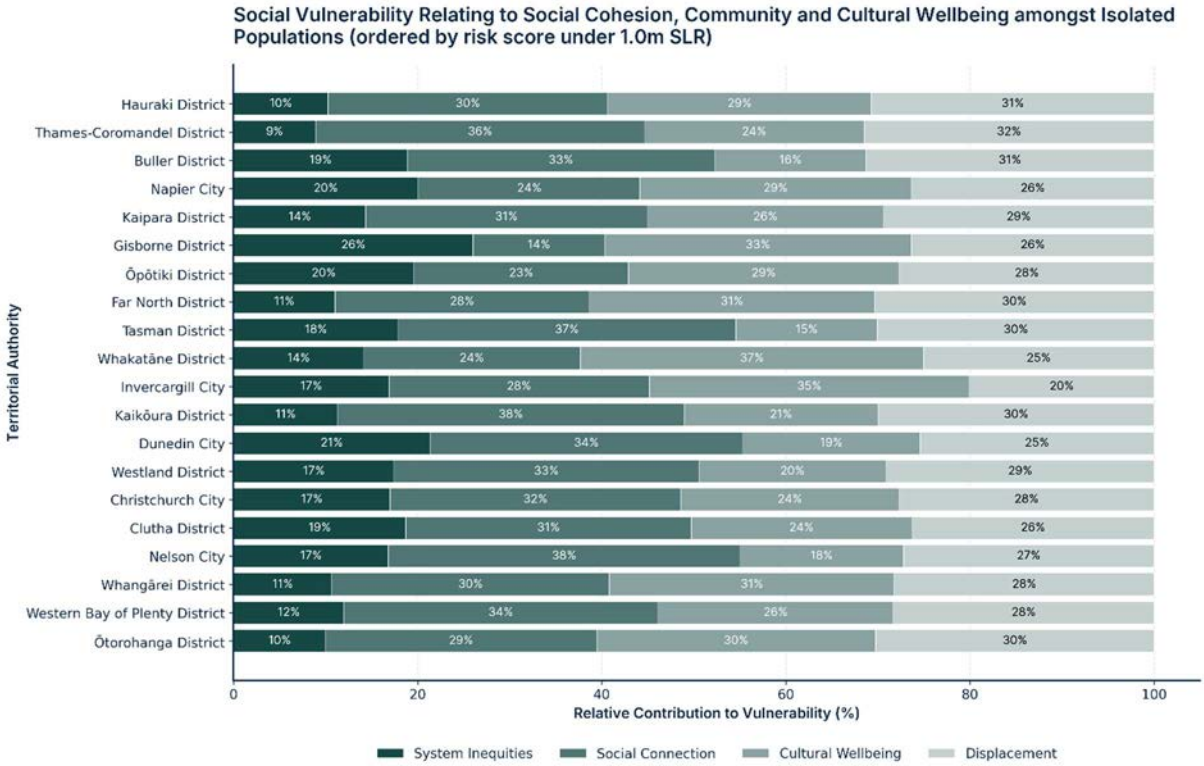

Figure A-28 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative welling outcomes where isolation due to 1% AEP coastal flooding undermines social cohesion, community wellbeing, or cultural wellbeing, under 1.0m SLR. This includes factors associated with people's social connections, experiences of systemic inequities, experiences of displacement, and impacts on cultural wellbeing. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

