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Kia manawaroa –
Ngā Ākina o
Te Ao Tūroa

The Resilience Warrant of Fitness Research Programme:

Towards a method for applying the New Zealand Resilience Index in a regional context

Ellie Kay
Joanne Stevenson
Chris Bowie
Vivienne Ivory
John Vargo

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Resilient
ORGANISATIONS
www.resorgs.org.nz

wsp | OPUS

Acknowledgements

Contact Details

Ellie Kay, Resilient Organisations Ltd., ellie.kay@resorgs.org.nz

Dr Vivienne Ivory, WSP Opus, Vivienne.Ivory@wsp.com

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1. Introduction

Resilience is "the ability to anticipate and resist the effects of a disruptive event, minimise adverse impacts, respond effectively post-event, maintain or recover functionality, and adapt in a way that allows for learning and thriving," (National Disaster Resilience Strategy, 2019, p.9). Improving our resilience to disasters is a national priority. Improving resilience begins with understanding where a system is, the desired future state for that system, and through repeated trials and evaluation, building pathways to get there. To find the best pathways toward community resilience in New Zealand, we need to understand where a community's resilience is now and track its progress over time.

Resilience is a complex and largely intangible concept; therefore, it can only be "measured" by observing the properties that might influence resilience (Martin-Breen & Andries, 2011). Characterising resilience by assessing observable assets and characteristics means gathering data points across the many systems that make up a community (Prior & Hagmann, 2014). In a systematic evaluation of 27 disaster resilience assessment tools, Cutter (2016, p.742) found that the most common elements in all of the approaches could be divided into "attributes and assets (economic, social, environmental, infrastructure) and capacities (social capital, community functions, connectivity, and planning)." As a result of this analysis, Cutter (2016) proposes a measurement core for community disaster resilience with a small number of quantitative variables assessing these fundamental elements and capacities. A measurement core provides a useful point to begin assessing baselines for resilience, benchmarking systems against relevant references, and monitoring the progress of resilience improvement.

Researchers and practitioners use a wide range of tools to assess hazards resilience. There are several comprehensive reviews of approaches to measuring resilience (e.g., Ostadtaghizadeh, 2015; Sharifi, 2016; Winderl, 2014). These reviews note that composite indicators have often been employed to assess a wide range of resilience concepts across a number of contexts in a way that is relatively easy to interpret, communicate, and repeat (e.g., Cutter et al., 2010; Hughes & Bushell, 2013; Saltelli, 2007).

New Zealand's Ministry of Civil Defence and Emergency Management (MCDEM) has developed a National Disaster Resilience Strategy (The Strategy) (National Disaster Resilience Strategy, 2019). The Strategy establishes the vision and long-term goals for civil defence and emergency management and proposes a holistic approach to strengthening resilience for New Zealanders. Measurement is a core theme of The Strategy. The Strategy highlights the need to develop robust methods for measuring and showing the impact of decision-making and actions on strengthening resilience. Part of this need was met by this research project: the Resilience Trajectories for a Future Proof New Zealand research programme, part of the Resilience to Nature's Challenges (RNC) National Science Challenge - Kia manawaroa – Ngā Ākina o Te Ao Tūroa funded by the Ministry of Business Innovation and Employment.

The New Zealand Resilience Index

The New Zealand Resilience Index (NZRI) has been developed by researchers associated with the Resilience Trajectories RNC programme, as a way of providing a repeatable, quantitative measure of community hazard resilience. The NZRI was designed to allow the standardised benchmarking and monitoring of disaster resilience across New Zealand. The NZRI provides a standardised quantitative

measure that can be used to track changes in the resilience of communities over time and, if used appropriately, may be used to help target interventions that improve resilience.

Composite indicators, like the NZRI, are relatively simple tools to construct. In practice, however, it is difficult to access the quantity and quality of data needed for statistically meaningful and representative analyses (Saltelli, 2007; Seville & Wilson, 2006; Stevenson et al., 2018). There are necessary trade-offs between quality and practicality (Stevenson et al., 2018). As a result, most indices that draw on nationally consistent datasets are only able to present a high-level, generic view of resilience and have limited applicability as decision-support tools (Barnett et al., 2008; Stevenson et al., 2018).

If a tool like the NZRI is going to be used to guide resilience interventions, help prioritise funding, or support decision-making in communities, it should be better integrated with local contexts and supported by more nuanced data. To push the boundaries of the NZRI and explore ways in which the index could be applied in a New Zealand community the RNC's Resilience Trajectories research programme designed the Resilience Assessment Warrant of Fitness (WOF) programme.

1.1. Resilience Assessment Warrant of Fitness Programme

Consideration of the way decision-makers would like to use assessments like a resilience index is an often-neglected component of the construction and refinement of these tools. Without user consultation, there is a risk of producing a tool that is interesting but impractical for those designing and implementing resilience intervention programmes and allocating funding to disaster risk reduction and resilience activities.

The Resilience Assessment WOF was designed to 'road test' and refine the NZRI through a community case study and to develop a framework for general use, while adding value to resilience planning in a partner community. The goals of the programme were to:

1. Assess the efficacy of the NZRI to guide community resilience planning and decision-making.
2. Work with co-creation partners to enhance the capacity of the NZRI to guide resilience planning and decision-making.
3. Develop an engagement framework and method for consistently deploying the NZRI within a NZ community context.

1.2. Report Structure

This document does not provide a comprehensive explanation of the methodology behind the NZRI's development. For a detailed explanation on the development of the NZRI, see Stevenson et al. (2018). Rather, the purpose of this report is to describe the application of the NZRI to a regional context.

First, the report includes an overview of the New Zealand Resilience Index, including the selection of indicators, the calculation and weighting of the index, and the visualisation process. Next, a description of the methods applied to the WOF case study is discussed, including the engagement process with a co-creation partner. The remainder of the report is structured around the three Resilience WOF programme objectives: assessment of the NZRI in a local setting, enhancement of the NZRI to guide planning and decision-making, and the development of an engagement framework and methodology. Finally, a discussion of the results and conclusions and next steps for the NZRI are considered.

2. Developing the New Zealand Resilience Index

The New Zealand Resilience Index (NZRI) is a tool that measures factors that are likely to influence and community's resilience outcomes. The NZRI combines indicators of resilience across seven capitals: built, economic, environmental, governance, cultural, social, and human. Each capital contributes to the ability of a society to function, learn, and adapt in the face of disruption.

Helpful Definitions

Capital	The resources and characteristics from which a community receives benefits.
Resilience Concept	Describes the processes that are thought to contribute or detract from resilience. Concepts are not measures, they are labels of abstract ideas or theories.
Indicator	An observable set of criteria that points to, measures, or otherwise summarises a concept. Indicators (unlike concepts) can be converted into measurable metrics or variables.
Metric	Precise definitions of a concept in empirical terms that are ready for data collection.
Index or Composite Indicator	The combination of several indicators into a single measure, which attempts to reduce the complexity of a system or phenomenon (like resilience) to a number which can be used to reliably track variations within and across the system.

The NZRI was developed in line with the Ministry of Civil Defence and Emergency Management's National Disaster Resilience Strategy (The Strategy). Similar to the NZRI, The Strategy uses a multi-capital approach[1]. The NZRI is included in the Monitoring and Evaluation Framework of The Strategy. This is important, as it links New Zealand's resilience goals to the actions being taken on the ground by local groups. Measuring resilience at the national, regional, and local level using a consistent framework will mean that we can more meaningfully compare progress and learn from one another's successes and failures.

