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National Science Challenges

RESILIENCE TO NATURE'S CHALLENGES

Kia manawaroa – Ngā Ākina o Te Ao Tūroa

Short-Term Project: Working Paper, Deliverable 3

Heuristic Guide for Selecting & Tailoring Measurement Suites

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1 Heuristic Overview

While 'resilience' is becoming increasingly common in the natural hazards and disaster literature its interpretation varies widely. Such variability is a necessary reflection of the multiple purposes and contexts of its use. Without a means of developing a common understanding, however, there is a risk of hindering transdisciplinary and translational research that works across boundaries.

This paper looks at how we can develop a cohesive approach to measurement across programmes and disciplines within the National Science Challenge – Resilience to Nature's Challenges (RNC-NSC) research programme so progress towards a more resilient New Zealand can be monitored effectively and efficiently. The paper introduces heuristics as a way to help researchers in complex study designs evaluate and select indicators for assessing and monitoring resilience across a number of systems. Heuristics support the transition between theory, measurement, and practice by providing researchers with a common decision-aid to prioritise and adapt what should be measured, and how that can realistically be achieved.

1.1 Measurement Heuristics

Heuristics can refer to an array of formal and informal learning and decision making mechanisms. All heuristics are defined by a set of simple and efficient rules or methods that help people to make deisions when faced with information that is complex or incomplete (Sullivan 2009). A good heuristic is readily accessible and understandable – designed to give a 'good enough' solution in a reasonable time.

In the research context, a heuristic approach can help with operationalising complex concepts such as resilience (Restemeyer et al. 2015; Ivory et al. 2013) and as a means of moving from thinking about the abstract idea to tangible action. Heuristics can help bridge the gap between theory, data, and practice. Such a shortcut can help achieve our resilience research aims if it is recognisable and useful across the Challenge.

Many resilience concepts and theories are yet to be operationalised, meaning that ideas and hypotheses are difficult to test (Carpenter et al. 2014). At the same time there are multiple indicators and data already being collected about factors that enhance and hinder resilience to natural hazards. These indicators are not always clearly founded in theory, may not sufficiently capture factors and processes relevant to the resilience 'system,' and may not align with needed monitoring and decision-making.

Heuristic devices can come in various forms, depending on the task at hand. Frohlich et al. (2007) identified the challenges researchers faced, for example, when trying to use administrative data to investigate concepts that are different from the original reason for the data to be collected. They proposed a template as a heuristic device that could provide a useful two way bridge between theory

and data, promoting both operationalisation of theory (deductive) and a means to locate indicators within concepts and theories (inductive) (Figure1).