Isolated Populations - Social Vulnerability Associated with Physical Health

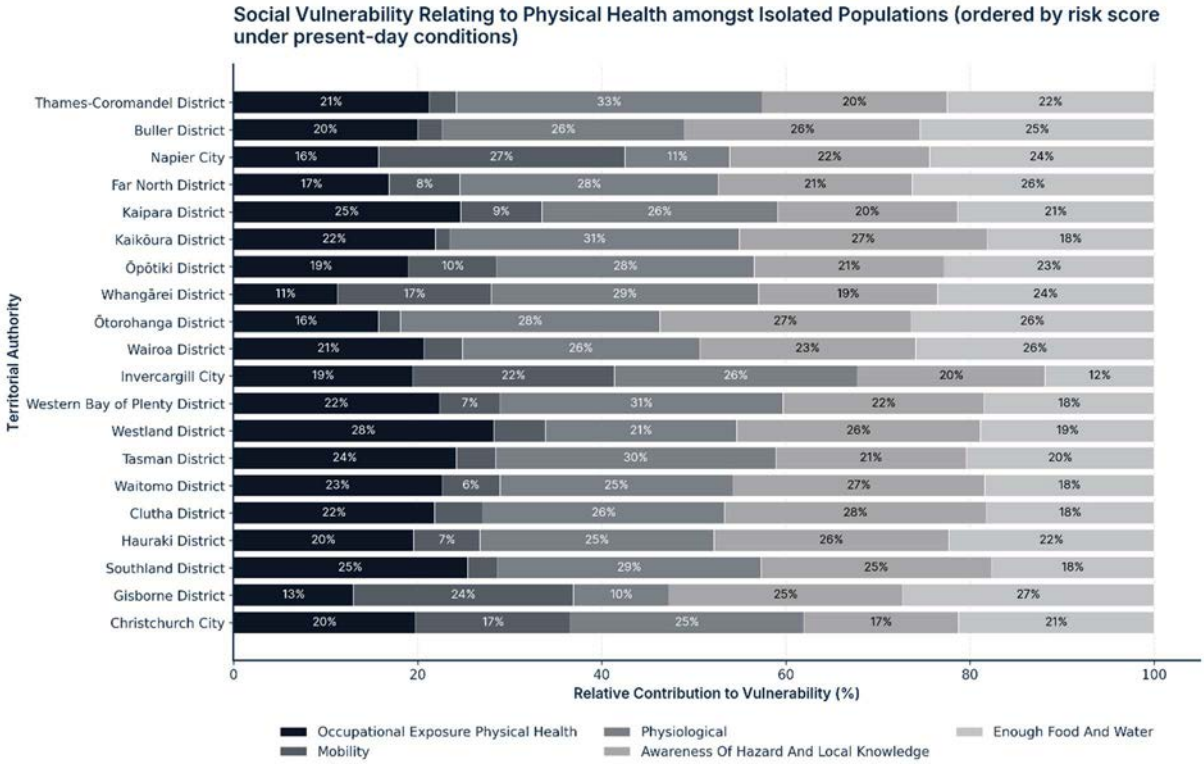

Figure A-29 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative physical health outcomes as a result of isolation due to 1% AEP coastal flooding, under present-day conditions. This includes factors associated with people's occupation, mobility, physiology, awareness of hazard and local knowledge, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