The NZRI is built on national and international research and theory. Over 30 resilience tools were analysed in-depth, resulting in a database of around 1600 indicators of resilience to be assessed for inclusion in the index. These indicators were categorised into distinct resilience concepts. Each concept describes an observable process, asset, or attribute that influences resilience. For example, household economic health can be tracked using quantitative metrics, and gives us some insight into households' financial capacity to respond to and recover from disruptions.

In the construction of the NZRI we prioritised concepts that:

- Aligned with The Strategy.
- Are relevant in a New Zealand context.
- Are relevant across a range of potential hazards (i.e., we did not consider or include specific hazard exposure assessment concepts).

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[1] Within The Strategy the human and social capitals are combined, resulting in six, rather than seven, capitals.

To consistently measure resilience across the country over time, we developed criteria to help determine what kinds of indicators should be used to measure the resilience concepts[2] (see Table 1). To facilitate consistent comparisons across time, the baseline indicators for the NZRI need to have quantitative (or quantised qualitative) metrics, consistently available at a standard geographic area (e.g., Census Area Unit (CAU)), and collected regularly. Indicators additionally needed to be measurable pre-disaster and sit within the six capitals outlined in The Strategy.

Table 1. Assessment process for selection of indicators in the NZRI.

Focus and phase	The indicator measures resilience in terms of 'means' (factors that contribute to resilience) rather than 'ends' (outcomes of resilience) and can be measured prior to a disruptive event.
Scale	The indicator is relevant to the scale of assessment (e.g., CAU*) and remains valid across scales (e.g., local to national).
Relevance	There is a clear logical relationship between the indicator and hazard resilience outcomes. Ideally, it has been verified in the academic/professional literature.
Purpose	The indicator can track change and variability in natural hazard resilience and can compare the level of resilience across space and time.
Data	The indicator measures resilience in a quantitative way, and is clear and simple in its content, purpose, and focus. Data is readily available at the required spatial scale and for the period of interest.

* NB. CAUs (Census Area Units) are a standard unit for data collection and are likely to capture a community. In general, they map on to suburb in urban areas, and are much larger in rural areas.

2.1. Selecting Resilience Concepts and Indicators

Finding indicators that meet all of the criteria in Table 1 is difficult in practice. Many concepts cannot be measured consistently at a sub-national level. One of the consistent challenges in the creation of resilience indices is data availability. For the most part, data is simply not captured or managed with 'resilience indicator' needs in mind. Data that is available may not be catalogued and publicly searchable or may be held by private organisations. There is often a significant gap between what data is needed to provide a holistic view of resilience and what can actually be measured using data that is publicly available.

For the baseline NZRI we sought free publicly available datasets with national coverage, ideally at the CAU level. Some compromises ultimately had to be made, with some data purchased (equivalised household income via Statistics New Zealand) and other indicators composed of datasets collected by researchers which are not openly available for public use (infrastructure disruption and local/regional hazard planning via external research groups).

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[2] These parameters were set using the Kickstart 2 Measurement (K2M) process (Ivory and Stevenson, 2017).

To develop a working model for the NZRI a subset of indicators for which data could be accessed were selected from the long list of resilience concepts. The indicators included in the New Zealand Resilience Index are shown by capital below in Figure 1.
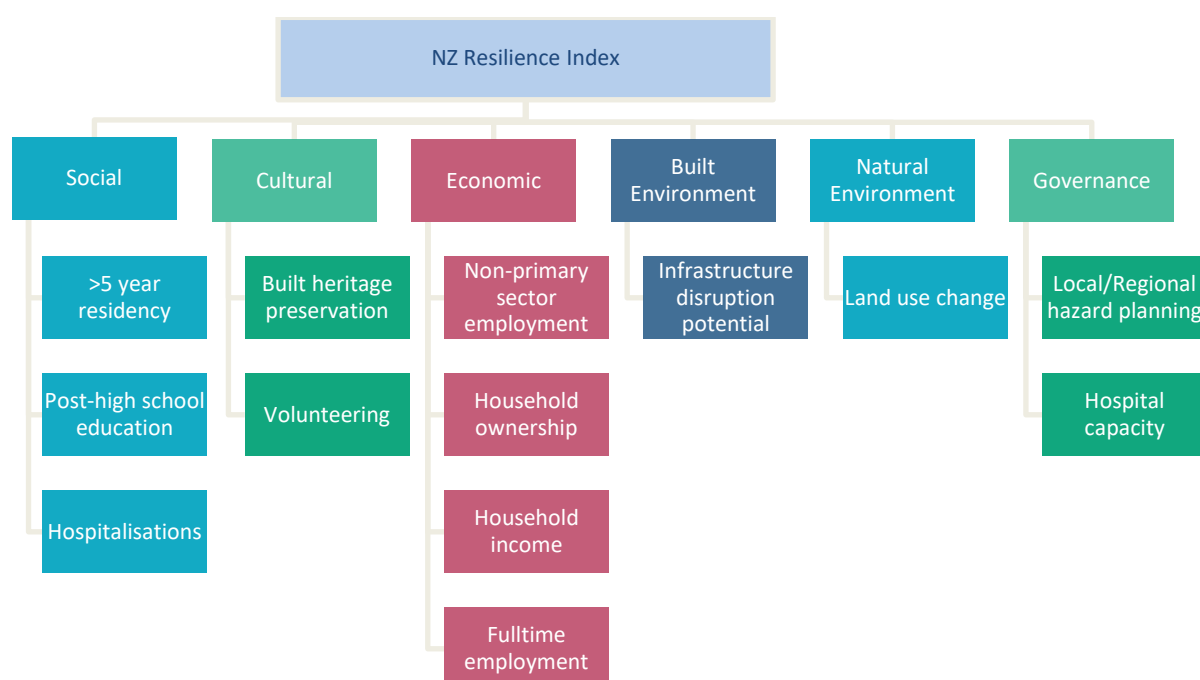

Figure 1. The 13 indicators included in the New Zealand Resilience Index categorised by capital.

2.2. Calculating the NZRI

Each indicator in the NZRI was normalised, compared to a benchmark, and weighted. Once this was complete, the NZRI was calculated and visualised using geographic information software.

Normalising the Data

The indicators in the NZRI must use numerical data, and for each indicator a 'benchmark' value is used to calculate values for each CAU in New Zealand. These benchmarks ensure that the indicator values for each area is comparable with other locations, and within the same location over time.

In many instances, the benchmark value was simply 100% (e.g., percent working age residents engaged in fulltime employment). Other benchmarks are set to a specific value (e.g., 10 hospital beds per 1,000 people). Calculations of the benchmarks, as described above, are included in Table 2, using two hypothetical areas. For the NZRI, all indicator values are set to a range of 0-1.

Table 2. Example of benchmark calculations in the NZRI.

Fulltime employment			
	Observed value	**Benchmark**	**NZRI value**
Area 1	85%	100%	0.85
Area 2	55%	100%	0.55

Hospital beds per 1,000 people			
Area 1	6 per 1,000	10 per 1,000	0.60
Area 2	8 per 1,000	10 per 1,000	0.80

All indicators are calculated positively; that is, higher values are better. All indicators have been transformed to meet this criterion. For example, "preservation of heritage sites" was derived from a dataset of lost registered heritage sites with a benchmark of 0% loss. To transform this, the indicator was calculated using a benchmark of 100% preservation expressed as: 100% - % loss. This example is shown in Table 3.

