Operationalising theory-informed practice: Developing resilience indicators for Wellington, Aotearoa New Zealand

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Abstract

Moving resilience thinking from theory to practice has been a national and international strategic imperative over the last decade. An ongoing collaboration between the Wellington Region Emergency Management Office (WREMO) and researchers associated with the International Research on Disaster Risk's International Centre of Excellence in Community Resilience (ICoE: CR) and Resilience to Nature's Challenges (RNC) Kia manawaroa – Ngā Ākina o Te Ao Tūroa National Science Challenge made progress towards operationalising theory-informed practice for disaster resilience measurement in the Wellington Region of Aotearoa New Zealand. Between 2014 and 2018, researchers, WREMO, and other key stakeholders engaged in a multi-stage co-learning process, including defining resilience, determining the measurement focus, and identifying measurable indicators. The process merged bottom-up and top-down resilience indicator identification and selection methods. This resulted in 10 resilience indicators that both link to national and international policy and meet the strategic, regional needs of WREMO.

Keywords: *Resilience measurement, operationalisation, knowledge co-production, top-down and bottom-up assessment*

Theory-informed practice is a model where gaps between research-based evidence and practice are identified. Community needs, values, and preferences, practitioner experience, and the best available research and theory are integrated to aid decision-making and intervention planning (French, Green, O'Connor, McKenzie, & Francis, 2012). Research should help inform practice and support practitioners' critical thinking, while integrating their experiences and judgements. This method allows for the development and implementation of successful community interventions in an environment that may have changeable goals, conditions, and experiences (Nevo & Slonim-Nevo, 2011). Although this may sound intuitive, negotiating this in real world situations is not always straightforward. In practice, researchers are seen as seldom producing information on Disaster Risk Reduction (DRR) that is directly usable by practitioners and decision-makers often face barriers to integrating scientific information when developing community interventions (Doyle, Becker, Neely, Johnston, & Pepperell, 2015; Weichselgartner & Kasperson, 2010; Weichselgartner & Pigeon, 2015). There needs to be continued efforts to shift the research and practice agenda towards increasing cross-sectoral relationships.

There are limited examples of how theory has been operationalised to improve resilience measurement in a way that helps communities understand and build their resilience (e.g., Paton, Kelly, Burgelt, & Doherty, 2006). This paper details a co-creation exercise involving researchers and practitioners to develop indicators of disaster resilience, referred to simply as resilience hereafter, for the Wellington Regional Emergency Management Office's (WREMO) Group Plan. An indicator is defined as an observable factor that influences the level of resilience in a community (e.g., social connections within a community) and is typically quantified by a metric (e.g., % of people who feel they belong to their community).

WREMO plays an important role, not only as an oversight and implementation body, but as a boundary organisation that can translate best-practice research into meaningful action. Their capacity as a boundary organisation is enacted through their coordinating role for councils in the region and through their networks in the research community, where they have long-term ongoing engagement through joint platforms such as the International Research on Disaster Risk's International Centre of Excellence in Community Resilience (ICoE: CR). WREMO also has a substantial presence in communities through programmes implemented as emergency management and community resilience practitioners such as 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).

The exercise described here was an attempt to operationalise resilience measurement for the Wellington Region of Aotearoa New Zealand (NZ). In this paper, we begin with a brief background of resilience theory, the challenges of operationalising resilience measurement, and the goals of the researchers and needs of the practitioners involved with the current study. We then outline the co-creation process undertaken to develop resilience indicators for the WREMO Group Plan and detail the results of this process. Finally, we consider future steps and provide insight into the key learnings of this multi-stage process.

Resilience Theory and Considerations for Operationalising Resilience Measurement

Over the years, theories of resilience have developed across many fields, and the way community resilience is defined often changes to fit the context in which the concept is being applied and interpreted (Kwok, Paton, Becker, Hudson-Doyle, & Johnson, 2018). Resilience relates to the capacity to persist and the ability to adapt or transform in the face of changes in the environment, whether these are gradual or abrupt (Folke, 2006; Paton et al., 2006). Resilience can be measured at many levels; the current study focuses on community resilience, taking a holistic, multi-capital approach to consider all aspects of society. Adaptation in this context is reliant on a variety of aspects including ensuring that the built environment is resistant to the effects of hazards, planning and resourcing to facilitate successful response and recovery, and the beliefs, capabilities, and capacities of society to undertake effective action in the face of adversity (Paton & Johnston, 2017). As a result of its multidimensional nature, there is significant variation in how resilience is operationalised through measurement (Kwok, Doyle, Becker, Johnston, & Paton, 2016).

Operationalisation is the process of strictly defining a concept into measurable factors. Until an abstract concept is operationalised, it is not possible to tell whether the "thing" is absent or present, in what circumstances it occurs, or the importance it has (Payne & Payne, 2004). Although the theory of community resilience continues to evolve, there is growing consensus among hazard scholars that the first step towards developing community resilience is understanding how it can be operationalised and measured (Aldunce, Beilin, Howden, & Handmer, 2015; Asadzadeh, Kötter, Salehi, & Birkmann, 2017; Cutter, 2016; Parsons & Thoms, 2018; Peterson, Salmon, Goode, & Gallina, 2014). Therefore, measuring resilience can be considered an essential translational step from theory to action, as it can guide decision-makers and other end-users towards holistic actions that cultivate and maintain resilience (Asadzadeh et al., 2017; Keck & Sakdapolrak, 2013).