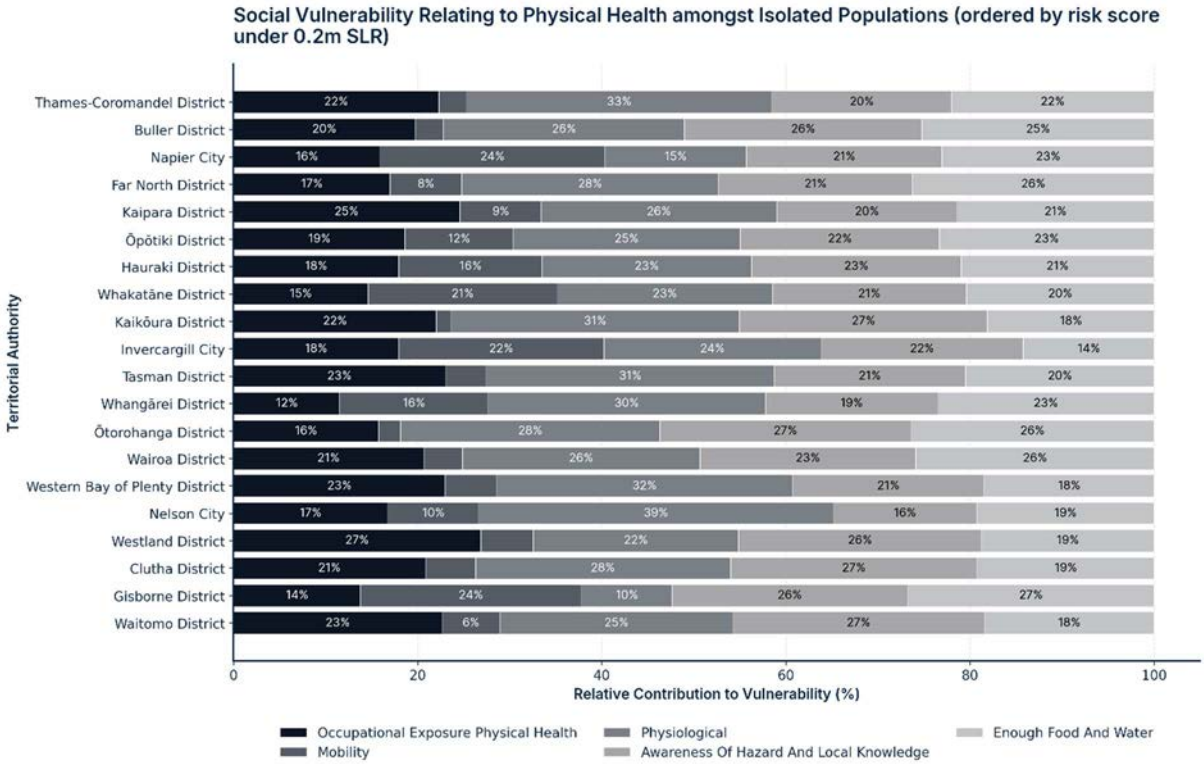

Figure A-30 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative physical health outcomes as a result of isolation due to 1% AEP coastal flooding, under 0.2m SLR. This includes factors associated with people's occupation, mobility, physiology, awareness of hazard and local knowledge, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

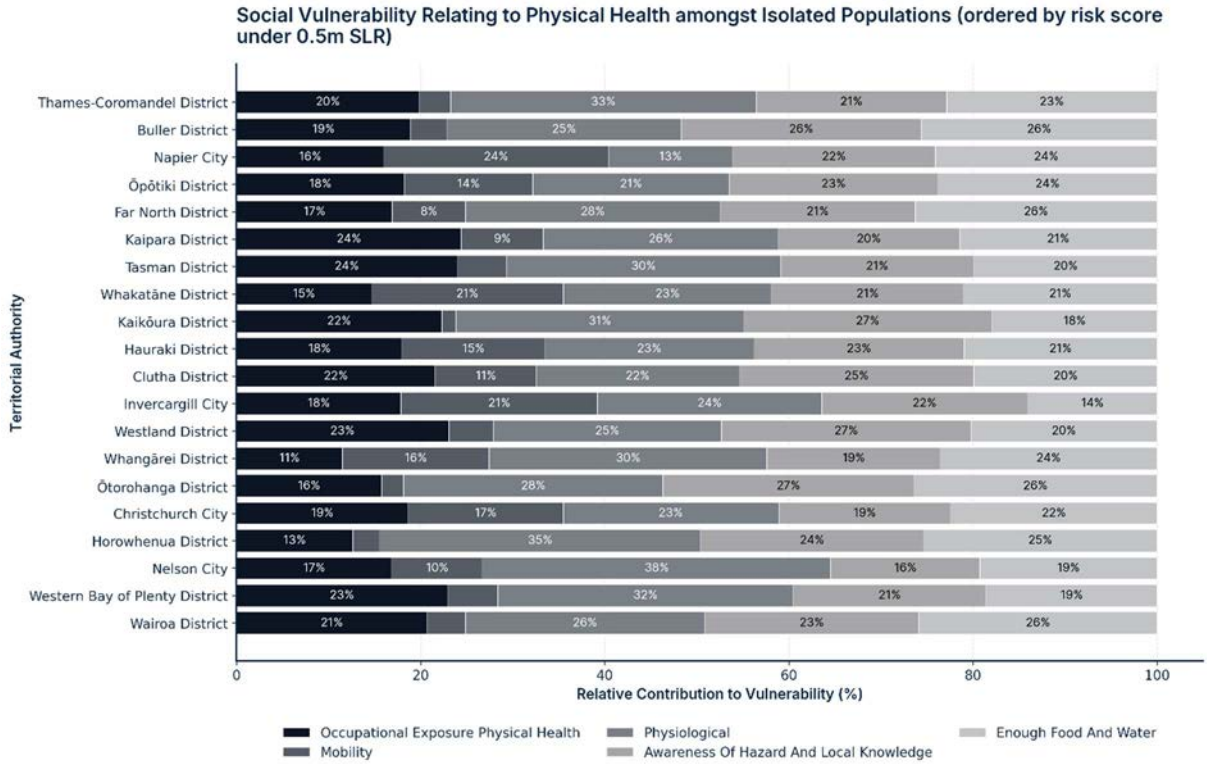

Figure A-31 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative physical health outcomes as a result of isolation due to 1% AEP coastal flooding, under 0.5m SLR. This includes factors associated with people's occupation, mobility, physiology, awareness of hazard and local knowledge, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