Table 3. Example of heritage preservation calculation

	% loss	% preserved (NZRI value)
Area 1	20%	0.80
Area 2	60%	0.40

The actual value of the benchmarks is arbitrary, so long as the value is used consistently for all areas and over time. If the value of any benchmark is modified between measurement years, a retrospective change should also be made to prior years to allow for monitoring of trends over time. It is also important to note that benchmarks are not targets for areas to aspire to, and in most cases it will be impossible to achieve 100% of a benchmark value. These are statistical constructs only and care should be taken when communicating these externally.

Expert Weighting

Some indicators may be more important (i.e., contribute more) to resilience than others, and so indicators within the NZRI were weighted using 1000 Minds (www.1000minds.com), a multi-criteria decision-making software app. A total of 89 resilience and disaster risk reduction experts from around the country participated in an expert weighting exercise to determine the weights of the indicators included in the NZRI[3]. The weights obtained from this exercise were directly applied to the relevant NZRI baseline indicators by multiplying the observed value by the indicator weight for each CAU.

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[3] For a full report on the 1000 Minds weighting exercise, see Kay et al. (2018).

Table 4. Resilience concept weights following expert weighting exercise.

| Resilience concept	Resilience capital	Weight
Buildings safety and functionality following a disruption	Resilience of the Built Environment	11.7%
Network infrastructure resilience (roads, electricity, water and wastewater)	Resilience of the Built Environment	11.5%
Levels of community networks and sense of belonging	Social Resilience	11.3%
Personal resilience capacities of individuals (e.g. education, physical and mental wellbeing)	Social Resilience	10.5%
Health system response capacity	Governance of Risk and Resilience	8.9%
Household capacity to cope with economic disruption	Economic Resilience	8.9%
Quality of legislation and plans addressing hazards	Governance of Risk and Resilience	8.0%
Household emergency preparedness	Social Resilience	6.7%
Economic diversity (businesses from several different sectors)	Economic Resilience	6.4%
Availability of natural buffers (e.g., green space, undeveloped flood plains)	Resilience of the Natural Environment	6.2%
Community access to shelters and welfare centres	Governance of Risk and Resilience	5.3%
Heritage and culture are valued and preserved	Cultural Resilience	4.7%

Visualising

Once the data was processed, weighted, and aggregated, it was visualised using geographic information software, showing the relative resilience of each area across the country.

Figure 2 shows the comparative resilience of communities in New Zealand using the baseline NZRI. CAUs are grouped into quintiles; quintiles are groups of equal size (n = ~365, 20% of all areas in each group) where quintile 1 is the "least resilient" and quintile 5 "most resilient" based on the NZRI calculation. That is, the darkest areas on the map are comparatively more resilient than the lightest areas on the map. This does not mean that the darker areas on the map have the best resilience scores possible, it simply means that they are higher compared to the lighter areas; an important distinction.

Some areas in Figure 2 had too much missing data to say anything meaningful (shown in grey). The populations in these areas are too small to include social and socioeconomic information, and so are omitted from the figure.

Limitations of the NZRI

The results of the NZRI are heavily dependent on the available data, and the current resilience scores are both partial and preliminary. There are other aspects of resilience that we would like to assess in greater detail but are currently unable to with presently available data. Additionally, choices of categories of resilience and the aggregation of these categories across the capital domains were also subjective exercises. Care was taken in the choices made, and these are outlined in detail in supplemental material[4]. Nevertheless, different choices may have resulted in different results, and interpretation of results should be made with care, and cognisant of the definitions adopted.
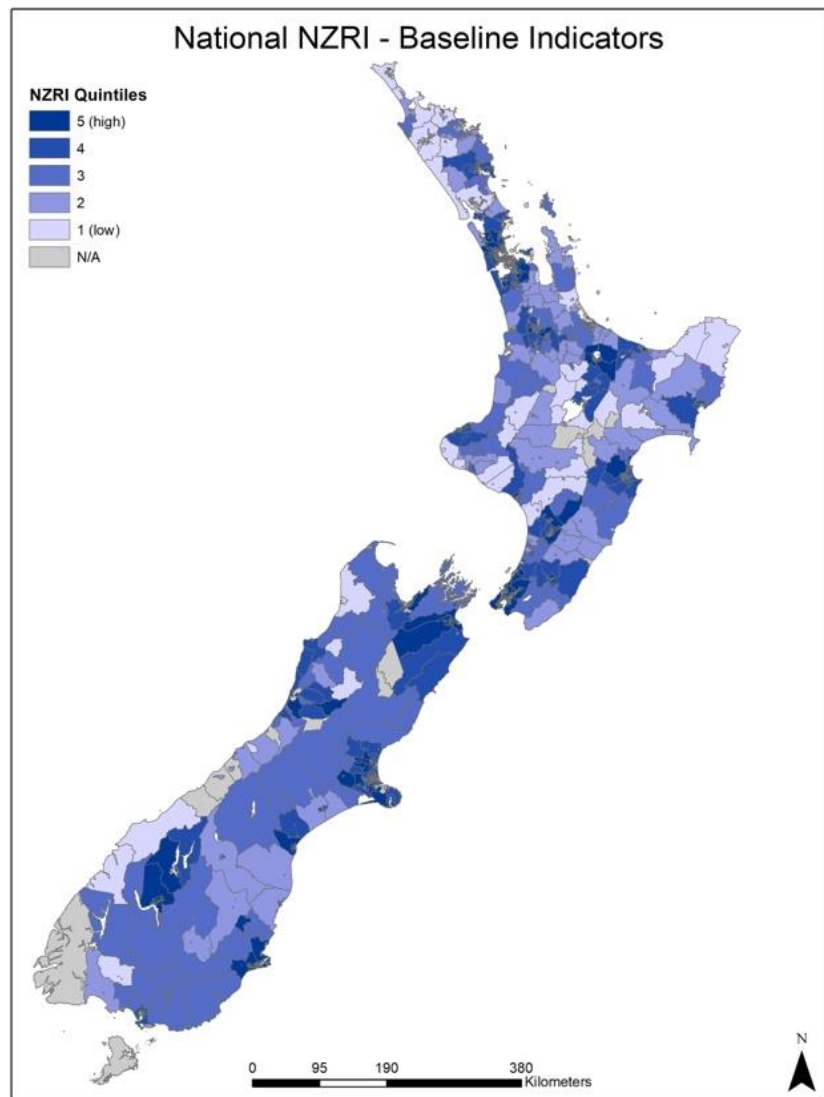
Figure 2. NZRI Scores shown by quintiles with 5 representing areas with the highest baseline scores and 1 with the lowest baseline scores. Note: CAUs vary in size based on population. More densely populated areas have smaller CAUs. As a result, it is not easy to the see variation within urban areas using a national map.

While the NZRI is theoretically sound, it has not been validated using pre- and post-disaster comparisons to see if resilience (e.g., in terms of speed and completeness of recovery) can be reliably predicted using the index. It has also not been tested in a policy context to determine how it might be applied to funding decision-making or intervention design. Additionally, due to data availability, there is also not yet a longitudinal database of changing resilience scores over time.