Operationalising resilience through clear definition of its characteristics in order to produce a standardised output (e.g., a quantitative "resilience score") allows observers to establish a common baseline and language to facilitate mutual learning and exchange across places, institutions, and people (Stevenson, Kay, Bowie, Ivory, & Vargo, 2018). Both qualitative and quantitative measures can be used to operationalise resilience, and there have been several comprehensive reviews of different approaches to measuring resilience (e.g., Becarri, 2016; Ostadtaghizadeh, Ardalan, Paton, Javvari, & Khankeh, 2015; Sharifi, 2016; Winderl, 2014). These reviews note that composite indicators have often been employed to operationalise the concept of resilience across a number of contexts (e.g., Cutter, Burton, & Emrich, 2010; Hughes & Bushell, 2013; Peterson et al., 2014). Indicators are valued for their relative simplicity and ability to facilitate communication and engagement across various stakeholder groups (Booysen, 2002; Saltelli, 2007). To allow for non-experts to engage with resilience measurement, and to allow for such facilitation of communication and engagement, a quantitative approach to the current study was used and composite indicator building is part of the approach to resilience operationalisation pursued in this study.

Operationalising Resilience Measurement: Joining "Top-down" and "Bottom-up" Models

Operationalising resilience measurement through composite indicator building requires a series of steps starting with defining the term resilience for the context and system of interest, determining the measurement focus, and selecting measurable indicators (Asadzadeh et al., 2017). Appropriate data must then be accessed and assessed and the index calculated (e.g., data transformed, standardised, normalised, weighted, and aggregated; Asadzadeh et al., 2017).

There are two general techniques for deriving indicators: top-down (also referred to as non-participatory and nomothetic) and bottom-up (also referred to as participatory and idiographic; Asadzadeh et al., 2017; Cutter, 2016). Nomothetic refers to the more generalised nature of top-down comparisons, which tend to be designed for comparing across places or varying units of analysis. Idiographic, or bottom-up measures, are so called as they tend to be locally generated and customised to a place (Cutter, 2016; Pfefferbaum, Pffeferbaum, Nitiéma, Houston, & Van Horn, 2015).

Top-down models tend to be based on an overarching theory or set of government-level priorities. Items selected for assessment and intervention are derived from deductive reasoning as elements that will shift a system towards or away from the overarching resilience construct (Butler et al., 2015). These models usually rely on quantitative, secondary data that has been collected at the regional, national, or international level for another purpose (such as the national census). They are useful in their ability to standardise measurement across time and place and to track trends. However, the selection of indicators to include in top-down measurement is often influenced by data availability, particularly as primary data collection is frequently cost-prohibitive. As a result, it can be difficult to ensure that included data is representative of the community being measured and this may create a disconnect between the outputs and interpretations of the measure and the values of the people living in the community (Gaillard & Mercer, 2013; Sharifi, 2016).

Bottom-up models solicit stakeholder input through participatory approaches to generate measures of resilience and indicators are linked to the needs and goals of the community (Kwok et al., 2018; Sharifi, 2016). Bottom-up approaches relying on community participation, however, are time and resource intensive and it can be difficult to achieve representation of all relevant groups (Kwok et al., 2018). Additionally, the variability of the community generated indicators means that scaling measures and facilitating comparisons and co-learning between different places is not often possible (Cutter, 2016).

Top-down and bottom-up approaches can be integrated to generate insights that are scalable, generalisable, relevant, and applicable by the communities applying the measures to guide actions (Sharifi, 2016). The purpose of the study described in the remainder of this paper is to capture the process of an integration between top-down and bottom-up methods, to ensure that the specific and relevant needs of the community are considered alongside top-down measurement. Although there is a multitude of literature on the development of indicators of resilience (e.g., Burton, 2014; Cutter et al., 2010), few studies have focused on indicators of resilience relevant to a NZ context (e.g., Huggins, Peace, Hill, Johnston, & Muñiz, 2015; Kwok et al., 2018). The following co-creative approach to resilience indicator selection through enduring engagement of practitioners, researchers, and community stakeholders aimed to achieve a more holistic operationalisation of resilience measurement in NZ, allowing better understanding and monitoring of resilience to support the country's national and international policy commitments.

Project Context

The following sections describe the initial stages of a process to integrate two resilience assessment approaches. The paper focuses on a co-creative collaboration process occurring between May and October 2018. This process, however, built on existing programmes of work, which we briefly review as part of the project context.

Co-creation Partners

Four primary co-creation partner groups were involved in this project. These partners included researchers associated with the Resilience to Nature's Challenges (RNC) National Science Challenge (Trajectories Toolbox and Cultural and Economic Resilience Toolboxes) and the Joint Centre for Disaster Research (JCDR), practitioners from WREMO, and community stakeholder

groups engaged by WREMO[1]. This collaboration was facilitated through the ICoE:CR networks.

Top-down Context: International and National Priority Setting

Top-down indicator selection was informed by NZ's national and international resilience strategies, the National Disaster Resilience Strategy (NDRS) and the Sendai Framework, as well as international peer-reviewed literature exploring resilience theory and practice across numerous contexts (e.g., Burton, 2014; Cutter et al., 2010; Folke, 2006).

