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Testing indicators of resilience for rural communities

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Invited paper presented at the New Zealand Agricultural and Resource Economics Society (NZARES) Conference, October 19-20, 2017, Rotorua, New Zealand.

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Testing indicators of resilience for rural communities
July 2017

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Abstract

The resilience of rural communities – their ability to adapt to change over time – is a concern in itself and for its effects on the agricultural sector. The present pilot study investigated the possibility of using official statistics for the purpose of measuring resilience, and in particular tested the possibility of identifying resilience thresholds for the indicators. The study used community workshops to investigate the drivers of self-reported resilience among residents of four rural communities in New Zealand, and then compared the self-reported ratings against indicators from official data sources. The self-reported ratings of overall community resilience tended to be more influenced by economic and institutional drivers than social, cultural, or environmental drivers. In addition, the overall self-reported resilience ratings tended to match estimations of resilience based on official statistics. It was therefore possible to identify resilience thresholds for these indicators, that is, values of indicators that reflect more and less resilient communities. Replicating this method in a larger study would provide policymakers with useful information about priorities for rural communities.

Keywords

Community resilience; indicators; thresholds; qualitative methods; rural communities.

1. Introduction

Agricultural policy in New Zealand, as elsewhere, has multiple objectives. One important goal for the sector is strong economic performance, as signalled particularly by the government's stated goal to double the value of primary sector exports by 2030 (Ministry for Primary Industries, 2015). At the same time, the government has announced its Clean Water Package, with the goal of having 90 per cent of rivers and lakes swimmable by 2040 (Ministry for the Environment, 2017). It can be challenging to integrate economic and environmental goals in agricultural policy, even focusing just on farm management and land use. Moreover, 'sustainability is commonly seen to encompass at least three dimensions, economic, environmental and social sustainability' (Wustenberghs, Coteur, Debruyne, & Marchand, 2015, p. 3). Rural communities are nevertheless facing challenges across all those dimensions (Steiner, 2016). The farmers that manage farms are members of communities; their families are part of schools, churches, and voluntary societies; the farm businesses are part of local economic flows; and the physical farms are part of the landscape and its ecosystems. This social embeddedness in particular has led to public concern recently in New Zealand that the agricultural sector cannot continue to support small towns throughout the country (Spoonley, 2016).

The present research was a pilot study to investigate the multiple values or goals associated with agriculture and rural communities. The core concern of the work was to develop an understanding of what 'more resilient' and 'less resilient' might mean with regard to rural communities, and thereby to provide, tentatively, an empirical measure or scale to incorporate resilience into agricultural policy. It is common to talk about community resilience growing or declining (Steiner, 2016), which suggests that resilience can be quantified. Based on this idea, further questions were developed:

- Can resilience be a useful concept for rural communities?
- Can resilience drivers be identified?
- If resilience is validated conceptually, can it be used as an organising framework for multidisciplinary research?
- Is it possible to provide empirical measures of resilience to inform agricultural policy?
- Can official statistics serve as a useful proxy for self-reported resilience?
- Which aspects of resilience most strongly influence community perceptions of resilience?

The pilot study demonstrates a method for addressing these questions. The study obtained two distinct data sets, which are termed *indicators* and *ratings* throughout the paper. The ratings data set was captured in

community workshops held in two regions in the North Island where participants rated the resilience of their community on a one to ten scale. The indicator data set consisted of a set of statistics collected from official sources such as Statistics New Zealand. The indicators are not determinative of resilience, but ideally will correlate with it – the indicators are not fundamental causes of towns being resilient or not-resilient but are only measurable signposts that allow policymakers to understand resilience. The research analysed the indicator data and ratings data to investigate the concept of resilience and potential ways to measure it. The findings suggest that there is some utility to the concept and the research method, and also suggest possible ways to extend the work.

2. Theory

2. 1 Community resilience

'Resilience' is seeing more use as a term and a concept, and is commonly understood as the ability to recover from a disturbance (Salt, 2016). The current use in research and policy derives from four main research areas: psycho-social, ecological, disaster relief, and engineering (Salt, 2016; Steiner, 2016). Resilience captures two somewhat different ideas. One is the idea that a system can 'bounce back' from a disturbance and recover to its prior state, while the second idea is about adapting to change while retaining essential features of its previous identity (Salt, 2016; Steiner, 2016; Mackay & Petersen, 2015).

At a community level, resilience involves the 'ability of groups of communities to cope with external stresses and disturbances as a result of social, political, and environmental change' (Wilson, 2012; Adger, 2000). One hypothesis regarding community resilience is that there are tipping points or thresholds: if a system is pushed too far, it cannot 'bounce back'. The idea has foundations in the environmental literature, which suggests that there are limits to ecological systems, such as the safe level of greenhouse gases in the atmosphere or the consumption of freshwater (Rockstrom, et al., 2009). Beyond those limits, ecological systems can have tipping points that lead to qualitatively different states (Lenton, et al., 2008). The hypothesis is that there 'are limits to how much a self-organising system can be changed and still recover. Beyond those limits it functions differently because some critical feedback process has changed. The system's identity changes when a threshold is crossed' (Salt, 2016). The idea of threshold effects becomes even more complicated when resilience, like sustainability, is seen as multi-dimensional. If resilience has economic, environmental, social, and other dimensions, then it is possible that thresholds are similarly multi-dimensional. This concern is the focus of Georgescu-Roegen's critique of economic modelling (Daly, 1997): that there is a minimum requirement for natural resources and no amount of built capital can fulfil that requirement.

Although 'community', like 'resilience', is a contested term, a spatial understanding of rural communities can be useful for collecting data on resilience (Wilson, 2010; Robinson & Carson, 2015) and for research on the future of rural areas (Spoonley, 2016). Viewed that way, 'community' is a term for the social system interactions that occur within a defined location (Wilson, 2010; Cutter, et al., 2008). While this approach does not resolve the issue around the term 'community', it provides something of a definition as well as a pragmatic approach (Wilson, 2012). The research approach aligns with discussions of how to do research when to tackling complex and interdisciplinary research (Bammer, 2013; Sarewitz, 2016).