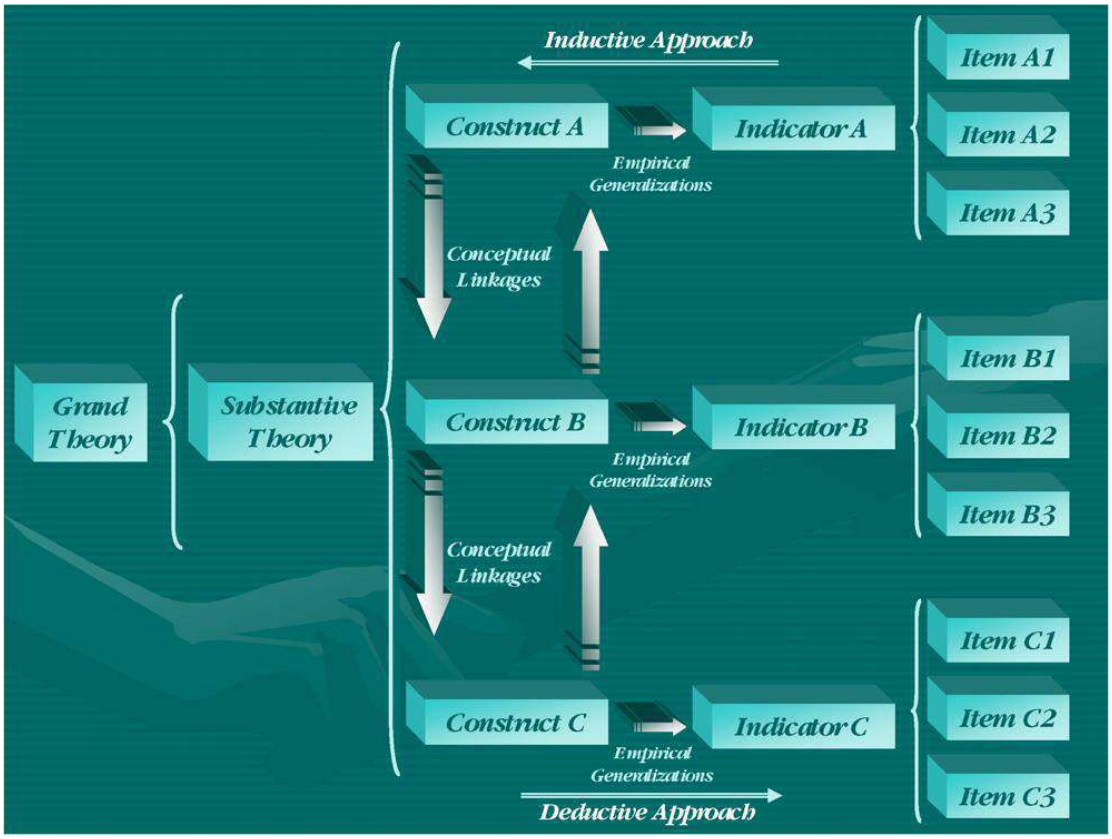

Figure 1: Heuristic Template (Frohlich et al. 2007)

The authors illustrate how to apply the heuristic by examining the operationalisation of two theories of social capital with various administratively collected data. Frohlich et al. (2007) used their heuristic template to examine multiple sources of secondary data to identify, "information (such as new secondary source materials regarding information about vandalism or traffic congestion in neighourhoods for example), along an 'explanatory pathway' for linking place and health" (Frohlich et al. 2007, p.301). The template moves between theories (at the most abstract level, 'grand theory' such as communitarism) to concrete, specific items that, importantly, are observable (such as percentage of people in a given scale or unit saying they trust their neighbours). They use the template to demonstrate how the mid-level construct of 'social capital' can be considered from different theoretical starting points that result in quite different operational items.

A measurement heuristic can be particularly useful when managing measurement priorities within a complex study design. For example, in the Growing Up in New Zealand study (Ivory et al. 2013), the measurement of 'wealth' in children and their families required the integration of constructs and tools across multiple forms of wealth (including social, material, and cultural capital) held across individual, household, and community levels, and that could vary over time. Data collection, therefore, needed to be able to recognise this complexity, but also to know when gaps in measurement would occur.

Ivory et al. (2013) developed a capital-based heuristic, presented as a matrix (Figure 2) to map how indicators could be used to assess wealth at various intersections, and then aid decisions about measurement priorities at each data collection.

Data collection priorities for the Growing Up in NZ study included:

- identifying key developmental stages,
- understand the determinants of child and family outcomes,
- capturing variations across population groups, and
- creating a policy-relevant evidence base.

Therefore, data collected as part of this study needed to:

- identify significant change or variation in wealth factors (such as change in labour force status and income),
- link variation in wealth factors with potential changes in outcomes (for example, child outcomes over the transition to school).
- enable comparison of factors and outcomes across groups and societal sectors, and
- identify opportunities for potential policy interventions, such as the population groups most likely to benefit from assistance or determining how the timing of assistance can best facilitate resilient trajectories.

The Capitals-based matrix heuristic helped make decisions about how to address gaps in wealth measurement. If a gap was considered a high priority then efforts could be made to source sufficiently robust proxies and drive innovative measurement methods. Alternatively, the implications of what is not being measured (and why) could be considered and acknowledged as a limitation of the study (Ivory et al. 2013).