The NDRS is built around six community capitals of resilience (see Figure 1). These are: social resilience, cultural resilience, economic resilience, resilience of the built environment, resilience of the natural environment, and governance of risk and resilience. Underpinning these capitals are five environments through which resilience is enacted: homes, families and whānau; businesses and organisations; communities and hapū; cities, districts, and regions; and government institutions.

The Sendai Framework articulates measurable DRR targets against which all participating countries are expected to report annually. The NDRS refers to a formal reporting process that will accompany the forthcoming strategy reported biennially by the Ministry of Civil Defence and Emergency Management (MCDEM), which will include "progress on goals and objectives, progress on resilience, and progress on [reducing] impacts," (MCDEM, 2019, p. 32). The NDRS also notes that "Progress towards the desired outcomes and interim outcomes will be measured against a series of indicators, including a resilience index developed as part of the National Science Challenge: Resilience to Nature's Challenges" (MCDEM, 2019, p. 36).

The RNC is a national research programme funded by NZ's central government to conduct research that will contribute to the country's resilience to natural hazards. Researchers contributing to the RNC are developing tools to help measure resilience, including the New Zealand Resilience Index (NZRI), a composite indicator developed to provide a simple, high-level baseline measurement of community disaster resilience across the country. The NZRI is designed to facilitate consistent comparisons between place-based communities in NZ, assessed through the lens of six community capitals. These capitals are drawn from international research (Stevenson et al., 2018). For more on the NZRI's conceptual development and indicator selection see Stevenson et al. (2018), Stevenson, Kay, Bowie, and Ivory (2019), and Kay, Stevenson, Bowie, Ivory, and Vargo (2019).

Figure 1. The six capitals and five environments of the National Disaster Resilience Strategy (NDRS; Ministry of Civil Defence and Emergency Management, 2019).

1 WREMO conducted all direct stakeholder engagement as part of their Group Plan development and as part of the development and implementation of their community-based initiatives. The researchers referred to in this paper did not directly engage with community stakeholders as part of the indicator selection process described in this paper.

Bottom-up Context

The bottom-up community participatory processes referred to here have been led by WREMO or result from collaborative projects with researchers engaging community stakeholders, rather than emerging at a grass-roots level from the communities themselves. Through the networks facilitated by the ICoE:CR, researchers and practitioners conducted several projects to enhance knowledge transfer among citizens, researchers, and practitioners (e.g., Doyle et al., 2015; Orchiston et al., 2016), including working with community stakeholder groups to generate potential social resilience indicators for the Wellington region (Kwok et al., 2016). WREMO works closely with researchers and communities on joint projects, many of which have been facilitated by the ICoE:CR (ICoE:CR, 2014; WREMO, 2018b). They also engage community-based stakeholders more formally as part of strategy and planning protocols.

WREMO is required to provide a Civil Defence Emergency Management (CDEM) Group Plan as mandated by the Civil Defence and Emergency Management Act 2002. This plan is a strategic document that guides the group for five years following implementation. Its purpose is to "enable the effective and efficient management of significant hazards and risks for which a coordinated approach will be required" (Wellington Region CDEM Group, 2013, p. 2).

During the development of the Group Plan for 2019-2024, WREMO conducted extensive engagement with stakeholders in the Wellington Region CDEM Group, which comprises the nine councils as well as emergency response agencies and lifelines utilities. Initial engagement and scoping for the Group Plan was accomplished by a review of plans and capabilities in reduction, readiness, response, and recovery. The work was reviewed by the Coordinating Executives Group (CEG) and their sub-committee (SubCEG) and expanded via 14 individual stakeholder workshops, with separate workshop sessions for each of the nine Territorial Authorities, lifeline utilities, planners and hazard analysts, welfare agencies, emergency response agencies, and WREMO staff. The final outputs of these workshops were then collated and organised by WREMO and vetted through a Joint Committee.

Drawing on input from stakeholder consultation, WREMO developed a draft vision statement and a series of outcomes and related outputs that could be achieved through the implementation of the plan. The vision statement as of June 2018 was to build "A Resilient Community: Ready, Connected, Capable". These attributes are further defined as follows:

Ready: All stakeholders are able to respond quickly and effectively to change and adversity by being well-informed and able to make good decisions.

Connected: All stakeholders are in touch with (relevant) others and able to support each other in times of need.

Capable: All stakeholders take practical steps to reduce their level of risk, are ready for change and adversity, can respond effectively to change and adversity, and recover quickly after a disruptive event.

The outcomes and outputs of the draft Group Plan map onto the four phases of emergency management (Reduction, Readiness, Response, and Recovery) and are aligned to one of five "environments" identified in the NDRS (Figure 1). As of June 2018, WREMO had drafted 61 outcomes and 127 outputs against which they could assess the implementation of their Group Plan.

Initiating Indicator Co-creation

With the establishment of the draft vision, outcomes, and outputs, WREMO staff identified a need to develop a comprehensive yet manageable framework of indicators for tracking their progress. The indicators should not only measure the quality and completion of Group Plan outputs and outcomes, but should also reflect progress towards WREMO's vision of building a more resilient region. To advance the development of these indicators, WREMO initiated a collaborative work programme with researchers associated with the ICoE:CR and RNC. The programme is referred to here as the WREMO Resilience Indicators Programme (WRIP). The ultimate goal of WRIP is to effectively merge practice-derived indicators with research and theory-derived indicators in a way that is applicable to WREMO's Group Plan 2019 – 2024.