One of the major limitations with the 13-indicator NZRI is the small number of indicators that are included (due to data availability issues). The authors hope that more open data sharing will soon allow for the population of additional indicators at a national level. Nevertheless, the 13-indicator NZRI begins to form a picture of place-based community resilience, providing a macro-perspective

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[4] See Stevenson et al. (2018) & Stevenson et al., (2019) for detailed background on the development of the NZRI.

on community resilience. In general, composite indicators are only able to capture some of the complexities of a community and should ideally be supplemented with regional or local-level data.

Interpretations of the NZRI

The NZRI was developed to easily visualise a quantitative representation of resilience and to clearly show variations across space and time. As a baseline tool for facilitating a national conversation, the NZRI presents a way of thinking about resilience as the responsibility of many parts of society (not just the civil defence and emergency management authorities). Decisions about hazard resilience initiatives need to engage decision-makers and actors across the social, cultural, economic, built, natural, and governance environments.

The national NZRI shows the variation in resilience across the country. With continuing development, the NZRI may be used to help allocate funds to resilience building programmes. When the NZRI is combined with high-quality hazards data it can also be used to identify "hot spots" for targeted programmes. For example, an area may have high risk of residential losses from flooding with low built and economic resilience but high social and cultural resilience, and therefore may be a good candidate for a community-managed building enhancement or relocation programme.

3. Resilience Assessment Warrant Of Fitness (WOF) Methods

The Resilience Warrant of Fitness (WOF) programme was designed to assess the New Zealand Resilience Index in a setting in which it could measure and inform community action. We explored a range of case study partners including government agencies, local and regional Civil Defence and Emergency Management (CDEM) groups, and place-based residential communities. Ultimately, we partnered with Wellington Regional Emergency Management Office (WREMO), a "semi-autonomous" organisation that coordinates civil defence and emergency management services on behalf of the nine local councils in the Wellington Region (WREMO, 2019). Through their coordinating role for councils in the region, WREMO acts as both an oversight body and is in a position to implement resilience, risk reduction, and readiness initiatives across the region (e.g., the tsunami blue lines project (Leonard et al., 2008), establishing a network of community emergency hubs, and distributing water storage tanks to private citizens (WREMO, 2018a)).

3.1. Engaging a Co-creation Partner

When the collaboration was initiated in April 2018, WREMO was in the process of developing their regional CDEM Group Plan for 2019-2024; a strategic document that guides the group for five years following the plan's implementation. During the development of the Group Plan for 2019-2024, WREMO conducted extensive engagement with stakeholders in the Wellington Region CDEM Group, which includes the nine councils, as well as emergency response agencies and lifelines utilities. Initial engagement and scoping for the Group Plan reviewed plans and capabilities in reduction, readiness, response, and recovery.

As part of the development of their Group Plan, WREMO staff identified a need to develop a comprehensive yet manageable framework of indicators for tracking their progress. The indicators

needed to not only measure the quality and completion of Group Plan outputs and outcomes but also reflect progress toward WREMO's vision of building a more resilient region. In April 2018, WREMO staff reached out to Resilience to Nature's Challenges researchers to gain insights into the process of indicator selection that would meet the needs they saw emerging from the WREMO Group Plan development.

3.2. Collaborative Process

The objective of the collaboration with WREMO was to develop indicators that fit with the existing structure of their Group Plan and to assess the possible applications and limitations of the NZRI in this context. A series of brief scoping meetings were held in May 2018 to determine the nature of WREMO's needs and the kinds of input the researchers should provide. The process of refining WREMO's assessment priorities was guided by the Kickstart 2 Measurement (K2M) tool, a heuristic process developed to guide people through complex conversations about resilience measurement (Stevenson et al., 2018). Two members of the research team conducted an initial K2M workshop with four key WREMO staff and nine experienced hazards and resilience researchers. The K2M tool progressed the group through several steps to refine an approach to resilience assessment and monitoring based on WREMO's specific needs. The steps included defining a purpose, determining focus areas, specifying desired outcomes, selecting and prioritising indicators, and linking to data.

To assess whether the framework underpinning the NZRI adequately covered the key concepts in resilience assessment that were relevant in a Wellington regional context, each workshop participant was provided with a list containing key resilience concepts and potential indicators selected from a bank of indicators established during NZRI development (Stevenson et al., 2019). The indicators were categorised into The Strategy's six community capitals of resilience. The group considered one capital at a time and, working alone, were asked to select the indicators that they believed were likely to have the greatest impact on resilience outcomes in the region. Members of the group were encouraged to consider any indicators that may be missing from the list, and to include these in their selections. Once all members had picked their indicators, the group reconvened to discuss the selections. All members were asked to identify to the group which indicators they had selected and their reasons for their selection. Each response was tallied to determine the indicators that received the most votes. This process was repeated for all six of the resilience capitals.

Following the workshop, participants' votes and comments were aggregated. Thematic content analysis was used to derive ten indicator categories, which aligned with the capitals outlined in The Strategy. This was refined through a series of discussions with the working group to examine how the indicators fit within the existing framework of the WREMO Group Plan. Between June 2018 and February 2019, the WOF researchers and WREMO staff collaboratively progressed a model of resilience assessment that both met the needs of WREMO's Group Plan (2019-2024) and an expanded NZRI that could be applied in local and regional contexts across the country.

4. Resilience Assessment WOF Findings and Outcomes

Through our collaborative engagement with WREMO we began the process of 'road testing' the New Zealand Resilience Index in a context in which it could be applied to guide resilience planning and action. While there are many different contexts that would provide different insights, this initial engagement allowed us to see how a regional CDEM group might interpret and apply the NZRI to achieve their goals and allowed us to develop a template for working with local and regional authorities to improve and apply the index.

4.1. Objective 1: Assess the NZRI in Local Application

The first objective of the Resilience Assessment WOF programme was to assess the efficacy of the NZRI to guide resilience planning and decision-making. Through the engagement with WREMO we found that:

- The baseline NZRI results for the Wellington region (using the 13 indicators discussed in Section 2) aligned with what WREMO staff expected to see based on their experience and knowledge of the region. Although this was only a "gut-check" response, it was useful to know that the NZRI was not noticeably misaligned with expert knowledge of different neighbourhoods' likely ability to respond, recover, and adapt in the face of hazards.
- The NZRI is only useful for assessing broad level resilience outcomes and can only be repeated every five years due to a reliance on census data. Additionally, indicators using researcher datasets may not be updated in this time and may need to be replaced with other datasets. It may be difficult to tie WREMO activities to changes in the NZRI results over time.
  - Further works should embed the NZRI in a larger programmatic monitoring and evaluation framework to ensure the regular updating of the data. This could be achieved at both a national and regional level, though national level monitoring and evaluation will allow for comparison across space.
  - There is a need to augment the NZRI with indicators that are more specifically related to WREMO activities and that can be collected more frequently. These indicators can be integrated into the NZRI (as described in Appendix 1) or assessed on their own on a regular basis as part of an annual programme evaluation. For example, indicators such as the proportion of total households with at least three days of emergency water available, is an indicator that WREMO could collect regularly with a regional survey. This would both supply information relevant to the household preparedness concept in the NZRI but also relates directly to WREMO programmes to enhance household preparedness.