Another type of heuristic is a conceptual or system model. Badland et al. (2015) wanted to go beyond traditional linear or static models and frameworks to better describe the causal pathways between the environment and children's independent mobility and in particular to incorporate feedback loops. The development of the model (Figure 3) called not just on a broad evidence base identifying significant factors and the direction of influence but also its potential to be tested in multi-level modelling methods so that potential interventions could be trialled.

	Locations				
Capitals	**Parent**	**Family (within household setting)**	**Wider family (supra household)**	**Informal social institutions**	**Formal institutions**
Economic: Assets & the means to acquire them.	*Household assets;* *- the means to acquire them,*		*- Presence / absence of non- household assets* *- Characteristics of non- household assets*		
Social: networks & the goods that come via them.	*Identify the social settings to which parents and child are connected* *Identify how those connections bring*		*Significant non- household social ties & settings* *Settings characteristics*		*Parent and child connections to institutions & resources that are therefore accessed*
Cultural: competence in given activities	*Parent 'competency' and status indicators Norms and values*	*Family participation in cultural practices and social institutions*		*'Availability' of cultural and social institutions to child*	

Figure 2: Wealth matrix of forms of capital and locations (Ivory et al. 2013)

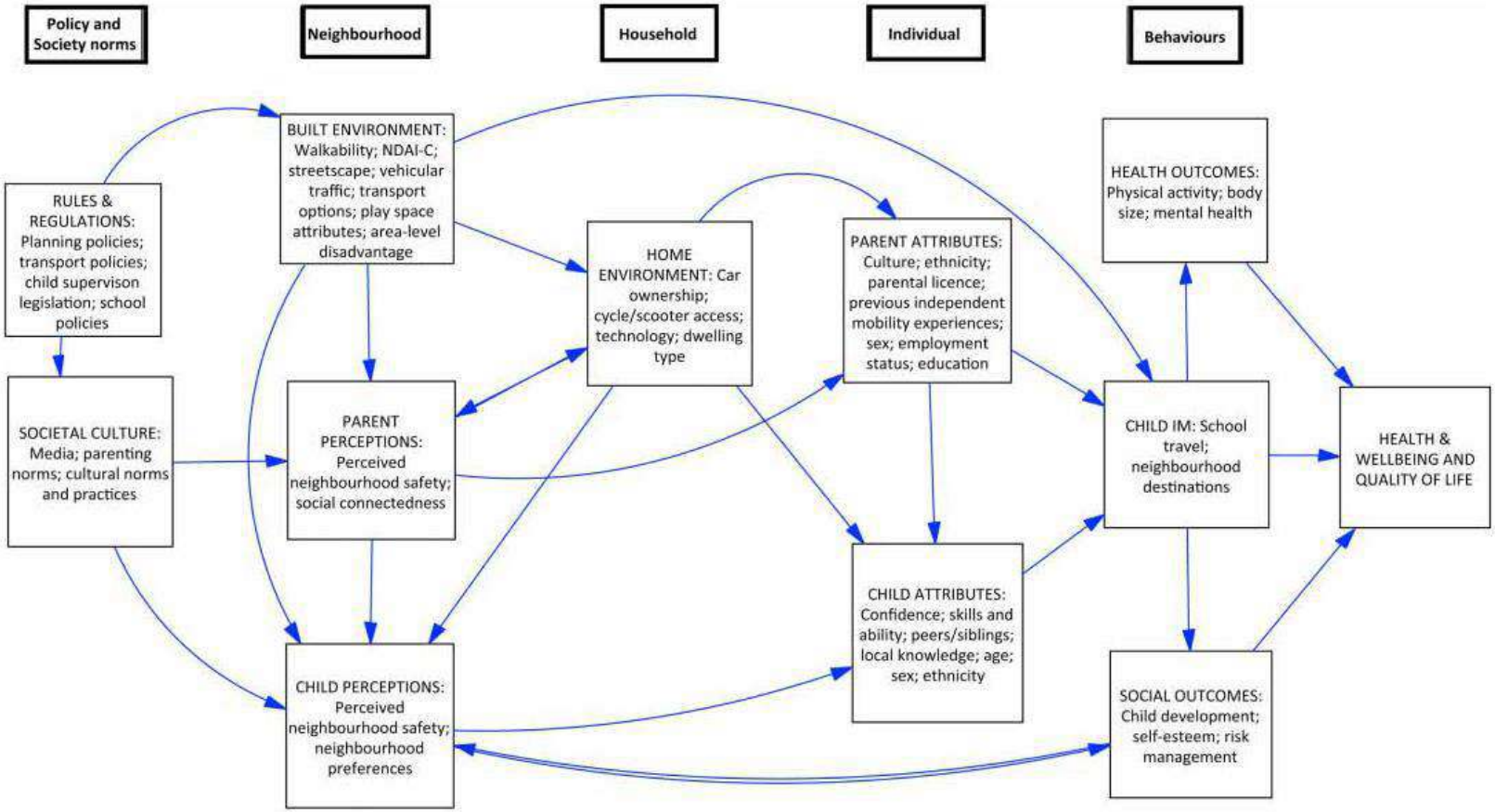

Figure 3: Systems maps of factors influencing child independent mobility (key: IM = independent mobility, NDAI-C= Neighbourhood Destination Index-Child) (from Badland et al. 2015)

Systems models can help researchers by visualising the interrelationships between factors, and potentially to aid thinking about future impacts (Macmillan et al. 2014). They can also be used to identify potentially effective intervention points through better understanding of the interaction between factors and therefore likely consequences, including the need to intervene at multiple levels (for example, regulations, perceptions, and local built environments)(Badland et al. 2015).