Methods

This section outlines the process taken to operationalise resilience measurement for WREMO's Group Plan. The co-creative process, summarised in Figure 2, began with a review of the relevant bottom-up and top-down approaches to resilience that would likely inform the development of indicators for WREMO.

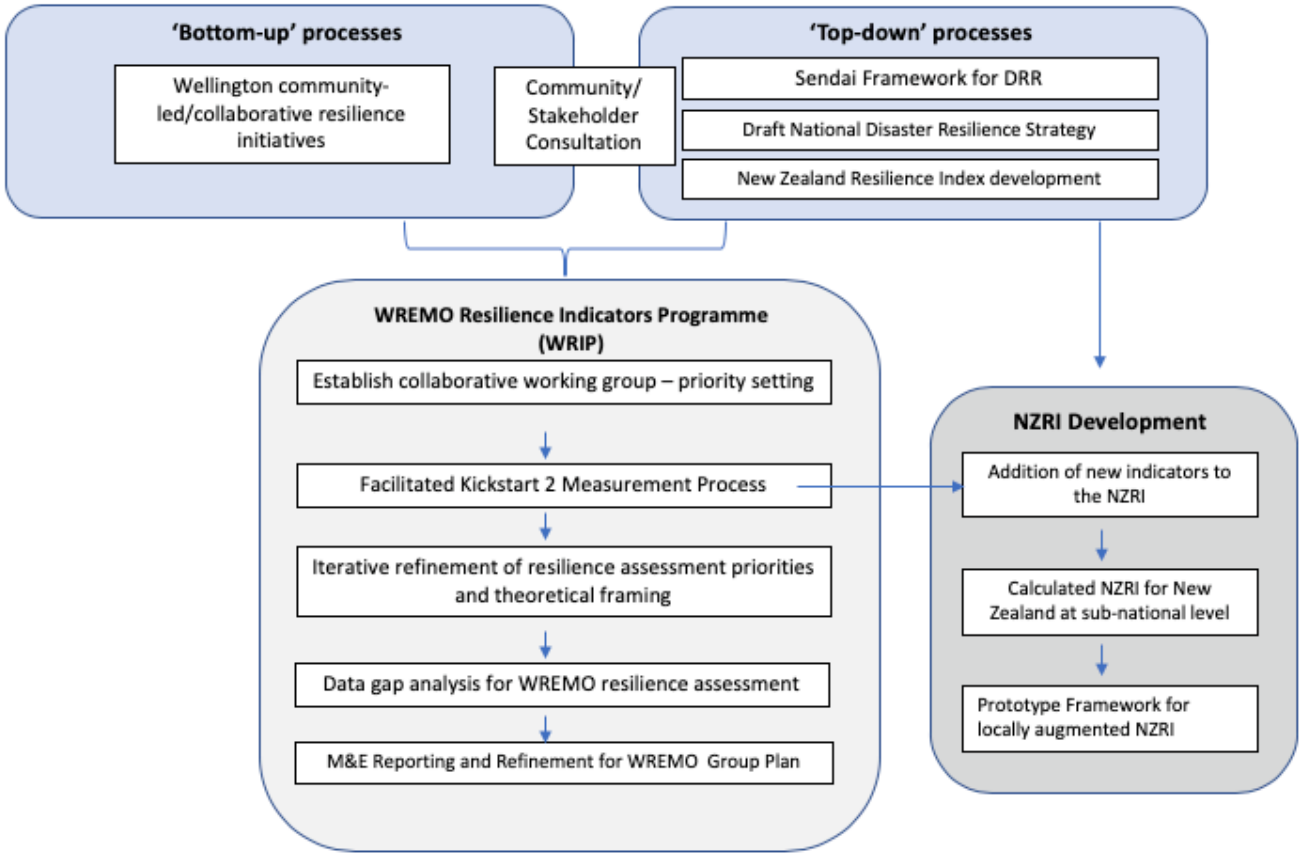

Figure 2. Resilience indicator framework for assessing resilience in Wellington, Aotearoa New Zealand.

Establishment of Working Group and Priority Setting

In April 2018, WREMO staff reached out to researchers through the ICoE:CR network to gain insights into the process of indicator selection that would meet the needs they saw emerging from the WREMO Group Plan development. Overall, there were 13 people directly involved in the WRIP working group; nine researchers and four WREMO staff members.

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. An initial action of the working group researchers was to conduct a review of possible indicators of DRR and resilience to act as a reference point for further conversation. The review incorporated bottom-up and top-down resilience assessment initiatives in Wellington (e.g., Kwok et al., 2018, and the Wellington Resilience Strategy; Wellington City Council, 2017) and indicators drawn from international literature (e.g., Burton, 2014; Orencio & Fuji, 2013; Pearson, Pearce, & Kingham, 2013; Pfefferbaum, Pfefferbaum, & Van Horn, 2011). A sub-working group of researchers compiled indicators drawn from the review into short reports.

In June 2018, all members of the working group met at the WREMO offices in Wellington for a collaborative workshop. The workshop had two key objectives. The first was to present an overview of the reviews conducted to date. Working group members presented the indicator summary reports and additional summaries of relevant portions of the Sendai Framework, NDRS, and NZRI. The second objective was to further refine the measurement priorities and approach that WREMO would pursue, drawing on the indicator summaries and assessing WREMO priorities against the objectives and targets identified in the Sendai Framework and the NDRS.