4.2. Objective 2: Enhancing the Capacity of the NZRI to Guide Resilience Planning and Decision-making

The WREMO group plan had a total of 55 outcomes related to community resilience and provides focus for Disaster Risk Reduction in Wellington. In order to enhance and guide resilience planning and decision-making, a thematic analysis of WREMO's group plan outcomes was conducted and metrics for each outcome were developed. The Group Plan outcomes were then compared to the NZRI indicators bank for similarities. Figure 3 shows the comparison between two outcomes in the

Group Plan, showing its linkage to the concepts within the NZRI Indicators Bank that would improve understanding of resilience in the region. As an organisation that has large stakes in building resilience in the Wellington region, this exercise provided WREMO with an opportunity to identify data that monitors the Group Plan outcomes while simultaneously helping to improve the understanding of Wellington region's resilience. The linkages in Figure 3 were conducted for all 55 Group Plan outcomes. Further work will need to be conducted by WREMO to collate appropriate secondary data, or collect primary data, that will monitor their Group Plan outcomes.
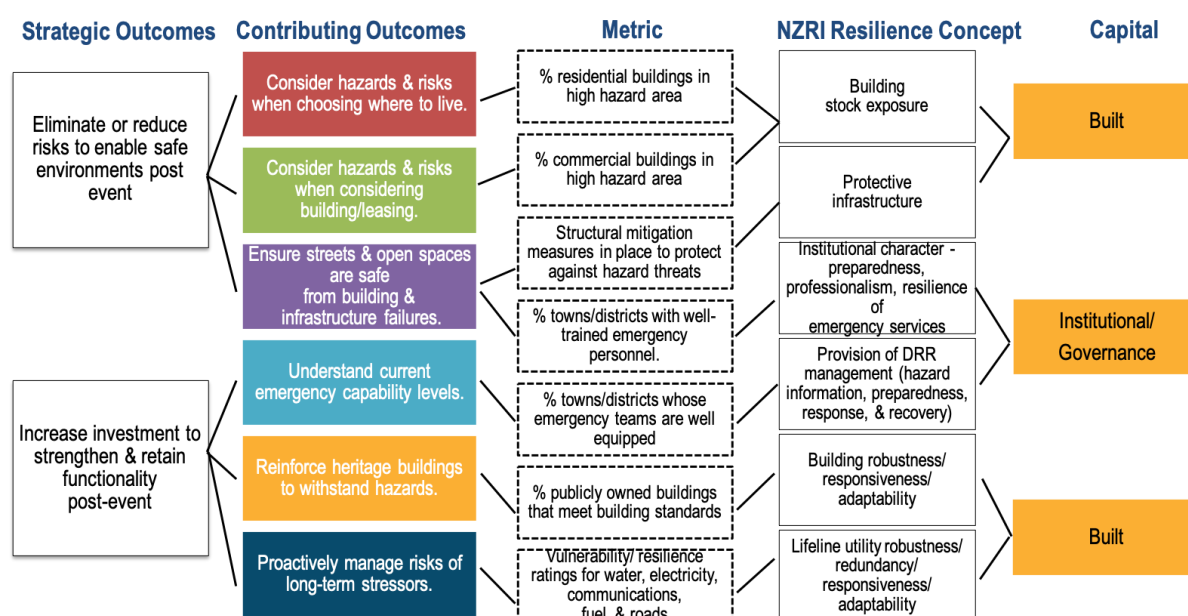

Figure 3. WREMO Group Plan outcomes and connections to the NZRI Indicators Bank.

The collaboration with WREMO showed that the NZRI can be useful in its capacity to align with regional planning and provide a mechanism to assist planning, prioritisation and decision-making.

4.3. Objective 3: Developing an Engagement Framework and Method

One of the main goals of the WOF programme was to develop an engagement framework and method that could be used to consistently apply the NZRI within a community context in New Zealand CDEM groups; and that local and regional authorities can use to better understand resilience in their communities. The 13-indicator NZRI only provides a very basic snapshot of resilience but provides a consistent baseline against which all areas of New Zealand can be compared. The engagement framework provides a mechanism where additional data can be added at the regional or local level to both a) supplement the NZRI with data that is not collected consistently at the national level, and b) reflect regional and local priorities within a consistent framework. The engagement framework (summarised in Figure 4) comprises an assessment of the alignment of NZRI with local and/or regional priorities, followed by a data gap assessment and the collection of appropriate data, for a more nuanced, region-specific NZRI.
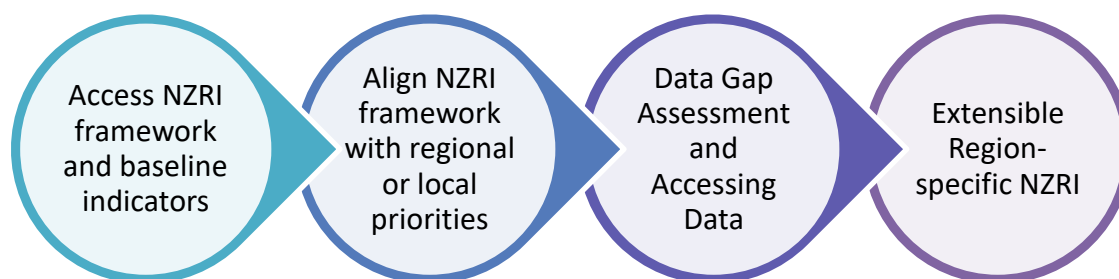
Figure 4. Process for creating a regional NZRI.

While adding data to the baseline NZRI means that we can no longer directly compare the region to the national baseline, it allows for an improved understanding of resilience in a sub-national area of interest. A full guide on how to achieve a region-specific NZRI can be found in Appendix 1. This guide walks the user through the steps in Figure 4.

5. Conclusions and Next Steps

The NZRI will continue to be developed and requires local and regional groups to pilot the methodology. The NZRI development so far, has focused on creating a measure of resilience that can serve as a consistent and comparable baseline across New Zealand. Repeatability allows places to track progress and assess the efficacy of interventions. Therefore, we will ideally calculate the NZRI for several places in the near future and then recalculate the NZRI when new data becomes available (possibly following the next census) to assess change within these locations over time.

Although the baseline NZRI currently only includes 13 indicators, future projects, such as the forthcoming Indicators Aotearoa programme (Stats NZ, 2019), plan to collect data in New Zealand that assesses the current and future wellbeing of New Zealand. Many of these indicators will complement the NZRI, filling the data gaps for indicators within the Indicators Bank (Stevenson et al., 2019). As long as data for these indicators is collected at regular intervals, the baseline 13 indicators may be complemented with additional indicators, allowing for an improved understanding of resilience across New Zealand. It is also possible that more sophisticated sources of data may also be used to populate the current indicators (e.g., infrastructure disruption and hazards planning), eliminating the reliance of these indicators on potentially stagnant datasets that may not be repeated in the future.

More work is needed to stress test and validate the NZRI. Future work and analysis will consider which indicators are best for building our understanding of resilience, making sure we are using the best data available, not the only available data. Additionally, it is important to establish the validity of the NZRI following disruptive events. Validation, in this context, means assessing the relationship between the indicators and concepts the indicators represent (Burton, 2014; Parsons et al., 2016). For example, if a set of resilience indicators is supposed to measure economic resilience, one can

observe how the economy of disaster affected places responds in the aftermath of an event to see whether the pre-event measurements align with post-event observed outcomes.