The final heuristic example, developed by Restemeyer et al. (2015), is designed as a strategy-based framework (Figure 4). The framwork works to operationalise the resilience concept so flood resilience can be evaluated by researchers and decision-makers. The authors used the framework understand the wider flood resilience context, rather beginning with prescribed interventions or strategies. This approach could help evaluate the resilience of a city, as well as to identify potential strategies to increase resilience.

	Robustness *'Reduce flood probability'*	**Adaptability** *'Reduce consequences of flooding'*	**Transformability** *'Foster societal change'*
Content Measures and policy instruments	- technical measures (e.g. dikes, dams, barriers) - spatial measures (e.g. river widening)	- discourage vulnerable land use in flood-prone areas - flood-proofing existing buildings and infrastructure in flood-prone areas - warning and evacuation schemes - flood insurance / recovery funds	risk communication and awareness raising among: - private stakeholders (e.g. brochures, public campaigns, early education in school) - public stakeholders (e.g. consensus-building, partnership practices, decision support tools)
Context Strategic issues, Institutional structure and legislation	- Water and climate: water as threat - strong public responsibility for water management - collaboration between water management and spatial planning on specific projects	- Land-use and socio-economic changes: need to create synergies - shared legal responsibility public – private - strong collaboration between water management, spatial planning and disaster management on all projects	- societal changes: need to establish water as asset - informal networks fostering a new 'water culture' - new interdisciplinary networks (e.g. 'think tanks') and learning organizations
Process Intellectual capital	- expert knowledge in engineering and planning	- expert knowledge and local knowledge (vulnerability reduction and adaptation options)	- creativity, openness towards new knowledge, learning
Social capital	- good relations among water managers and spatial planners	- good relations among water managers, spatial planners and disaster managers; civil awareness and willingness to invest in flood risk management measures	- mutual trust between public and private stakeholders and social acceptance of new interdisciplinary networks
Political capital	- strong political and financial support for bigger structures (public funds)	- strong political and financial support for adaptation and a risk-based approach	- change agents, leadership; financial support for informal and interdisciplinary networks