Kickstart 2 Measurement Workshop

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 working group conducted this portion of the

workshop with WREMO and the rest of the working group as participants. The K2M tool progresses users through several steps to refine an approach to resilience assessment and monitoring. This includes defining a purpose, determining focus areas, specifying desired outcomes, selecting and prioritising indicators, and linking to data.

Each member of the working group was provided with a list containing the resilience concepts and indicators identified in the above DRR indicator review, comprising both bottom-up and top-down derived indicators. The indicators were categorised into the six community capitals of resilience underpinning the NDRS (Figure 1). The group considered one capital at a time and, working alone, were asked to select three 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 tthey had selected and their reasons for their selections. Each response was tallied to determine the indicators that received the most votes. No ties occurred in the number of votes, eliminating the need for a tie-breaker. This process was repeated for all six of the resilience capitals.

Iterative Refinement

Following the workshop, participants' votes and comments were aggregated. Thematic content analysis was used to derive 10 indicator categories out of the highest rated indicators by grouping similar concepts. 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.

Several additional meetings between the researchers who conducted the workshop and WREMO ensured that the indicator categories met the needs of the Group Plan. The results of this workshop, data gap analysis, monitoring and evaluation, and development of the NZRI are presented in the following sections.

Results

A total of 10 resilience indicator categories were developed from the indicator selections made by the working group. These categories are outlined in Table 1. Each category was linked to one or more of the five environments outlined in the forthcoming NDRS, the six capitals of resilience, and the WREMO vision statements of ready, connected, and capable. This demonstrated clear links from each of the categories to community stakeholder needs outlined by WREMO for the Group Plan[2].

Data Gap Analysis for Wellington

Suitable metrics (i.e., ways to measure each indicator within the indicator categories) and data that correspond with the 10 indicator categories will be identified and refined in future work. For each category, researchers have identified several measurable indicators that will capture dimensions of resilience across the capitals and environments. A further gap analysis of the categories showed additional resilience concepts that were not captured adequately within these 10 concepts. Examples include: household economic health; hazard exposure of people, property, and livelihoods; and human capital components such as levels of education. However, these concepts are already captured in the NZRI, which will soon be calculated for the Wellington region.

There are many other concepts in the Group Plan that WREMO would like to measure but for which they currently do not have data (e.g., safety and robustness of residential and commercial buildings and facilitation of cross-community networking). To gain a better understanding of local nuances of the Wellington region, future work should explore existing publicly and privately-held datasets and the possibility of primary data collection that could be used to measure such additional concepts.

Monitoring and Evaluation Reporting and Refinement

Part of the purpose for pursuing the WRIP was to allow WREMO to assess whether the programmes and interventions initiated by them and their counterparts at local CDEM Groups influence resilience over time. Repeated measurement of indicators within each of the concepts derived from the current study will allow for tracking of resilience improvements. These efforts will need to be reviewed and refined as issues become apparent and better data become available.

Addition of New Indicators to the NZRI

The consultation with WREMO caused the working group members involved in the development of the NZRI to consider additional indicators that might be available

2 WREMO conducted all direct stakeholder engagement as part of their Group Plan development via workshops within their communities. Indicators needed to link to Group Plan concepts as a result.

Table 1
Definitions of WREMO Group Plan resilience indicator categories.

		Social	Economic	Infrastructure	Environmental	Cultural	Governance/ Institutional	Individ/Household	Businesses/Orgs	Communities	Cities, Districts, & the Region	Critical Infrastruc.	Ready	Connected	Capable
Category Name	**Definition**	**Resilience capital**						**Environment/s**					**Vision**		
DRR Engagement (Awareness and Information)	Encompasses awareness of hazard risk and access to information about hazards, DRR, and post-disaster recovery information. It also includes agency engagement with diverse communities, both across multiple communication platforms and in relevant different languages.						■	■	■	■	■	■	■	■	
DRR Action and Capacity	Assesses the degree to which all environments have reduced risks in their respective areas. This includes pre and post-disaster measures such as sheltering capacity.						■	■	■	■	■	■			■
Adequacy of Planning and Land Management/ Hazard Exposure Reduction	Includes planning, zoning, and environmental management of the environment. It also includes reduction of hazard exposure, best practice planning, and efficacy measurement to avoid the creation of new hazards.				■						■		■		
Buildings are Built or Retrofitted to a High Standard	Measures the extent to which buildings are built or retrofitted to a high standard. This includes residential and commercial buildings, as well as public building resilience (e.g., schools and hospitals).			■				■	■				■		
Leadership Quality and Capacity	Encompasses the adequacy (e.g., diversity, accountability, and transparency) of leadership and representation, the degree of trust in governance, and council effectiveness. This also includes local NGOs, Community Based Organisations, and communities of interest's level of engagements with issues capable of supporting DRR and response, and the quality of agency-agency networks.						■		■	■	■	■	■	■	■
Business and Organisational Resilience and Redundancy	Assesses business and organisational resilience and redundancy through effective business continuity planning. This component may include special indicators for rural or primary sector businesses and planning and resilience for infrastructure providers, hospitals, and education organisations. This additionally includes facility redundancy across the respective environments.		■						■		■	■	■	■	■
Access to and Quality of Critical Services	Assesses access to and quality of critical services, including communications, electricity, water, and sewerage/sanitation.						■	■	■	■	■	■	■	■	■
Social Capital	Includes bridging and linking capital, community connectiveness, and community and civic engagement.	■						■			■		■	■	
Human Health and Wellbeing	Assesses the health and wellbeing of the region across all environments. This component may include health capacity metrics as well as quality of life metrics.	■					■	■	■	■	■	■	■	■	■
Cultural and Heritage Health	Encompasses access to and engagement in cultural activities. It also captures the value of the heritage in the region through the protection and perceived value of cultural and heritage assets.					■		■		■	■			■	

to capture CDEM efforts and capacity. It became clear through the engagement with the working group that DRR capacity and engagement should be included in our calculations of resilience. Indicators assessing these categories have subsequently been included in the draft index (indicated in Figure 2).