There is also a need to investigate how the index is and can be applied and how it can best support policy and practice. In particular, further research is needed into how the NZRI can best support decision-making and systematically evaluate resilience investments (pre- and post-investment) to improve the effectiveness of resilience building initiatives. There is also opportunity to explore methods of integrating active community engagement within the NZRI framework.

Achieving real progress toward resilient post-disaster outcomes will require significant investment of time and resources across New Zealand. The development of resilience-building policy and interventions should integrate the identification of goals and targets against which efficacy, or 'on-the-ground' outcomes, might be assessed. The NZRI could be a useful tool for monitoring the progress of New Zealand toward its resilience goals. The NZRI is an affordable option with relatively low-barriers for entry for small councils and other agencies across New Zealand. The NZRI offers the benefit of providing a nationally consistent framework, that can be tailored to local priorities. The baseline measurement provides a common starting point, but generally should not be used on its own to measure resilience. The baseline should be supplemented by additional data sourced at the regional and local level, as described int his report.

Further work will need to be done, not only to enhance the national NZRI with better data, but also to develop a framework for integrating the NZRI into programmatic evaluation. There is a growing body of work developing monitoring and evaluation protocols for resilience projects globally (see for example Brooks, Aure, & Whiteside, 2014 and Villanueva & Sword-Daniels, 2017). In New Zealand such a framework would need to be applicable across different kinds of organisations, project-types, and funding bodies.

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7. Appendix One: A guide to creating a region-specific NZRI

The following guide walks users through steps to achieving a region-specific NZRI. To achieve this, we begin with a baseline multi-capital theoretical framework in Step 0 (Figure A1 below), the baseline NZRI). Next, at Step 1 users can consider additional concepts that will complement those already included in the baseline NZRI. These can be assessed against the priorities of the local or regional area before a data gap assessment is completed in Step 2. Step 3 and 4 include calculation and visualisation of the region-specific NZRI.
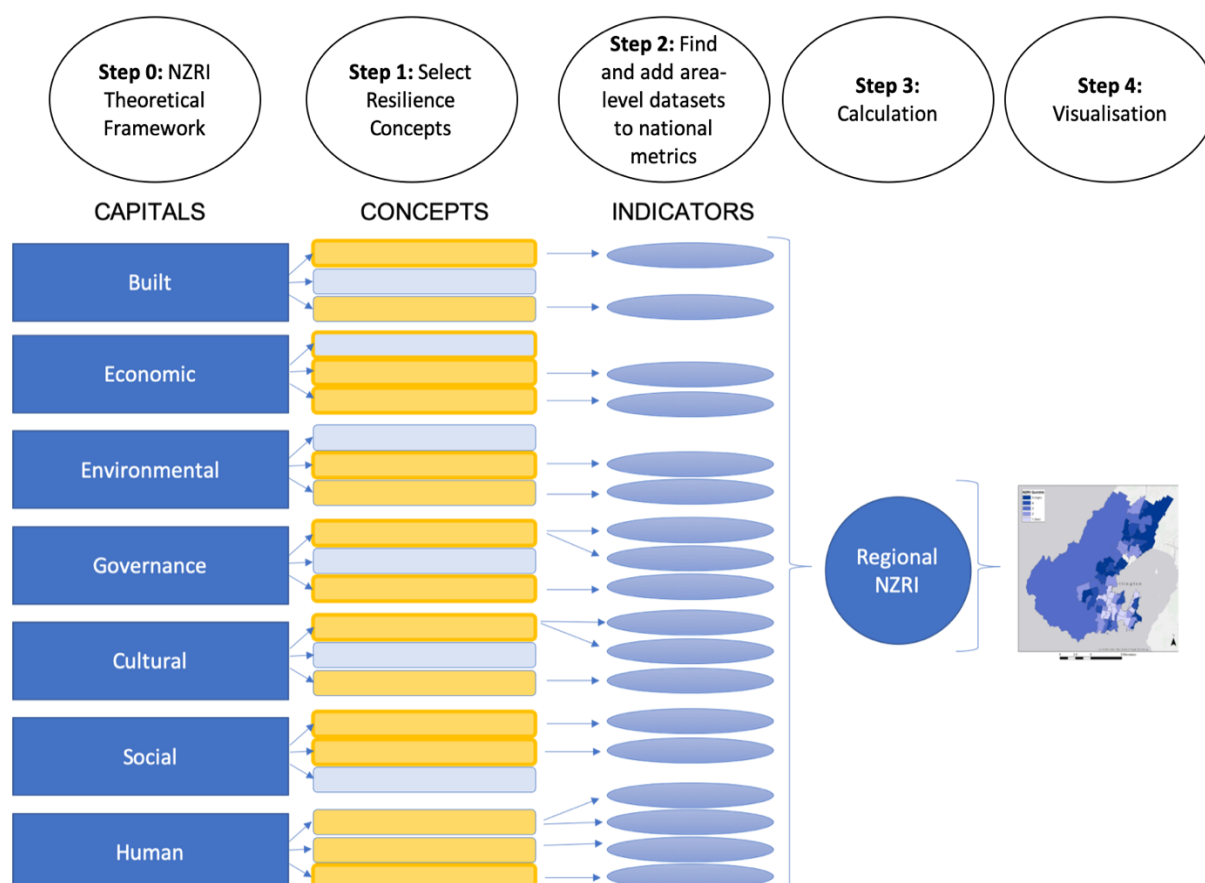

Figure A1. Steps involved in the construction of a region-specific NZRI.

7.1. Step 1: Determine regional and/or local priorities

To ensure that the regional NZRI is aligned with the regional and/or local priorities of the user, we suggest conducting an initial Kickstart 2 Measurement (K2M) workshop process (Ivory & Stevenson, 2017) with a range of stakeholders involved in the development of the regional or local resilience strategy. The goals of the K2M workshop are to define resilience and to scope and establish expectations around resilience measurement. This workshop process will assist in understanding any resilience initiatives that have been undertaken and consider any past, current, or future measurement and evaluations. It will also assess how a regional version of the NZRI will fit in to any other strategic priorities of the group and set expectations around what the NZRI will be able to achieve, while providing a line of sight from local/regional resilience building initiatives to New Zealand's National Disaster Resilience Strategy (the Strategy). For a local CDEM group, this process

may include, for example, consideration of what indicators of emergency preparedness and disaster risk reduction need to be evaluated under the "four R's" framework.

A second workshop will work to prioritise which resilience concepts the group want to measure under The Strategy Capitals Framework. Using the understanding of other related strategic priorities in the area, this workshop will help select concepts that are relevant to the region's needs and link to motivations for measuring resilience. The NZRI is intended to be used to track changes over time, so adding or changing indicators between measurement years reduces the ability to monitor progress over time for an individual area. This may influence the indicators that are considered for inclusion.

7.2. Step 2: Data gap assessment and data accessing data

Following these workshops, users will need to complete a data availability assessment. For the selected 'priority' resilience concepts, the following questions will be useful.

- What is the best way to measure this concept?
- What data do we have that could be used to measure these concepts?
- Who might hold data that might be useful?

Begin by talking to council Geographic Information System (GIS) experts, look at previous documents and reports, and do an inventory of prior surveys and studies that have gone on in these concepts areas. Identify groups that might hold data and begin a conversation about data sharing.