Figure 4: A strategy-based framework for assessing the flood resilience of cities

Restemeyer et al. (2015) identified three resilience attributes – robustness, adaptability, and transformability. Each of these attributes can be assessed in terms of content, context, and process. For example, the adaptability of a city

could include content such as land-use planning instruments (for example, building restrictions or measures to manage rainfall); context could include collaboration between water management, planning and disaster management; and process could include information about available levels of expertise, social networks between key players, and political support. By emphasising strategies rather than just description, they argue the heuristic can help resilience be "a normative concept that can actively be achieved through intervention" (Restemeyer et al. 2015, p.58)

2 How can a Resilient Measurement Heuristics help the RNC-NSC?

Three ways in which a heuristic device could help the Challenge have become apparent over the development of the programme to date. The Resilience Measurement Heuristics can help researchers (1) prioritise what needs to be measured and how, (2) systematically assess the quality of indicators and other resilience assessment tools, and (3) collaborate and coordinate resilience measurement approaches across the RNC-NSC research programme.

2.1 What should be measured?

First, a heuristic can aid researchers and stakeholders to decide what needs to be measured, and how dynamic processes are captured with indicators. Heuristics can help researchers identify significant aspects of resilient systems such as incorporating spatial and temporal scales, and different forms of capital (see Deliverable 1: Resilience Benchmarking and Monitoring Review for more detail). They can also help highlight the interrelationships between components of a system, enabling the visualisation of causal pathways to be examined.

A heuristic can provide a means to think about the best way to operationalise specific resilience theories and constructs (deductive); deciding what a given item could best be a proxy for (inductive); and how various proxies and indicators relate to each other in respect to broader theories.

2.2 Quality of operationalising items

Second, a heuristic can guide decisions about the quality and adequacy of potential items and tools. This aspect could be particularly valuable for the Challenge given the range of indicators currently in use, and diversity of disciplines and methods represented across the RNC-NSC.

Questions a heuristic could help researchers answer include:

- What type of data can best operationalise the construct to be able to make appropriate inferences? Is it available? What would I have to do to gather or use it adequately?

- What aspects of resilience are not being measured with existing data (Frohlich et al. 2007; Ivory et al. 2013)? And therefore what are we currently not able to test?

Frohlich et al. (2007) argued that what is recorded in administrative datasets will reflect certain theories and priorities about what is important. For example, health datasets tend to measure illness rather than wellbeing. Thus, it may be more difficult to use such datasets to capture positive constructs such as resilience and thriving compared with risk and vulnerability. By emphasising the bigger picture a heuristic can help researchers decide that available data is sufficient for the case at hand or that the risks of using that data are too great and therefore alternative data needs to be developed.

2.3 Coordination across the Challenge

Third, and perhaps most importantly, a heuristic can aid discussions across the RNC-NSC about what should be measured over time and how measurement can be coordinated. A good heuristic facilitates discussion rather than prescribes what should be done. It can:

- 'Sharpen' thinking (Frohlich et al. 2007) across researchers by providing a common platform to discuss measurement and priorities.
- Require that measurement takes place within the wider context and so makes clearer the purpose of a given tool, both for doing good research and to achieve the Challenge's goals.
- Aid the qualitative evaluation of priorities and gaps across workstreams, meaning the team can better decide how to spend limited resources and reducing fragmentation in measurement.

Discussion about priorities and approaches can occur within the research team, as well as with stakeholders and the wider community as Challenge partners.

2.4 Resilience heuristic protoype (example)

Figure 5 provides an indicative example of how a heuristic matrix could be used to aid a comprehensive and cohesive approach to measurement across the Resilience Challenge. The matrix comprises of four interacting boxes (starting from the left in a clockwise fashion): Content, Scale, Quality, and Disaster Risk Reduction (DRR) stage. Each box within the matrix highlights strategic questions and issues about what needs to be measured, and how that can best be achieved. For example, can we measure resilience outcomes across multiple scales, with good quality data, at each of the DRR stages? Can measures capture change over time, either factors before and after a disaster, or changes in levels of preparedness (for example) over the course of the Challenge? Or allow necessary comparisons between sectors or places in response to a disaster? How does a particular measure relate to others? And most importantly for making progress

on resilience measurement, what do we do if we cannot measure resilience outcomes in a satisfactory way?