Discussion

Reflections from Blending Research and Practice

Practitioners charged with integrating scientific findings into community interventions and improvements while juggling various policy requirements and operational goals may neglect to include appropriate scientific information (Weichselgartner & Kasperson, 2010). Likewise, researchers may struggle to comprehend the views of the user when they are not involved in the operationalisation of their theory-driven concepts and neglect to include end user needs when conducting research (Weichselgartner & Kasperson, 2010). If researchers are not involved in the application of their findings, they may unintentionally disregard important practitioner experiences (Nevo & Slonim-Nevo, 2011). Therefore, it is important to recognise that as science informs practice, practice can equally inform science. This study is an example of scientific co-production of knowledge, a collaborative process between multiple stakeholders, to ensure knowledge is useful, useable, and used.

Limitations and Future Research

This study is a practical example of how science and practice can be combined to operationalise resilience measurement. The process of the current study evolved through a series of engagements initiated by WREMO and, as such, it could not be designed as an end-to-end process managed by the researchers. The project experienced significant time constraints, due both to the competing priorities of researchers who were volunteering their time and the time pressure of the WREMO Group Planning process. However, achieving rigour from a controlled environment in the real world is often unrealistic (Guba & Lincoln, 1981; Hood, Hopson, & Kirkhart, 2015) and the process undertaken reflected and adapted to the reality of the practice-theory interface.

Integrating research and practice will often be unlikely to follow an exact scientific process, meaning that researchers and practitioners need to navigate together under the constraints and parameters of a project. The process that was used in this study, and the indicators and framework that were developed, will need to be reviewed, refined, and validated over time. Going forward, the developers of the NZRI are continuing to explore options for including more local nuance. Building on the WRIP, they will assess locally available datasets and develop a process for these to be integrated into a regional version of the NZRI.

Concluding Thoughts and Lessons for Future Practitioner-Researcher Collaborations

As a boundary organisation, WREMO plays an important role not only as an oversight and implementation body, but in creating opportunities and incentives for engagement across scientific and policy domains and, in a practical sense, translating best-practice research into meaningful action on the ground (Beavan, 2015). The current study has benefited both researchers and practitioners in the operationalisation of resilience assessment in the Wellington Region. The development of the resilience indicators and metrics for the region through this co-creation exercise has provided WREMO with guidance on how to measure changes in resilience within place-based communities.

The combination of top-down and bottom-up derived approaches in this case study has shown the critical importance of a collaborative process for theory-informed practice and practice-informed theory for evaluating and monitoring community resilience. Moving forward, WREMO is in a position to further operationalise their vision of resilience and drive change to ensure that the region's citizens are capable of flexibility and change; or are, in other words, "ready, connected, and capable" of preparing for, responding to, and recovering from an emergency.

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References

Aldunce, P., Beilin, R., Howden, M., & Handmer, J. (2015). Resilience for disaster risk management in a changing climate: Practitioners' frames and practices. *Global Environmental Change*, *30*, 1-11. doi: 10.1016/j.gloenvcha.2014.10.010

Asadzadeh, A., Kötter, T., Salehi, P., & Birkmann, J. (2017). Operationalizing a concept: The systematic review of composite indicator building for measuring community disaster resilience. *International Journal of Disaster Risk Reduction*, *25*, 147–162. doi: 10.1016/j.ijdrr.2017.09.015

Beaven, S. J. (2015). *Managing the science/policy boundary after a disaster: The research response to the 2010-2011 Canterbury earthquake sequence* (Doctoral dissertation). Retrieved from the University of Canterbury Research Repository (11596).

Beccari, B. (2016). A comparative analysis of disaster risk, vulnerability and resilience composite indicators. *PLOS Current Disasters,* 1-54. doi: 10.1371/currents.dis.453df025e34b682e9737f95070f9b970

Booysen, F. (2002). An overview and evaluation of composite indices of development. *Social Indicators Research, 59*(2), 115–151. doi: 10.1023/A:10162755

Burton, C G. (2014). A validation of metrics for community resilience to natural hazards and disasters using the recovery from Hurricane Katrina as a case study. *Annals of the Association of American Geographers, 105,* 67-86. doi: 10.1080/00045608.2014.960039

Butler, J. R. A., Wise, R. M., Skewes, T. D., Bohensky, E. L., Peterson, N., Suadnya, W., … & Rochester, W. (2015). Integrating top-down and bottom-up adaptation planning to build adaptive capacity: A structured learning approach. *Coastal Management, 43*, 346–364. doi: 10.1080/08920753.2015.1046802.