2.2 Resilience framework

The present research did not try to resolve the conceptual issues of resilience or achieve *a priori* consensus on appropriate indicators. Using the language of Binder, Feola, & Steinberger (2010), it focused less on the 'normative' dimension that concerns the link between indicators and the concept of sustainability. Instead, the focus was on the 'systemic' dimension, which considers both parsimony and sufficiency: do the indicators adequately reflect resilience without too much complexity. It also incorporated the 'procedural' dimension by considering replication and consistency as well as the participation of stakeholders. To do this, the research started with a framework reported in Fielke, Kaye-Blake, & Vibart (2017). The framework can be presented in a diagram, as shown in Figure 1. Building on prior research, such as the Community Capitals Framework (Emery & Flora, 2006), the resilience framework covers cultural, environmental, institutional, economic and social dimensions of resilience, as well as external factors or drivers affecting a community. Although all these dimensions have been included in prior research, it is not uncommon for indicators schemes to focus

mainly on economic, environmental, and social indicators (Wustenberghs, Coteur, Debruyne, & Marchand, 2015) because they are central to the concept of community resilience. Each of the five dimensions (excepting the external dimension) is presented as a wedge of a circle, and each wedge can be larger or smaller. Together, the wedges make a single, circular area, which represent the resilience of a particular community.

The framework diagram explicitly incorporates three ideas about resilience. The first idea is that resilience can be quantified, at least to the extent that it can be represented as an area on a diagram. Furthermore, each resilience dimension can be quantified separately, so that, for example, social resilience can be meaningfully separated from economic resilience. The second idea is that total resilience is a function of the separate dimensions of resilience. For the purpose of the diagram, total resilience is the coloured area, and it is made up of the wedges for each of the five resilience dimensions. This presentation suggests that, to some extent, it is possible to substitute one dimension for another. A bit more environmental resilience with a bit less cultural resilience can still produce the same overall area on the diagram; the suggestion is that it also produces the same overall resilience in the community. Finally, the third idea incorporated into the diagram is that of thresholds. An inner dashed-line circle denotes a minimum necessary level for each resilience dimension. The concept, as discussed above, is that communities must have a minimum level of each dimension in order to be resilient overall.

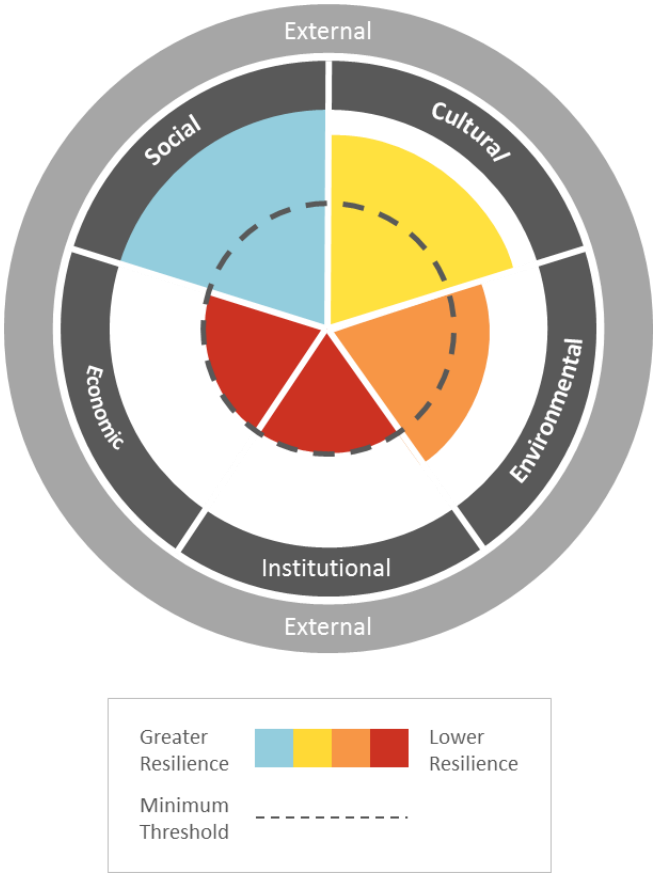


Figure 1 Resilience Framework

The resilience framework provided structure to the present research and a way to organise the data from official sources and community workshops. As explained in the following section on method, the individual resilience dimensions were tested for links between self-reported ratings and indicators based on official data, and links between the dimensions and overall community resilience were also investigated. The analysis demonstrated how to use indicators to add specificity to the concept of resilience, and even to inform a discussion about minimum thresholds for these indicators (Parris & Kates, 2003).

3. Method

3.1 Choosing the locations for the project

The first step in the method was to choose locations for study. To identify possible towns, a list was developed of all the population centres in New Zealand with a population of between 2,000 and 10,000 people. The population figures were taken from Statistics New Zealand's population estimates for minor urban areas[1] as of June 2016. The exercise identified 67 possible rural communities. The list was refined by narrowing the range of towns to between 4,500 and 10,000 people, resulting in a list of 32 towns. In order to ensure that representative data would be available on the towns selected, the ward boundaries were matched against town boundaries for the towns on the short list since wards are Statistics New Zealand's smallest area unit for publishing census statistics. The concern was to establish for each town whether most of the population was contained in one or two central wards or was more dispersed, since dispersed communities would be difficult to match workshop data to official statistics spread over many units, or where perceptions of a community's resilience may vary over a wide area within a community. The result was a short list of 15 towns where the population within the town matched closely to the population within a well-defined ward. Finally, a wider group of researchers, including university researchers in community resilience, was consulted on the short list.[2] Four towns were chosen from the short list based on the research group's expert judgement, a paired-sample case study design involving four towns in two regions, and perceptions of two of the towns being resilient (Huntly and Dannevirke) and two being less resilient (Te Kuiti and Taumarunui). The towns are in two regions in the North Island of New Zealand, Waikato and Horizons. The location of the four towns are shown in Figure 2 below.