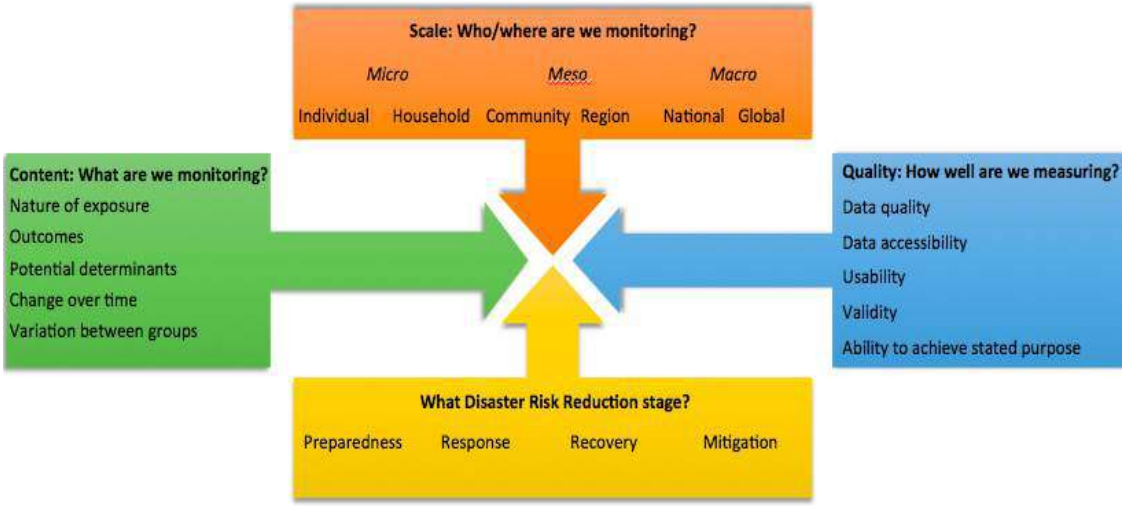

Figure 5: Critical questions for cohesive measurement of resilience trajectories: an example of a resilience heuristic matrix

Factors and processes identified in the accompanying full report (Deliverable 1) include:

- The degree of exposure to natural hazards including magnitude and duration (e.g., how long have individuals lived in a neighbourhood experiencing extensive damage and subsequent recovery, what is the frequency of flood events in a given location).
- Resilience determinants / risk factors (e.g., housing, age, wealth, social support, policies, local norms, infrastructure fragility)
- Outcomes either from exposure to natural hazards (e.g., health outcomes, shelter, community functions), or intermediary processes (such as level of preparedness)
- Scale or level: individual > household > community > urban centre > region > country>global
- Time in DRR cycle: pre-event (including historical change) (everyday) > during > after recovery

Other pragmatic considerations when evaluating data include:

- Ease of use (and therefore ease of updating or replicating measures) including accessibility of the data, costs (data and time), and the burden on users
- Adequacy for the job
- Applicability across hazards, but sensitive to specific hazards
- Applicability across environments (built, natural, social etc.)

The four dimensional nature of the matrix highlights how multiple dimensions need to be considered together. Figure 6 illustrates how the heuristic can be applied to facilitate discussion, in this instance focusing on

assessing transport in the recovery stage (the bottom DRR box) of a disaster. The arrows signify key questions about what needs to be measured and how.