Civil Defence and Emergency Management Act 2002. Retrieved from www.legislation.govt.nz/act/public/2002/0033/51.0/DLM149789.html

Cutter, S. L. (2016). The landscape of disaster resilience indicators in the USA. *Natural Hazards, 80*, 741–758. doi: 10.1007/s11069-015-1993-2.

Cutter, S. L., Burton, C. G., & Emrich, C. T. (2010). Disaster resilience indicators for benchmarking baseline conditions. *Journal of Homeland Security and Emergency Management, 7*, 1–22. doi: 10.2202/1547-7355.1732

Doyle, E. E. H., Becker, J., Neely, D. P., Johnston, D. M., & Pepperell, B. (2015). Knowledge transfer between communities, practitioners, and researchers: A case study for community resilience in Wellington, New Zealand. *Australasian Journal of Disaster and Trauma Studies, 19*(2), 55–66.

Folke, C. (2006). Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change, 16*, 253–267. doi: 10.1016/j.glovenvcha.2006.04.002

French, S., Green, S., O'Connor, D. A., McKenzie, J. E., & Francis, J. J. (2012) Developing theory-informed behaviour change interventions to implement evidence into practice: A systematic approach using the theoretical domains. *Implementation Science, 7*, 1–8. doi: 10.1186/1748-5908-7-38.

Gaillard, J. C., & Mercer, J. (2013). From knowledge to action: Bridging gaps in disaster risk reduction. *Progress in Human Geography, 37*, 93-114. doi: 10.1177/0309132512446717

Guba, E. G., & Lincoln, Y. S. (1981). *Effective evaluation: Improving the usefulness of evaluation results through responsive and naturalistic approaches*. San Francisco, CA: Jossey-Bass.

Hood, S., Hopson, R. K., & Kirkhart, K. E. (2015). Culturally responsive evaluation. In K. E. Newcomer, H. P. Hatry, & J. S. Wholey (Eds.), *Handbook of Practical Program Evaluation* (4th ed.) (pp. 281-317). San Francisco, CA: Jossey-Bass.

Huggins, T. J., Peace, R., Hill, S. R., Johnston, D. M., & Muñiz, A. C. (2015). Politics of practical and academic knowledge: A Q-method analysis of gauging community disaster resilience. *Journal of Contingencies and Crisis Management*, *23*(4), 246-256. doi: 10.1111/1468-5973.12092

Hughes, K. & Bushell, H. (2013) A multidimensional approach for measuring resilience. Retrieved from: https://oxfamilibrary.openrepository.com/bitstream/handle/10546/302641/dp-measuring-resilience-010813-en.pdf;jsessionid=97AE9044FCA22FC767096CE9DDF722D4?sequence=4

International Centre of Excellence in Community Resilience. (2014). Wellington information sheet. Retrieved from www.massey.ac.nz/massey/fms/Colleges/College%20of%20Humanities%20and%20Social%20Sciences/Psychology/Disasters/ICoE-CR/ICoE_final_Information_Sheet_2014.pdf?0B6A262FA357FDF0CA79662B0AD412A9

Kay, E., Stevenson, J., Bowie, C., Ivory, V., & Vargo, J. (2019). The Resilience Warrant of Fitness Research Programme: Toward a method for applying the New Zealand Resilience Index in a regional context. Retrieved from www.resorgs.org.nz/publications/resilience-wof/

Keck, M., & Sakdapolrak, P. (2013). What is social resilience? Lessons learned and ways forward. *Erdkunde, 67*, 5–19. doi: 10.3112/erdkunde.2013.01.02

Kwok, A. H., Doyle, E. E. H., Becker, J., Johnston, D., & Paton, D. (2016). What is 'social resilience'? Perspectives of disaster researchers, emergency management practitioners, and policymakers in New Zealand. *International Journal of Disaster Risk Reduction, 19*, 197–211. doi: 10.1016/j.ijdrr.2016.08.013

Kwok, A. H., Paton, D., Becker, J., Hudson-Doyle, E. E., & Johnston, D. (2018). A bottom-up approach to developing a neighbourhood-based resilience measurement framework. *Disaster Prevention and Management, 27*(2), 255-270. doi: 10/1108/DPM-07-2017-0169

Leonard, G. S., Power, W. L., Lukovic, B., Smith, W. D., Johnston, D. M., Langridge, R., & Downes, G. (2008). Interim tsunami evacuation planning zone boundary mapping for the Wellington and Horizons regions defined by a GIS-calculated attenuation rule. *GNS Science Report 2008/30*. 22 p.

Ministry of Civil Defence and Emergency Management. (2019). National Disaster Resilience Strategy: Rautaki ā-Motu Manawaroa Aituā. Retrieved from www.civildefence.govt.nz/assets/Uploads/publications/National-Disaster-Resilience-Strategy/National-Disaster-Resilience-Strategy-10-April-2019.pdf

Nevo, I. & Slonim-Nevo, V. (2011). The myth of evidence-based practice: Towards evidence-informed practice. *British Journal of Social Work, 46*, 1176–1197. doi: 10.1093/bjsw/bcq149.