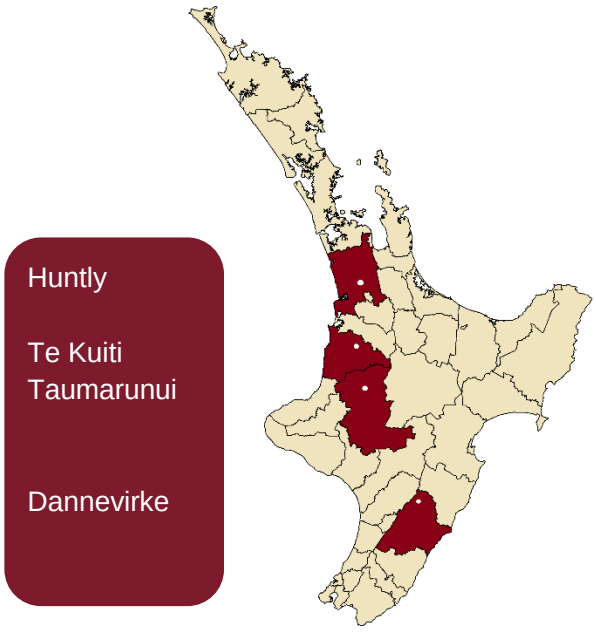


Figure 2 Locations of the four towns

3.2 Indicator data from official sources

The next step in the research was obtaining official data to compare the four towns. Data were collected from Census statistics (Statistics New Zealand, 2015; Statistics New Zealand, 2008), Regional Council websites and reports (Horizons Regional Council, 2013; Horizons Regional Council, 2014; Waikato Regional Council, 2015), as well as Ministry for the Environment (Ministry for the Environment, 2015). All data informing

[1] http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE7541#

[2] Researchers consulted were: AgResearch – Margaret Brown, Ronaldo Vibart, Robyn Dynes, Alec Mackay. Lincoln University – Michael Mackay. Others – Meredith Niles, Willie Smith.

social, economic and cultural indicators were collected from the territorial ward boundaries that spatially covered the entire town boundaries.
As conceptualisations of community resilience transcend disciplinary silos it is important to clarify what is meant by the dimensions of community resilience. Table 1 highlights the dimensions of community resilience that have been utilised in previous work in the space, with a particular focus on research that has focused on ongoing characteristics of resilience as opposed to rapid onset, post-hazard characteristics (McCrea et al., 2014; Ross and Berkes, 2014; Steiner and Atterton, 2014; Wilson et al., 2016). The dimensions in Table 1 indicate the indicators subsequently utilised in the framework developed here (Akamani & Hall, 2015), (Bailey & Buck, 2016), (Buikstra, et al., 2010), (Cutter, et al., 2008), (Kirmayer, Sehdev, Whitley, Dandeneau, & Isaac, 2009), (Maclean, Cuthill, & Ross, 2014), (Magis, 2010), (McManus, et al., 2012), (Sherrieb, Norris, & Galea, 2010), (Skerratt, 2013), (Steiner & Markantoni, 2014), (Wilson, 2010), (Wilson, 2012).

Table 1: Indicators of community resilience utilised in the RRC framework

Dimension	Indicator/question to ask
Economic	Income, employment levels, diversity of income streams, diversity of occupations
Environmental	Fresh water quality, soil erosion, biodiversity, air quality.
Social	Population change, education levels, dependency ratio, volunteering, access to phone, access to internet.
Institutional	Self-rated health, court convictions, local voting percentage, state owned housing.
Cultural	Māori affiliated, te reo (Māori language) speaking, born overseas, religious affiliation.

After gathering the data available at the smallest spatial levels possible for each township, an index for each variable was developed to consolidate the different measures. It allowed for the averaging and comparison of indices across townships and to the National indices. To produce the categorisation for each of the variables, the range was set for the whole of New Zealand as it was necessary to compare to national benchmarks. The resulting index key is included in Appendix A. The subdivision of the range into five categories was considered in light of the variation in the data between the four towns and the national measure. The categories were divided evenly to achieve some form of variation in the data to show meaningful differences. If expanded to other areas, particularly urban communities, the averages of the rural towns will likely be much more similar and require either new subdivision ranges, which would likely result in these towns falling into the same index categories, or the expansion of the scale to elucidate the larger variation in measures.

There were two key issues with the raw data available and calculating accurate township resilience dimensions and overall resilience indices: data inconsistency and spatial incompatibility. The data inconsistency issue arose particularly with obtaining appropriate data on environmental and institutional dimensions. The social, economic and cultural indicators used, although at times quite crude, were at least representative of local townships with the same geographical boundaries and at the same point in time (during 2013 Census collection). On the other hand, the environmental and cultural indicators were less reliable, with varying time periods and boundaries. The data inconsistency highlighted an important problem in obtaining and producing accurate measurements of community resilience. There are variations across the variables in terms of the spatial level at which data are available. For instance, all of the environmental indicators were only available at the regional council level and the data varied over time periods. Similarly, court convictions were registered at the local court in each town but included different judicial boundaries to the ward boundaries for which Census data were available. The implication was that the data are not completely reliable or comparable across the resilience dimensions.

3.3 Ratings data from community workshops

To obtain data on the perceived resilience of towns, workshops were held in each of the four selected towns. Invitees were those likely to have a view on the resilience of the local community, including local government representatives, church leaders, medical practitioners, social workers, local businesspeople, iwi (Māori),

farmers and teachers. Participants were invited to contribute in their professional capacities and therefore ethics approval was not required. In all, 24 people attended across four workshops. Of those, 22 people remained to the end of the three-hour workshops and provided quantitative data. Out of the workshop discussion participants also provided a description of the issues and strengths in their town.

The workshops included an activity focused on official indicator data about the towns. Information was provided on two to four indicators for each resilience dimension. Given the workshop format and focus on participation, the indicators were provided in a 'pub quiz' format rather than a presentation. For each indicator, participants were asked to estimate the value for their town, with points awarded for providing the answer closest to the actual value. This approach had the added benefit that participants discussed whether they were more pessimistic or more optimistic about their town than the official data would suggest.

Lastly, participants were asked to rate the resilience of their towns and their regions on a scale of 1 (least) to 10 (most). They were asked to rate each of the five resilience dimensions for the town and region, and as well to provide a rating of overall resilience. The ratings were followed by further discussion, highlighting points where participants had diverging views or where their view of the region was very different from the view of the town. The workshop was then closed with a small token of appreciation for participants' time (a $20 fuel voucher), and a brief explanation of the next steps of the project.