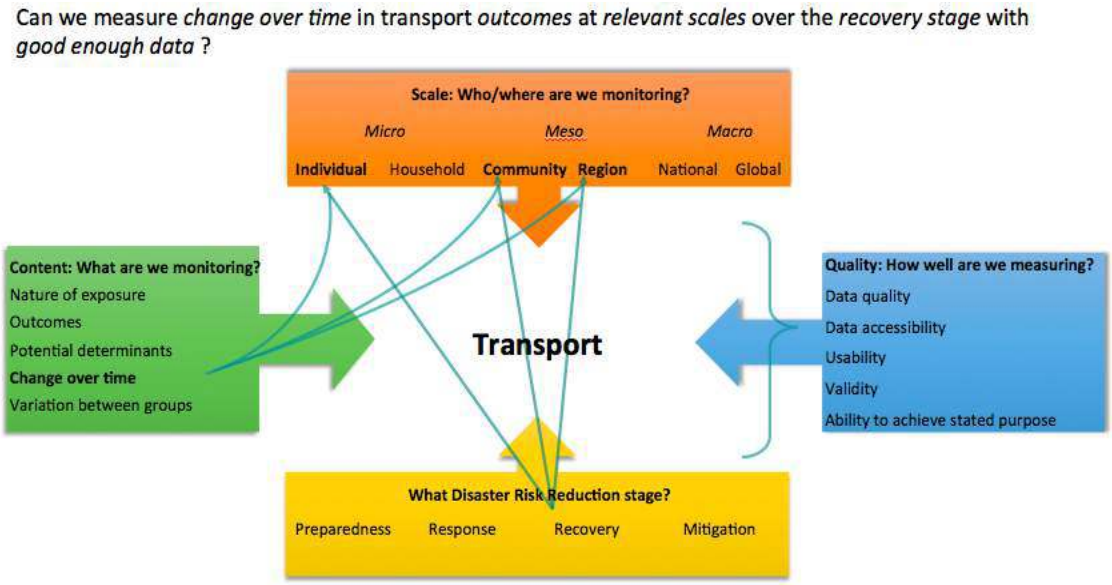

Figure 6: Identifying gaps and priorities in describing trajectories

The top 'Scale' box identifies three scales where transport could be affected during recovery; individual mobility (for example, how easy is it for people to get to work or school), community accessibility (levels of access to key resources such as employment, food retailers, etc.), and regional networks (levels of service, traffic flows, etc.). The green Content box on the left prompts consideration of the desired transport outcomes to be observed, and the extent to which they can be seen to change over time. For example, can we measure a return to desirable traffic flows within a network as recovery takes place? As transport infrastructure is repaired, does it translate through to improved individual mobility where people can move freely around their town? Finally, the Quality box on the right asks how we can develop robust, fit for purpose measures suitable for the New Zealand context.

The heuristic matrix can also be used to evaluate potential measurement tools in the context of the Challenge. Figure 7 demonstrates how Baseline Resilience Indicators Model for Communities (BRIC) developed by Cutter and colleagues (Cutter et al. 2008, 2010, 2014) can be considered in terms of wider measurement needs. Purple arrows illustrate what the BRIC can offer to the Challenge, whereas dashed red arrows signify queries the Challenge might have about the tool. BRIC seeks to measure factors at a spatial community level, rather than individual or regional scales (Scale box).

In terms of Quality, a feature of the tool is its use of existing administrative data, aiding usability and cost-effectiveness. However questions about the validity of the domains and indicators in BRIC for the New Zealand

population will need to be addressed. With regard to the bottom DRR box, BRIC was established as a baseline tool, informing preparedness by capturing levels of vulnerability and adaptive capacity. What will it be able to tell us about the recovery stage in the New Zealand context?