Orchiston, C., Hudson-Doyle, E., Johnston, D., Becker, J., Crowley, K., Beatson, A., … Pepperell, B. (2016). Citizen science in disaster risk management workshop: Summary report [PDF file]. Retrieved from www.massey.ac.nz/massey/fms/Colleges/College%20of%20Humanities%20and%20Social%20Sciences/Psychology/Disasters/ICoE-CR/Publications/CitizenScience_2015workshop_minutes.pdf?235E6C43CF9AA7CC4013FE86618F128A

Orencio, P. M., & Fujii, M. (2013). A localized disaster-resilience index to assess coastal communities based on an analytic hierarchy process (AHP). *International Journal of Disaster Risk Reduction, 3*, 62–75. doi: 10.1016/j.ijdrr.2012.11.006

Ostadtaghizadeh, A., Ardalan, A., Paton, D., Javvari, H., & Khankeh, H. R. (2015). Community disaster resilience: A systematic review on assessment models and tools. *PLOS Currents Disasters*, 1–21. doi: 10.1371/currents.dis.f224ef8efbdfcf1d508dd0de4d8210ed.

Parsons, M. & Thoms, M.C. (2018). From academic to applied: Operationalising resilience in river systems. *Geomorphology*, *305*, 242-251. doi: 10.1016/j.geomorph.2017.08.040

Paton, D., & Johnston, D. (Eds.). (2017) *Disaster resilience: An integrated approach* (2nd ed.). Springfield, IL: Charles C Thomas.

Paton, D., Kelly, G., Burgelt, P.T., & Doherty, M. (2006). Preparing for bushfires: Understanding intentions. *Disaster Prevention and Management*, *15*(4), 566-575. doi: 10.1108/09653560610685893

Payne, G., & Payne, J. (2004). Indicators and operationalisations. In G. Payne & J. Payne (Eds.), *Key concepts in social research* (pp. 117–120). London: SAGE Publications, Ltd.

Pearson, A. L., Pearce, J., & Kingham, S. (2013). Deprived yet healthy: Neighbourhood-level resilience in New Zealand. *Social Science & Medicine*, *91*, 238-245. doi: 10.1016/j.socscimed.2012.09.046

Peterson, L., Salmon, P., Goode, N., & Gallina, J. (2014). Translation and evaluation of the baseline resilience indicators for communities on the Sunshine Coast, Queensland Australia. *International Journal of Disaster Risk Reduction*, *10*, 116–126. doi: 10. 1016/j.ijdrr.2014.07.004.

Pfefferbaum, R. L., Pfefferbaum, B., Nitiéma, P., Houston, J. B., & Van Horn, R. L. (2015). Assessing community resilience : An application of the expanded CART survey instrument with affiliated volunteer responders. *American Behavioral Scientist, 59*, 181–199. doi: 10.1177/0002764214550295

Pfefferbaum, R., Pfefferbaum, B., & Van Horn, R. (2011). Communities Advancing Resilience Toolkit (CART): The CART integrated system [PDF file]. Retrieved from www.oumedicine.com/docs/ad-psychiatry-workfiles/cart_online-final_042012.pdf

Saltelli, A. (2007). Composite indicators between analysis and advocacy. *Social Indicators Research, 81*, 65-77. doi: 10.1007/s11205-006-0024-9

Sharifi, A. (2016). A critical review of selected tools for assessing community resilience. *Ecological Indicators, 69*, 629-647. doi: 10.1016/j.ecolind.2016.05.023

Stevenson, J.R., Kay, E., Bowie, C., & Ivory, V. (2019). The Resilience Indicators Bank and the New Zealand Resilience Index [PDF file]. Retrieved from www.resorgs.org.nz/wp-content/uploads/2019/06/Resilience_Indicators_Bank__NZRI_Jun2019.pdf

Stevenson, J. R., Kay, E., Bowie, C., Ivory, V., & Vargo, J. (2018). The data challenges of monitoring resilience. In K. Stock & D. Bunker (Eds.), *Proceedings of the Information Systems for Crisis Response and Management Asia Pacific 2018 Conference Innovating for Resilience 5 – 7 November, Wellington, New Zealand* (pp. 153–165). Retrieved from www.confer.co.nz/iscramasiapacific2018/conference-proceedings-online/

Weichselgartner, J., & Kasperson, R. E. (2010). Barriers in the science-policy-practice interface: Toward a knowledge-action- system in global environmental change research. *Global Entvironmental Change, 20*, 266–277. doi: 10.1016/j.gloenvcha.2009.11.006

Weichselgartner, J. & Pigeon, P. (2015). The role of knowledge in disaster risk reduction. *International Journal of Disaster Risk Science, 6*, 107–116. doi: 10.1007/s13753-015-0052-7.

Wellington City Council. (2017). Wellington Resilience Strategy (Rockefeller Foundation: 100 Resilient Cities). Retrieved from www.100resilientcities.org/cities/wellington/

Wellington Region Civil Defence Emergency Management Group (2013). Wellington Region Emergency Management Group Plan 2013-2018 [PDF file]. Retrieved from https://wremo.nz/assets/Publications/Group-Plan-2013-2018.pdf

Winderl, T. (2014). Disaster resilience measurements: stocktaking of ongoing efforts in developing systems for measuring resilience [PDF file]. Retrieved from www.preventionweb.net/files/37916_disasterresiliencemeasurementsundpt.pdf

WREMO. (2018a). Initiatives. Retrieved from https://wremo.nz/about-us/initiatives/

WREMO. (2018b). International Centre of Excellence in Community Resilience. Retrieved from https://wremo.nz/about-us/initiatives/icoe/