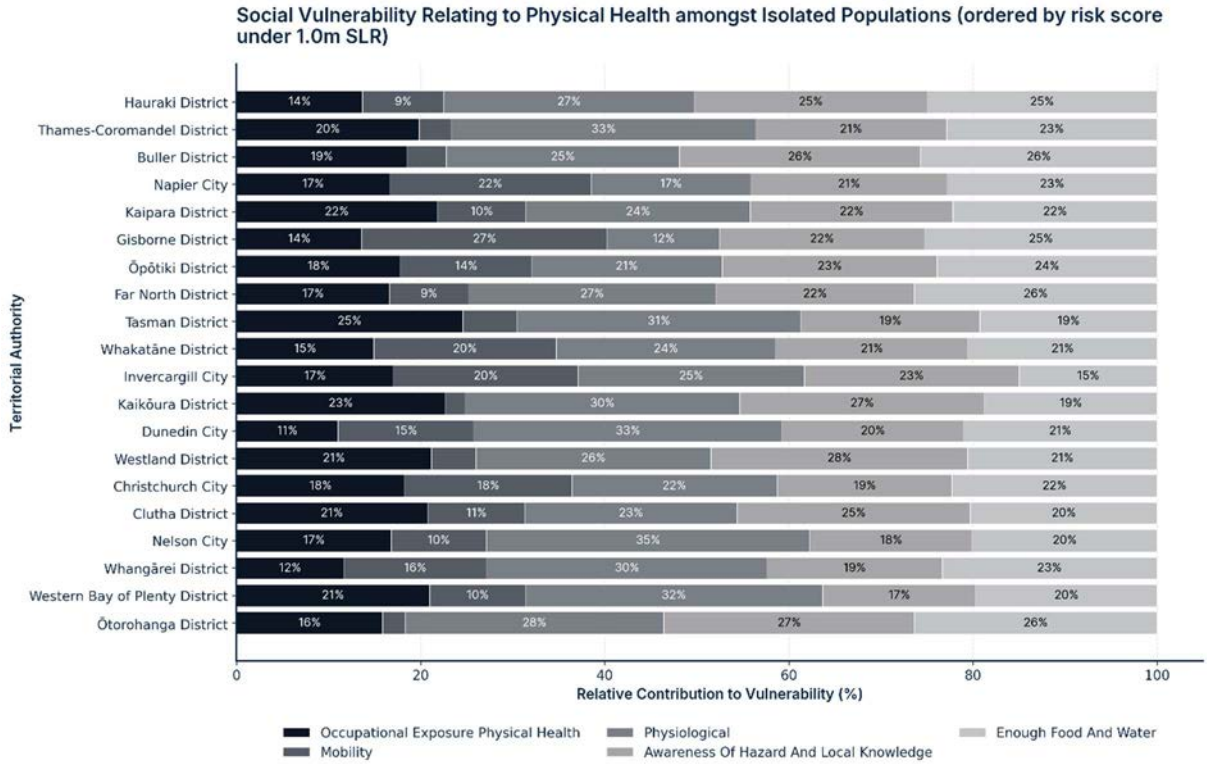

Figure A-32 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative physical health outcomes as a result of isolation due to 1% AEP coastal flooding, under 1.0m SLR. This includes factors associated with people's occupation, mobility, physiology, awareness of hazard and local knowledge, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

Isolated Populations - Social Vulnerability Associated with Mental Health, Identity, Autonomy and Sense of Belonging and Wellbeing