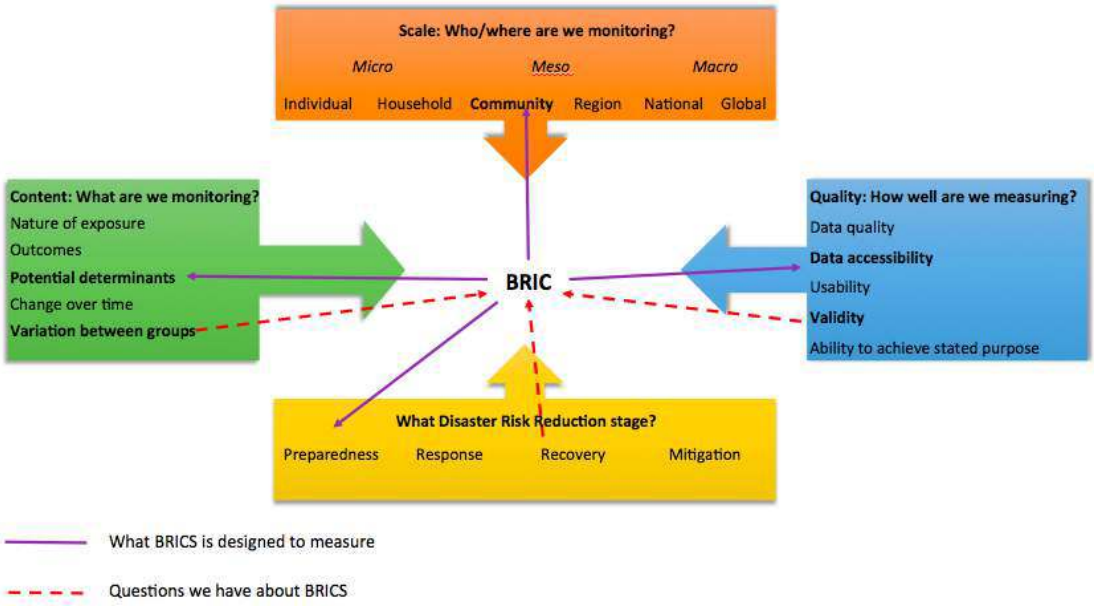

Figure 7: Evaluating potential tools - the Baseline Resilience Indicators for Communities (BRIC)

And finally with regard to Content on the left, an important feature of BRIC is that it seeks to identify potential determinants of community resilience. Yet is it sensitive enough to capture potential variation between, for example, rural and urban communities?

Clearly, it will be difficult to achieve comprehensive and high quality measurement. For example, would regional rather than community scales be good enough to inform policy and practice? Would 5 five yearly data such as census be an acceptable time scale rather than the ideal yearly data collection? Are there alternative sources of data that can be explored? The heuristic then acts as a discussion aid across the Challenge, within projects, and with stakeholders and communities to deciding how compromises be made.

3 Conclusion

As the Resilience Trajectory Toolbox launches in July 2015 as part of the RNC-NSC, an initial priority is creating prototype Resilience Measurement Heuristics as easy to use tools that can be used by researchers and stakeholders in the early stages of developing their resilience benchmarking and monitoring approaches. These heuristics will provide a series of steps through which researchers can systematically progress to evaluate and select indicators, tie indicators to theory, and align the various assessments that will be developed to a general resilience

framework. This short paper, along with other outputs from the Resilience Benchmarking and Monitoring Review will provide a starting point to guide discussions between researchers across the RNC-NSC about the development of a Resilience Measurement Heuristic.

Frameworks and models have been used successfully in similarly complex research programmes and situations to aid researchers with navigating their way through to effective and robust measurement. The process of developing a heuristic can in itself bring about useful discussion about how measurement needs to take place. One of the first steps in the RNC-NSC will be to bring together understandings of potential resilience pathways, including the various terminologies, constructs, and tools currently in use. An overarching heuristic could be therefore valuable for developing a shared understanding of causal pathways (for example). Specific work streams could benefit from more specialised devices, based for example, on a conceptual model to visualise theorised pathways or a strategic framework to identify opportunities and barriers to resilience action. What is most significant is that any device be useful to the team, and push our thinking and research about how to achieve a more resilient New Zealand.

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