Different numbers of people attended the workshops in each town. While a large number of people were invited to each workshop, participation varied between towns as shown in the table below.

Table 2: Number of participants at each workshop

Town	**Number of participants**
Huntly	4
Te Kuiti	6
Taumarunui	4
Dannevirke	8

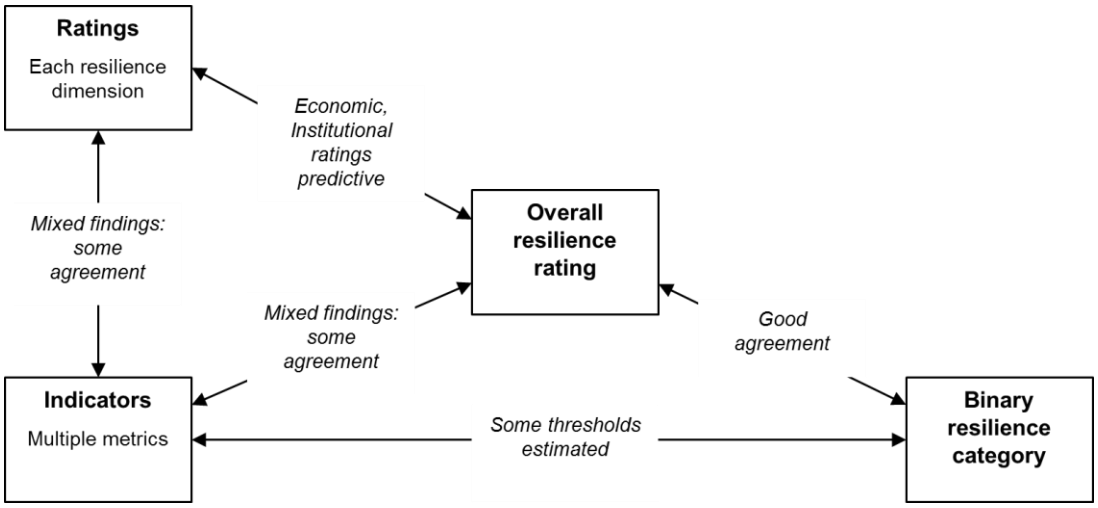
3.4 Method for data analysis

The research obtained two distinct data sets – indicators and ratings. The indicator data set consisted of the statistics collected from official sources such as Statistics New Zealand, as described above (raw data are provided in Appendix A). The ratings data set consisted of the subjective ratings given by the workshop participants from each town. Each of these ratings was between zero and 10 for their town for each of the five dimensions and overall resilience. Generally, the significance and goodness-of-fit statistics were calculated and reported. Conventionally, a p-value of 0.05 is used to determine the variables that are significant to the outcome. It is improper, however, to draw any conclusions about statistical significance from this pilot study due to the small sample size. Instead, the p-values and goodness-of-fit statistics were used as a guide for assessing the variables relative to each other.

Several different relationships between ratings of resilience and indicators were examined as illustrated

below. This paper focuses on the links between ratings of resilience in each dimension and participants' overall ratings of resilience and the links between indicators of resilience, overall resilience ratings and binary categorisations of resilience. The link between indicators of resilience and ratings of resilience by dimension was investigated but is not reported here.

Figure 3 Summary of datasets and research findings



For the indicator data set, indicator scores for each dimension were developed. The scores were a composite of several indices. First, the raw statistics were turned into a value on a scale from one to five. Next, the index for each dimension was calculated by taking the mean of those scores (on the five-point scale) for the indicators in that dimension. The overall index for each town, in turn, was calculated by taking the mean of the indices for all five dimensions. In this way, the overall indicator score was simply an average that took into account all five resilience dimensions equally. The rating of overall resilience given in the workshop, however, was simply a rating out of ten given by each attendee. The overall resilience rating from the workshops, therefore, was not a mathematical average of the ratings for each dimension but a rating provided independently by participants.

The table below outlines the statistical tests that were carried out, the variables that were tested and the type of model used.

Table 3. Summary of tests conducted

Test	**Number of models in test**	**Dependent variable**	**Independent variables**	**Type of model**
Test 1	1	Workshop ratings – overall resilience	Workshop ratings – each dimension	Linear model
Test 2	5	Workshop ratings – each dimension and overall resilience	Indicators – indices for each dimension and overall resilience	Linear models
Test 3	15	Workshop ratings – social, economic, cultural and institutional dimensions	Indicators – values of each indicator in social, economic, cultural and institutional dimensions	Linear models
Test 4	15	Workshop ratings – overall resilience	Indicators – values of each indicator	Linear models
Test 5	16	Binary resilience	Workshop ratings – overall resilience	Logit models

			Indicators – values of each indicator	

3.5 Limitations of the resilience data

The ratings data from the workshops had limitations. The data were, at root, ordinal data specific to each person and resilience dimension. In the research, there was no attempt to understand what specific ratings meant to participants, such as what a '5' or a '6' meant about resilience. There was also no attempt to standardise ratings across participants, or, in fact, across dimensions. Future research could consider approaches to standardizing this data. Nevertheless, the analysis assumed that the ratings are interval data, and that the scales can be compared across participants (and towns) and dimensions. These assumptions could be challenged. Another limitation of the data was the small sample size, both in terms of number of towns and number of participants per town. Partly, the small sample size is a function of the nature of the method, which included engagement with town residents and qualitative data collection. The small size is also due to the pilot nature of the study.