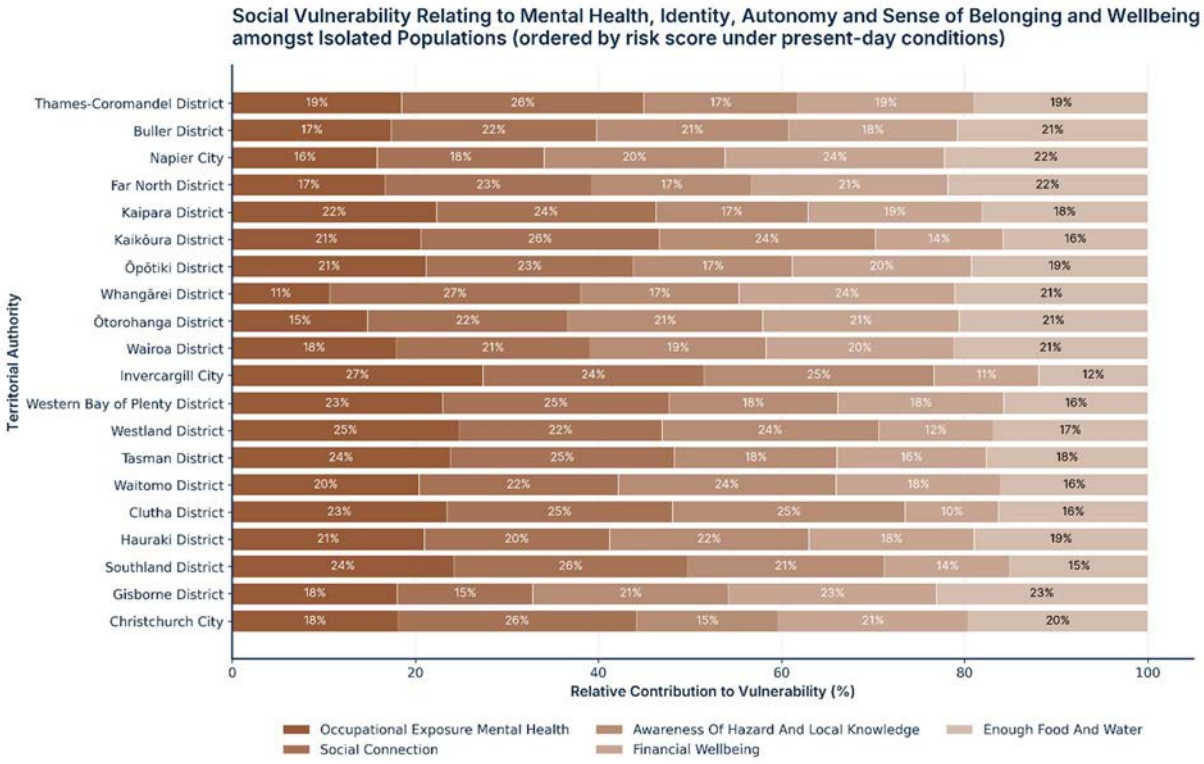

Figure A-33 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative mental health outcomes as a result of isolation due to 1% AEP coastal flooding, under present-day conditions. This includes factors associated with people's occupation, social connections, awareness of hazard and local knowledge, financial status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