After completing these steps, you should have the beginnings of an inventory of the datasets that you need to determine your indicators. If there are resilience concepts for which data does not already exist, you will need to assess whether it is worthwhile collecting this data and what kinds of resources would be required to do so. Users may find it helpful to engage a data collection specialist in a relevant field.

When selecting indicators for a regional view, in line with the K2M process (Ivory & Stevenson, 2017), we recommend considering:

- The resilience concept you are interested in and how it can be measured[5].
- The appropriateness of the data to measure the selected resilience concept of interest.
- Data quality. Does the data come from a reliable source?
- Data availability. Is the data readily accessible, and is the data likely to be updated over time? To track resilience over time it is important to include datasets that will be updated in the future.
- Geographic coverage. Is data available to measure the indicator for all areas in the region of interest and at an appropriate scale? This might be statistical data referenced to boundaries (e.g. CAUs), or geospatially referenced information that can be related back to each CAU in a meaningful way (e.g., distance via the transport network between each CAU and the nearest emergency service centre).

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[5] We have accumulated list of around 150 possible indicators as part of this research to serve as a starting point for organisations wishing to use this framework to develop a local or region-specific NZRI (Stevenson et al., 2019). These indicators will need to be refined depending on data availability in your area.

- Balancing indicators across the capitals (i.e., avoid including too many indicators into only one or two capital themes). This avoids creating a composite indicator that reflects only a portion of important considerations for resilience building.

Sometimes data availability will drive what can be included in the NZRI for assessment, so Steps 1 and 2 are likely to be repeated a handful of times until users are happy with the indicators and data availability, before proceeding forward with calculation of the NZRI. The Indicators Bank of resilience concepts (Stevenson, 2019) ensures consistency in what aspects of resilience are being measured, even if the selection of indicators and metrics differs between places and organisations (for example, users of the NZRI will have different geographic areas and scales of interest, as well as different access to data).

7.3. Step 3 and 4: Calculation, aggregation, and visualisation of region-specific NZRI

All data included in the regional version of the NZRI will need to be quantified (i.e., be numeric, or translated into numeric format) and normalised against a benchmark and framed positively so that all indicators are 'pointing' in the same direction (higher values should mean higher resilience) before it is included in the index (see Section 2.2 of this report).

Once these steps have been completed, indicators can be included in the NZRI and used to calculate an overall resilience "score" for each census area unit within the region/local territory[6]. To be able to visualise these scores, GIS software and expertise is needed. Local and regional councils often employ GIS specialists who may be able to assist in this area.

7.4. Case Study: Resilience Assessment in the Wellington Region

We worked through Steps 1 and 2 with the Wellington Region Emegerncy Management Office (WREMO) to develop our approach to assess a regional application of the NZRI. In collaboration with WREMO employees and other researchers working in the resilience space, K2M workshops were run to develop a regional NZRI that aligns with WREMO's CDEM Group Plan. This alignment ensured that WREMO were able to link their actions in the disaster risk reduction space to national and international resilience priorities. This allows WREMO to contribute to the understanding of the Wellington region's resilience while monitoring the strategic outcomes of their Group Plan, which was developed around the four R's of emergency management in New Zealand (Reduction, Readiness, Response, Recovery). This workshop determined resilience priorities for WREMO and it will also help to measure resilience enhancement progress against the National Disaster Resilience Strategy in the future.

We have not yet completed Step 3 (a full data assessment) and Step 4 (visualisation of a completed resilience measure) for the Wellington Region. However, to demonstrate the potential of a region-specific NZRI, two additional regional datasets were added to the NZRI. These datasets contained

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[6] Although the 13 NZRI indicators are weighted, we have not included this step in the region-specific NZRI due to practicality. Weighting exercises incur a financial cost and require access to resilience and DRR experts, which may not be feasible to all users. Therefore additional indicators added in the regional-specific version are unweighted.

information on the location of Community Hubs[7] and earthquake-prone buildings in Wellington. The extended NZRI for Wellington is shown below in Figure A2.

The Community Hub indicator was a measure of accessibility comprising CAUs within 800m of a community hub location. Earthquake prone buildings are those that do not meet current seismic performance standards. This indicator was calculated as the percentage of total earthquake prone buildings in Wellington City that are located in each CAU.

As seen by comparing Figures A2.1 and A2.2, the addition of these two indicators has slightly changed the NZRI resilience scores for Wellington. With the addition of more indicators we would expect further change.

7.4.1. Regional Wellington Resilience Assessment and hazards data

The NZRI does not include any hazard exposure or risk data. If available, users may be able to analyse hazard data in conjunction with the NZRI. This allows users to identify those areas that may be particularly vulnerable during a disaster (i.e., those with low resilience and high hazard exposure) and can be used to start conversations about resilience building initiatives. For example, Figure **Error! Reference source not found.**A2 shows that there are multiple areas in Wellington that are vulnerable to flood and also are comparatively less resilient than other areas. Similarly, Figure A3 shows what areas may be more vulnerable in the event of an earthquake due to ground shaking.