4. Results

4.1 Issues raised by workshop participants

During the workshop discussions, participants raised a number of issues affecting their towns. Across the four towns there were some common themes. The majority of common concerns related to economic or institutional issues. One common concern was employment. Participants were concerned with the availability of jobs in their town, citing declining industries that had closed over a number of years such as mines, freezing works or milling. Related to this was a lack of opportunity for youth also commonly cited as a concern. This was leading to young adults leaving town when they had the opportunity and others joining gangs or not seeking work. A second, related concern was the narrow economic base of each town. Specific aspects of this concern included being heavily dependent on agriculture, losing industries that had been important or explicitly wanting more economic diversity. A third common concern was a lack of understanding from central government of how issues worked in the regions. Participants said that central government did not like to operate at the small scale necessary to effect change in smaller towns, which often meant issues went unaddressed. One example provided was of a dysfunctional family not being prioritised for support by a central government agency, when the local view was that a few individuals were having significant impacts on the town. Participants said that a change in that family could have had wider beneficial effects but central government was not willing to operate on that basis. Another example given was of a social sector trial with a church group working with at risk youth in holiday programmes. The trial was apparently very successful and participants said that because it was so successful central government withdrew funding for the programme on the basis that it was worthwhile for the community to fund it themselves. A fourth issue raised was water. Participants commonly had concerns about the governance of water in their region. However these concerns varied from place to place with some communities concerned about the limits placed on them by environmental regulations, with others concerned about the poor/hazardous quality of local waterways.

The majority of towns felt they have significant strengths in cultural and social aspects of resilience. One advantage cited repeatedly was local iwi (Māori). Local kohanga reo (immersion schools), marae (meeting houses) or treaty settlements[3] were discussed as making participants proud of or happy about their towns. Strong involvement of Māori in local communities was felt to be a major positive influence in the rural communities in the study. Treaty settlements were being invested in local communities and participants generally spoke very positively about iwi's role in the community. A second strength in the communities was local schools. Participants in all four towns talked about the strength of their schools as a positive aspect to living in their community. For example, participants said that the local high school in Huntly also includes Academies for students to gain skills in particular industries. According to the school, the Academy courses are recognised by relevant tertiary institutions and teach practical, employable skills in primary industries, hospitality and tourism, trades (wood and metal work in particular), services and outdoor education. Finally, the workshops discussed the value of community. Many of the participants spoke of a supportive community

[3] Treaty settlements refers to redress provided by the government, both financial and cultural, to indigenous communities for breaches of New Zealand's Treaty of Waitangi – one of the founding documents of New Zealand's constitution.

spirit among residents. The community was often described as tight-knit, welcoming and friendly. A strong sense of community where people support each other was often described by participants as a major strength of living in a rural community.

4.2 Ratings from the workshops

Holding collaborative workshops in the four case study towns proved to be an effective way to collect subjective ratings of resilience. Participants were able to provide numerical ratings for their individual towns and their wider regions. They provided ratings on a scale from 1 (least resilient) to 10 (most resilient) for all five dimensions of resilience, plus one overall rating across all dimensions. The tables below report the mean value for each town for each dimension, as well as the minimum and maximum overall resilience rating for each town.

Table 4. Minimum, maximum and average overall resilience rating for each town

	Huntly	**Te Kuiti**	**Taumarunui**	**Dannevirke**
Cultural	7.00	6.50	7.00	6.50
Economic	6.38	6.00	4.63	5.56
Environmental	4.88	4.83	7.75	6.13
Institutional	6.25	5.00	5.63	7.13
Social	5.63	7.17	7.13	7.19
Overall	6.75	6.17	5.63	7.38

Table 5. Mean values of workshop ratings

	Huntly	**Te Kuiti**	**Taumarunui**	**Dannevirke**
Minimum	6.0	4.5	5.0	7.0
Maximum	8.0	7.5	6.5	8.5
Average	6.75	6.17	5.63	7.38

These ratings reflected the opinions and perceptions that local participants had of their towns towards the end of the three-hour workshops. Of the four towns, Dannevirke received the highest mean rating for overall resilience, as well as the highest ratings for environmental, institutional and social resilience. Taumarunui received the lowest mean rating of overall resilience; however, the only dimension in which it received the lowest rating was economic resilience.

Across all the towns, participants generally rated their social resilience highest out of the five dimensions, while the economic resilience ratings were generally lowest. The majority of the mean ratings were above 5.0, although it is not clear from this research whether the rating scale was anything other than relative.
Test 1 examined the relationship between the overall rating and the ratings for the five dimensions by workshop participants. The ratings from all the participants were combined into a single data set, which produced an overall sample size of 22. The goal was to identify which dimensions were most important to participants when they gave their overall ratings of resilience.

Table 6. Test 1: Model to estimate overall rating from dimension ratings

Variable	**Coefficient estimates**	**Standard errors**	**Pr(>|t|)**
(Intercept)	2.73	0.607	0.000369
Social	0.0674	0.129	0.610
Economic	0.300	0.134	0.0394
Cultural	-0.159	0.155	0.320
Institutional	0.576	0.110	0.000082
Environmental	-0.127	0.118	0.297
Adjusted R^2	0.794		

The results of this test showed that institutional and economic resilience were the most important dimensions to the ratings of overall resilience: they had the largest coefficients and the highest statistical significance.[4] In particular, institutional resilience – a dimension sometimes excluded in discussions of resilience or sustainability – was an important variable in this model. The result may be due to the significant role that local institutions, such as local government, play in rural communities. It may also be a function of the people invited to the workshops, who tended to be from local government, churches, healthcare organisations or other institutions. Not surprisingly, economic resilience is also a key variable in the model. This result is likely due to the importance of jobs and incomes in rural communities (as well as elsewhere). Participants' opinions on social and cultural resilience appear to be less important to their overall resilience rating of their towns. The model also showed good fit with the data, which, given the small sample size, is interesting.

4.3 Workshop ratings and external indicators

The next part of the analysis focused on determining whether the indicator data gathered could be used to model the resilience ratings. Test 2 compared the mean ratings of each dimension and overall resilience for each town to their corresponding indicator indices using linear regression.

In general there were positive relationships between a town's indicator score and its workshop ratings. The results indicated that participants largely perceived their town's resilience in a way that was consistent with statistical information about the town. While there was some consistency across these two sets of data, they did not correlate perfectly.

Testing overall resilience, in particular, showed that the town with the highest mean workshop rating also had the highest score according to the indicator data. Notably, the town with the second highest workshop rating, Huntly, had the lowest indicator score. There are many possible reasons why participants of Huntly rated their overall resilience higher than the indicator-based metric. The indicators, the ratings or both could be poor measures of resilience. Alternatively, experimental errors, including sample selection bias or missing variables, could be affecting the results.