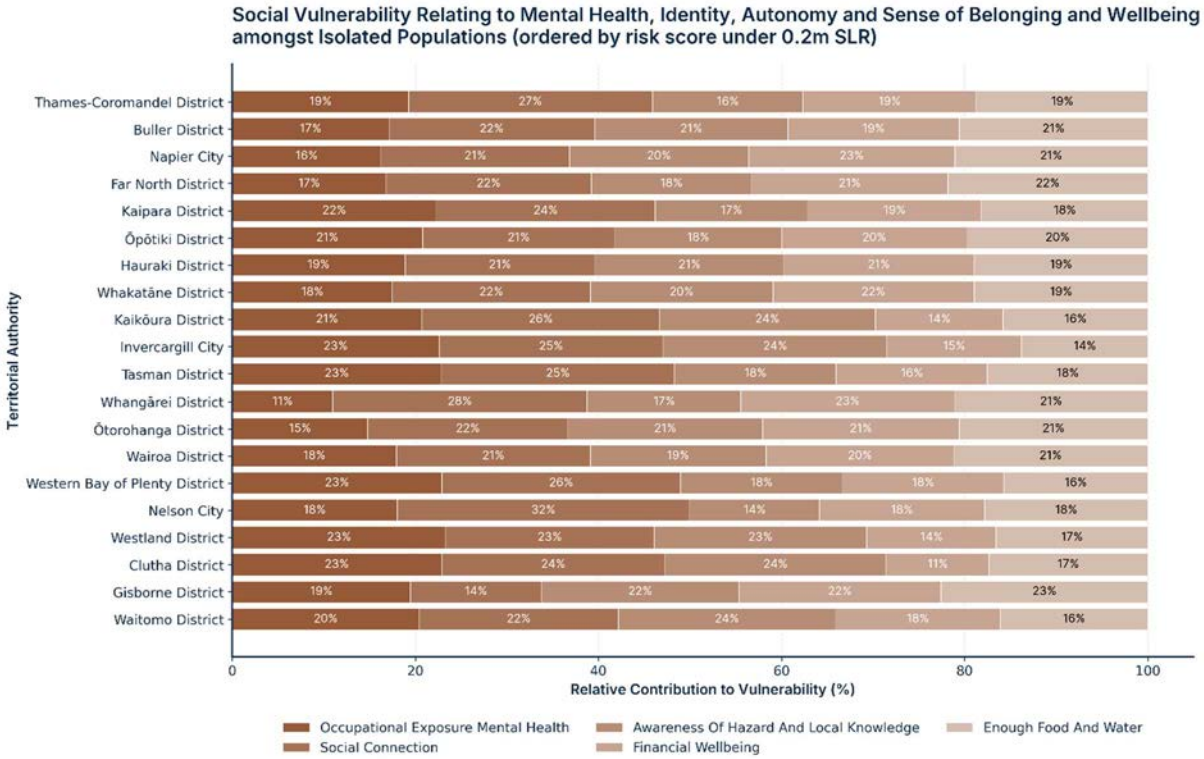

Figure A-34 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative mental health outcomes as a result of isolation due to 1% AEP coastal flooding, under 0.2m SLR. This includes factors associated with people's occupation, social connections, awareness of hazard and local knowledge, financial status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