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[7] Community hubs are pre-identified locations for people to come together in times of significant emergency. They are staffed exclusively by community members, who liaise with emergency management personnel as necessary.
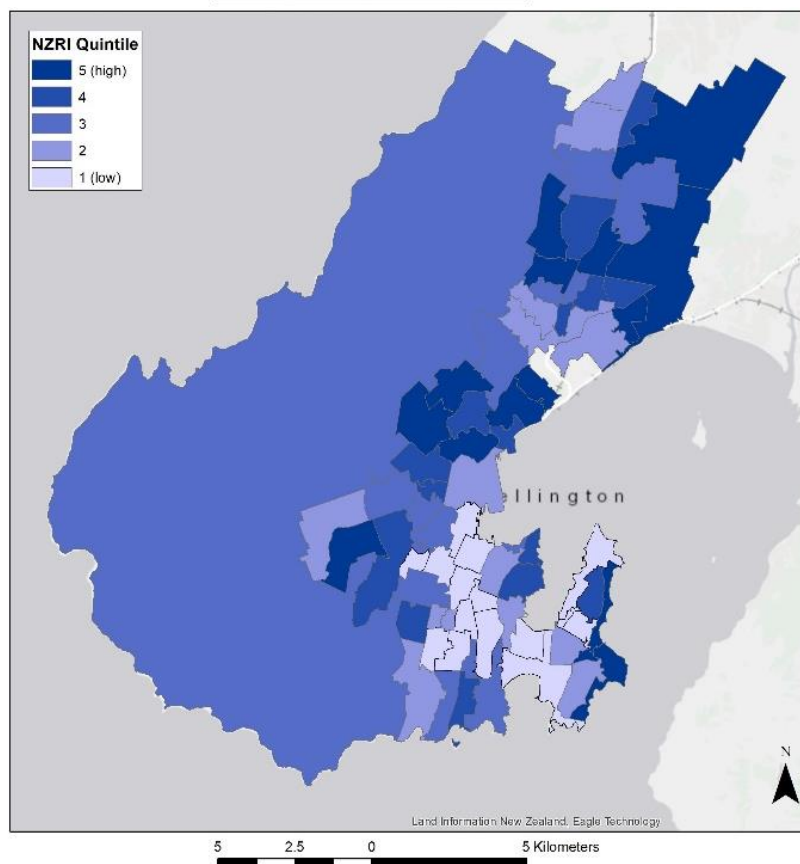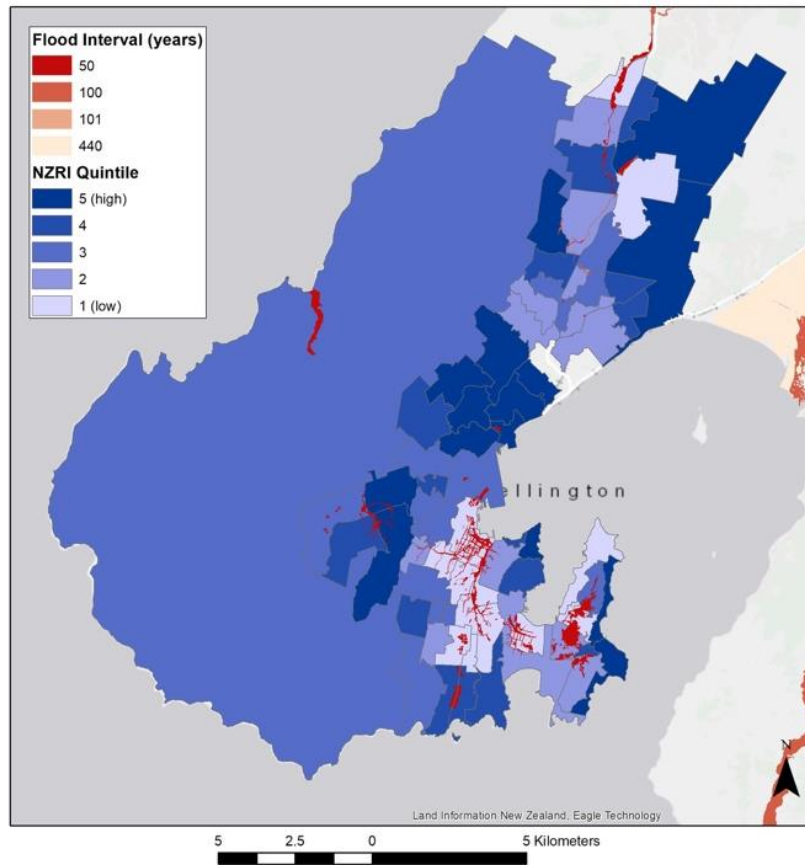
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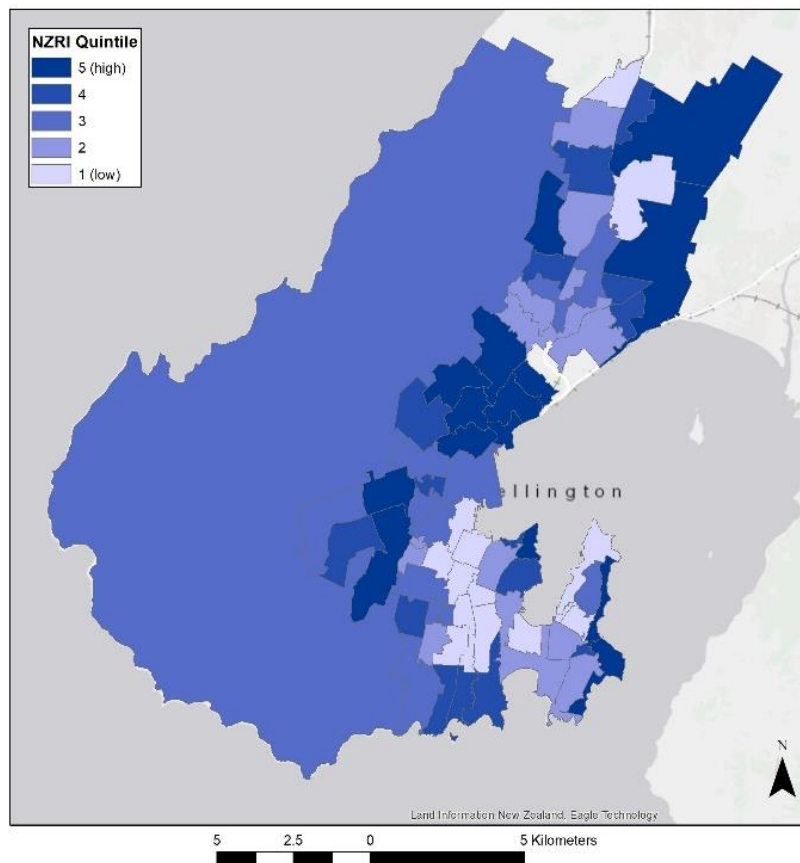
2.

Figure A2.1, A2.2: NZRI baseline for the Wellington Region (top) and extended assessment for Wellington Region including additional indicators.
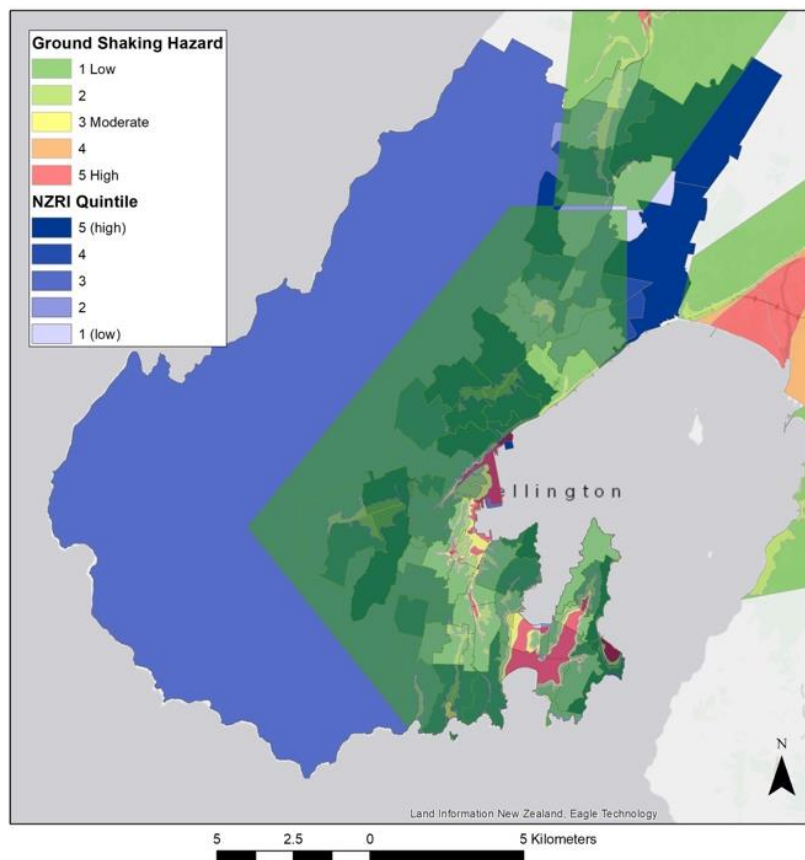
1.

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Figure A3.1.A3.2. Extended NZRI for the Wellington region with flood prone areas (1) and earthquake shaking zones (2).

7.4.2. From measurement to action

Following the visualisation of the region-specific NZRI, users now have a baseline against which they can evaluate changes prompted by resilience initiatives. Users should consider how they will measure the impact of any resilience improvements. That is, how will we know that the actions and interventions we are planning will improve resilience? It is important to establish a timeline for repeating the measurement of the NZRI to track progress toward your resilience goals. This may be driven by local or regional surveys or measurement of strategic or operational mandates.