The next test (Test 3) considered the individual indicators rather than the indices, in order to provide a more detailed picture of the relationship between indicators and ratings. Each individual indicator was modelled against the rating for the dimension related to the indicator.

The next step was to model the Overall resilience rating as a function of the indicator data. In Test 4 the Overall rating was the dependent variable and each model had one indicator. The indicator data were in percentage points as before, the Overall ratings were on a 100-point scale. Indicators were chosen from all the different resilience dimensions. The results are presented in the table below.

[4] Throughout this analysis, the statistical significance of results is downplayed. This is a pilot study with a small sample size, so assumptions underpinning the statistical tests are violated. The statistical tests have been done for two reasons. First, they demonstrate the method, which can be applied to a larger sample. Secondly, they provide a suggestion of which effects may be more important, although there is no attempt to conclude that the results are definitive.

Table 7. Test 4: Models of Overall resilience rating as function of indicators

Model / Indicator	Intercept parameter (st. error)	Indicator parameter (st. error)	Pr(>|t|) for Indicator parameter	Adjusted R^2
Population change	66.7 (4.70)	0.0782 (0.609)	0.899	-0.0491
Secondary school qualifications	247 (708)	-5.49 (21.3)	0.799	-0.0465
Tertiary qualification	109 (84.6)	-6.06 (11.9)	0.618	-0.0367
Phone access	-9.07 (40.6)	0.999 (0.539)	0.0785	0.104
Internet access	-88.7 (42.7)	2.83 (0.78)	0.00166	0.367
Volunteering	106 (15.7)	-2.1 (0.823)	0.019	0.208
Unemployment rate	72.5 (9.43)	-0.572 (0.825)	0.496	-0.0254
Median income	-31.7 (42.9)	1.26 (0.553)	0.0336	0.167
Religious affiliation	28.1 (24.9)	0.69 (0.451)	0.141	0.06
Māori population	92.8 (8.41)	-0.589 (0.181)	0.00398	0.313
Te reo speakers	85.0 (7.26)	-1.53 (0.568)	0.0137	0.231
Born overseas	87.7 (15.9)	-2.26 (1.65)	0.186	0.0399
Voter turnout	51.3 (11.4)	0.337 (0.255)	0.202	0.0339
State owned houses	73.6 (3.99)	-0.559 (0.257)	0.0418	0.151
Self-rated poor health	97.1 (36.1)	-2.84 (3.30)	0.400	-0.0126

This test found that Overall resilience had a different relationship to the indicators than the individual resilience dimensions. For Overall resilience, the best-fitting indicators were phone access, internet access, voluntary work, median income, identifying as Māori, speaking te reo and State-owned housing, with weaker relationships between the Overall ratings and religious affiliation, being born overseas and voter turnout. Population change was not strongly predictive of Overall ratings, although it was strongly predictive of the Social ratings. State-owned housing remained a strong predictor, but the other institutional indicators were weaker at predicting Overall ratings than they were at predicting Institutional ratings. Median income became important, and cultural indicators were also good predictors of Overall ratings. These findings were consistent with the earlier analysis, which found that the ratings for individual dimensions were only weakly linked to the rating for Overall resilience. It was therefore unsurprising that the ability of indicators to predict dimensional ratings would tie only weakly to predictions of Overall resilience.

4.4 Testing the idea of thresholds

As discussed earlier, the resilience literature included the idea of thresholds below which a community's resilience is compromised. While the ratings were a way to quantify resilience, the study also aimed to understand how to categorise rural communities as resilient or not-resilient based on indicators. The 10-point scale used in the workshops did not contain an explicit threshold that participants could use to anchor their impressions. They were not asked to label their communities as 'resilient' or 'not-resilient', but rather to provide a rating from less resilient to more resilient. Thus, the workshop ratings did not provide the binary