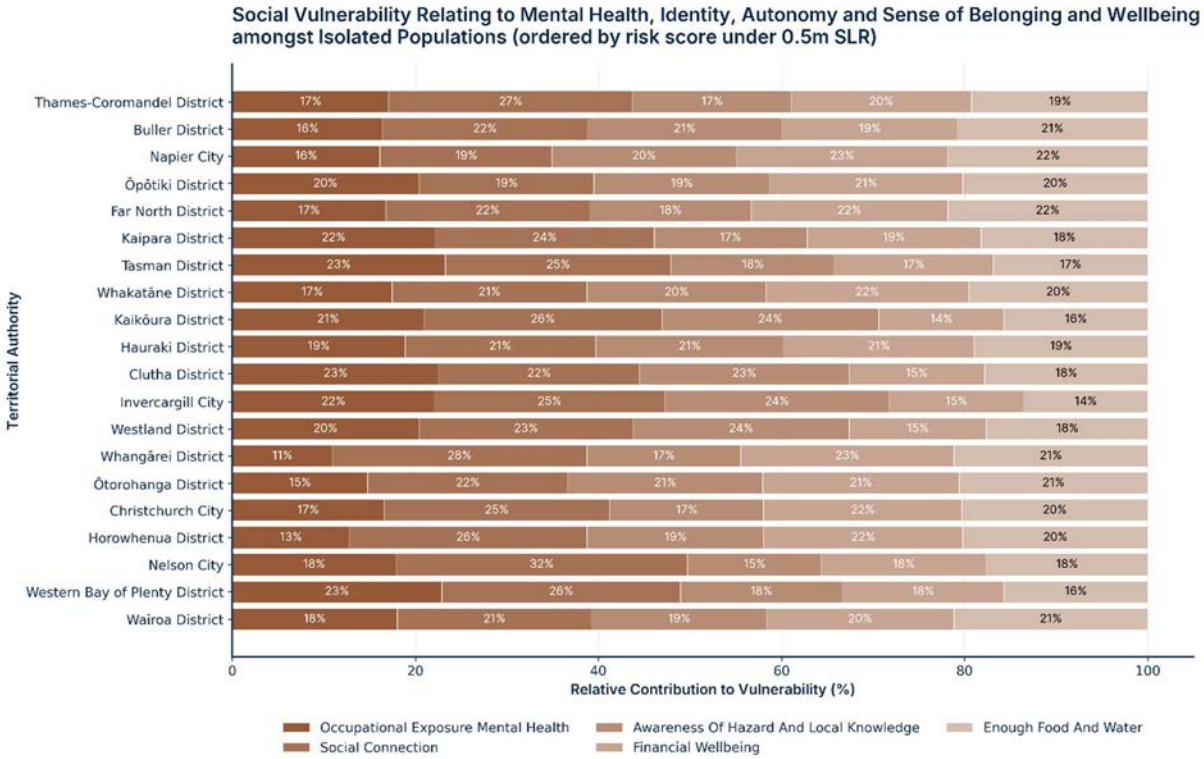

Figure A-35 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative mental health outcomes as a result of isolation due to 1% AEP coastal flooding, under 0.5m SLR. This includes factors associated with people's occupation, social connections, awareness of hazard and local knowledge, financial status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

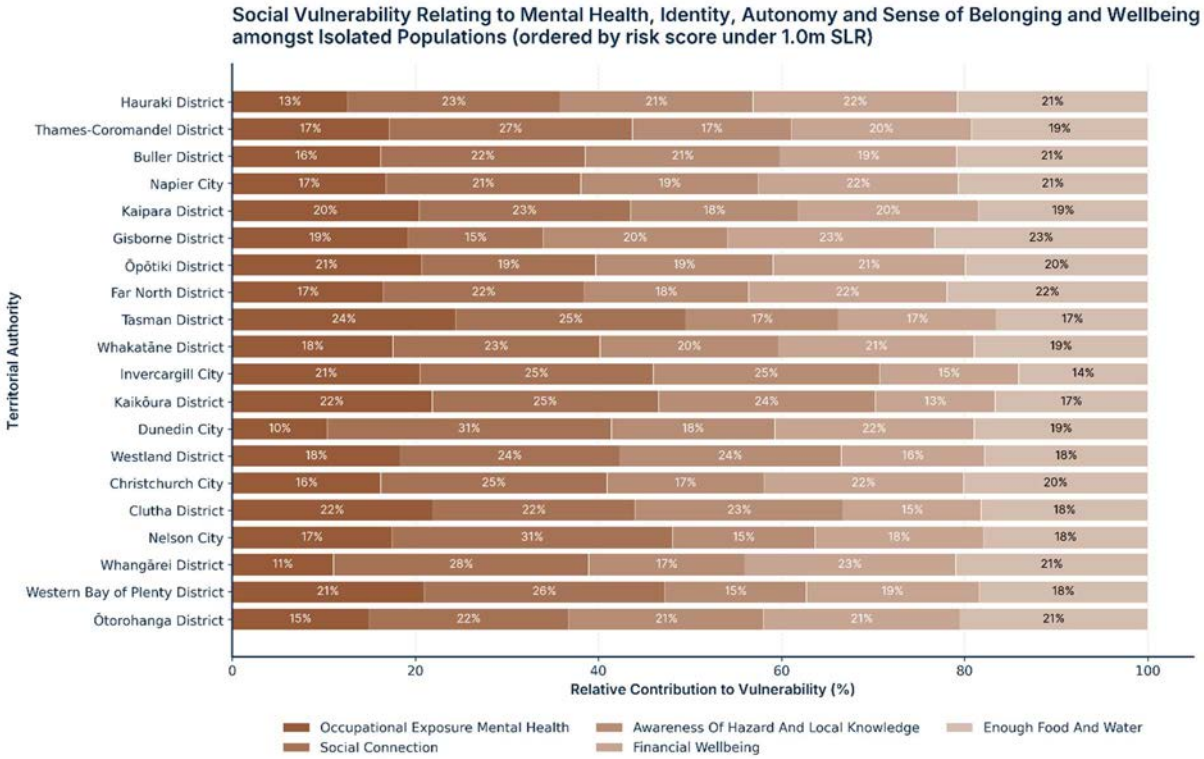

Figure A-36 This figure shows a breakdown of the different reasons why some individuals or groups may be at higher risk of experiencing negative mental health outcomes as a result of isolation due to 1% AEP coastal flooding, under 1.0m SLR. This includes factors associated with people's occupation, social connections, awareness of hazard and local knowledge, financial status, and sufficiency of food and water supplies to cope with a shortage. The top 20 TAs are shown, ranked according to their risk score (i.e. the TAs with the highest vulnerability due to isolation as a proportion of their total population).

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