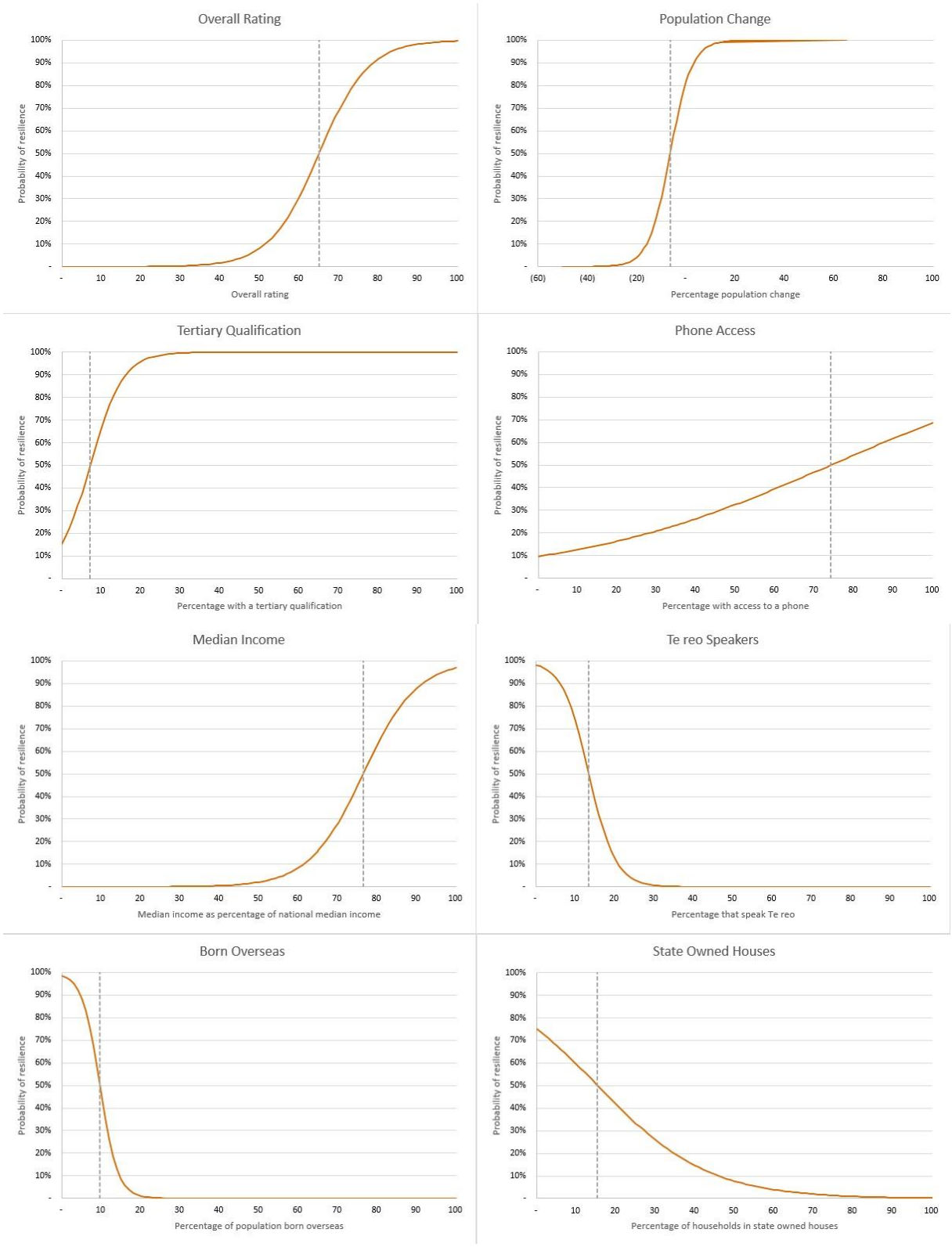
indicator required to analyse threshold effects. Instead, the research team had relied on expert judgement to categorise the four town as either resilient or not-resilient. When the towns were selected, they were chosen so that the sample contained one resilient town and one not-resilient town in each of two regions. Huntly and Dannevirke were chosen as the resilient towns; Te Kuiti and Taumarunui were chosen as the not-resilient communities. Importantly, the workshops confirmed the categorisation of these towns. Huntly and Dannevirke were the two towns with the highest mean ratings of overall resilience for the four towns, and Te Kuiti and Taumarunui had the lowest ratings. Those results were provided in an earlier table. With the categorisation confirmed by the participants' ratings, a binary 'resilient' variable was created: Huntly and Dannevirke were assigned a '1' and Te Kuiti and Taumarunui were assigned a '0'.

With the resilience indicator created and confirmed, the next step was modelling the indicators against the binary dependent variable. For this modelling, a binomial logit model was used. The results showed that some of the indicators were better than others for predicting whether or not a town is resilient. None of these indicators had a strong effect on resilience, however this is likely due to the small sample size. The relationship between the binary resilience variable and the overall ratings was tested and it was found that the overall ratings were a good predictor of resilience. This confirmed the initial hypothesis that Huntly and Dannevirke were resilient and Te Kuiti and Taumarunui were not-resilient. These binary models were used to find a threshold for the resilience variable. The results are provided in Appendix B.

For Test 5, the overall ratings out of 10 were converted to percentages for the sake of consistency across all explanatory variables. All of the indicators had a range between zero and 100 per cent, except for population change which was between -50 and 50 per cent. The intercept parameter and indicator parameter values from the logit models were used to calculate the odds of a town being resilient for each possible value in the indicator range. For this analysis, the threshold was defined by finding the value for each indicator when the odds of being resilient are equal to one. This defined the threshold as being the point where the probability of the resilient variable is equal to 0.5.

The threshold was found for selected indicators: overall rating, population change, tertiary qualification, phone access, median income, Te reo speakers, born overseas and state owned houses. The graphs of cumulative density functions (CDFs) for these indicators are shown below, with the dotted lines on the charts representing the threshold of resilience for each indicator.

Figure 4 CDFs and resilience thresholds for multiple indicators



For the overall rating, the threshold was 65 per cent. Overall rating had a positive relationship with resilience, meaning any town with a rating over 65 per cent was resilient. A town with an overall resilience rating lower than 65 per cent was not-resilient based on this threshold. Of the communities in the pilot study, Huntly and Dannevirke had mean overall ratings over this threshold (68 per cent and 74 per cent respectively) and

therefore could be categorised as resilient. Te Kuiti and Taumarunui had mean overall ratings below this threshold (62 per cent and 56 per cent respectively) and therefore could be categorised as not-resilient.
Population change also had a positive relationship with resilience, though interestingly the threshold was negative six per cent for change over the period 2006 to 2013[5]. This implies that a town's population could decrease, but as long as that decrease was less than six per cent over seven years the town is still resilient. A town with a population decrease greater than six per cent over the period was not resilient based on this threshold. Of the communities in the study, Huntly and Te Kuiti had a population change of above negative six per cent over the period (one per cent and negative five per cent respectively) and therefore were resilient based on this indicator. Taumarunui and Dannevirke had population change below this threshold (-11 per cent and negative nine per cent respectively) and were therefore not-resilient when it comes to population change.

Tertiary qualifications, phone access and median income all also had a positive relationship with resilience. The threshold for tertiary qualifications was seven per cent, and any town with a higher percentage of population with a tertiary qualification than this was resilient. Based on this Huntly, Taumarunui and Dannevirke were resilient and Te Kuiti was not-resilient. The threshold for phone access was 74 per cent so any town with more than 74 per cent of its population having access to a phone was resilient. Based on this Te Kuiti and Dannevirke could be categorised as resilient, while Huntly and Taumarunui were not-resilient. The threshold for median income was 76 per cent. Any town with a median income more than 76 per cent of the national median could be categorised as resilient. Based on this, Te Kuiti and Dannevirke were resilient and Huntly and Taumarunui were not-resilient.

Te reo speakers, born overseas and state owned houses all had a negative relationship with resilience. This means that the higher the percentage value for each of these indicators, the lower the likelihood of that town being resilient. The threshold for te reo speakers was 13 per cent, so any town with fewer te reo speakers than that was resilient. Of the case study towns, only Dannevirke had fewer than 13 per cent te reo speakers and was therefore resilient. Huntly, Te Kuiti and Taumarunui all had a higher percentage of te reo speakers so were categorised as not-resilient. The threshold for born overseas was 10 per cent so any town with a lower proportion of population born overseas was resilient. Based on this threshold, Taumarunui and Dannevirke were resilient and Huntly and Te Kuiti were not-resilient. The threshold for state owned houses was 15 per cent and any town with fewer state owned houses than this was resilient. Only Dannevirke had fewer state owned houses than this and therefore was resilient. Huntly, Te Kuiti and Taumarunui were categorised as not-resilient based on this threshold.

Table 8 below provides a summary of the results of the binary analysis, showing which towns appeared to be resilient according to the indicators and the Overall rating. The table shows that the indicators provided a somewhat inconsistent picture of resilience across the four towns. Dannevirke appeared resilient according to nearly every indicator. Taumarunui appeared resilient on the fewest indicators, but still has a few ticks on the table. Huntly and Te Kuiti appeared similarly resilient on a simple count of the results. The full list of thresholds found for each indicator and the corresponding values for each town are provided in Appendix C.

Table 8. Resilience of each town, by selected indicator

Indicator	Dannevirke	Huntly	Taumarunui	Te Kuiti
Overall rating	✓	✓		
Population change		✓		✓
Tertiary qualification	✓	✓	✓	
Phone access	✓			✓
Median income	✓			✓
Te reo speakers	✓			
Born overseas	✓		✓	
State owned houses	✓			

[5] The two most recent censuses. Censuses are usually every five years, however the 2011 census was delayed until 2013 due to a major earthquake in and around Christchurch in February 2011. See http://www.stats.govt.nz/Census/2011-census.aspx for more information.

5. Discussion

The overall structure of the analysis is presented in

. The research obtained two data sets: the workshop ratings and the indicators. These two sets of data were compared with the Overall resilience ratings from the workshop participants. From there, the Overall resilience ratings and the indicators were compared with the binary resilience categories.

also reports the strength of the relationships among the different data sets and variables. The external indicators showed some agreement with the ratings of resilience dimensions from the workshops. For the Overall ratings of resilience, both the ratings for individual resilience dimensions and the indicator data were somewhat predictive. In turn, both the Overall resilience ratings and the indicators provided support for the binary categorisation of resilience.

The research has demonstrated that it is possible to establish thresholds for different aspects of resilience that should be met for a rural community to be resilient. While the thresholds developed here are indicative only due to the pilot nature of this project, the research showed that it is possible to link data on outside indicators of resilience to meaningful measures of resilience as reported by residents of rural communities. Several of the indicators examined were found to be useful predictors of residents' perceptions of the resilience of their community.

Where those relationships exist, a threshold can be determined by logistic regression of the minimum value of a given indicator for the town to be resilient. This first requires that towns be classified as 'resilient' or 'not resilient', or at least as 'more resilient' or 'less resilient'. This can be done either as an expert judgement or based on the ratings of participants themselves. In this case the initial judgement of researchers matched how participants in the workshops rated their towns' resilience. While not all indicators were useful, the research elicited several relationships between resilience and externally measured variables. The most significant outcome of this pilot analysis was that it is possible to collect a measure of resilience in this way and to perform analysis on the results.

The data on indicators of resilience were available at a suitable level of granularity for most indicators of resilience. Data on environmental resilience of rural communities was not available at a town level. However this is not a significant limitation since environmental resilience was not one of the aspects that strongly influenced participants' ratings of the overall resilience of their towns. Furthermore, the relationships demonstrated between particular variables and towns reinforced the narratives heard in the workshops. For example, median income suggested that Te Kuiti and Dannevirke were the more resilient of the four towns. In the workshops, participants in Te Kuiti spoke of the strength of their local institutions and were generally optimistic about the resilience of the town. In Dannevirke, the strength of the agriculture sector was discussed as providing economic resilience to the town. These narratives were supported by the median income indicator.

Self-rated resilience proved to be a meaningful measure. Participants' overall rating of their town's resilience reflected both their expressed concerns and the underlying state of their town as described in the official data. Not all aspects of resilience were equally useful. Ratings of institutional and economic resilience matched well with ratings of overall resilience and this likely reflects participants understanding of the idea of resilience. Self-ratings have limitations – ratings will vary depending on who is taking part which calls their accuracy and comparability into question – however it is inherent in the notion of resilience itself that it is the local residents themselves who are either resilient or not resilient. Their perceptions, while potentially divergent, are a key part of defining the resilience of the town.

The workshop method used to obtain ratings of resilience had several advantages. First it engaged local residents and provided for their participation. Workshop participants were eager to share their thoughts about their community. Secondly, the issues-based discussion usefully engaged participants in thinking about a variety of aspects of resilience ahead of establishing the ratings, ensuring that the ratings were well considered and thought through. Discussion with participants after they provided the ratings showed that they had given a lot of thought to why they rated their community's resilience the way they did. Lastly, the qualitative

discussion provided a great deal of background on the local issues, history and geography that put the ratings in their proper context.

One of the themes at the workshops was a concern about a narrow economic base. It was a common theme that cut across both more-resilient and less-resilient towns. Contrary to what might be expected, it did not appear that a narrow economic base or concern about it was useful for distinguishing towns' resilience. Even resilient towns expressed concern about being overly reliant on one industry or wishing for a greater diversity of jobs. Aspects of this concern that were discussed at the workshops included:

- Concern about being heavily dependent on agriculture (Dannevirke and Te Kuiti)
- Concern that many industries had left the town (Taumarunui and Huntly)
- Explicitly wanting more economic diversity (Taumarunui, Te Kuiti)
- Concern about the general lack of jobs (Huntly).

The results concerning Māori, iwi and te reo appeared somewhat inconsistent. Participants in each town described local iwi as making a significant positive contribution to the resilience of the community, through provision of social services and inspiring a sense of cultural identity and purpose in youth. In the workshop discussions, participants highlighted the benefits of strong Māori institutions and community participation, such as active and welcoming marae, successful kohanga reo and substantial treaty settlements focused on local economic development. On the other hand, some indicators that correlated with resilience ratings suggested different trends. In particular, the proportion of the population who identified as Māori correlated negatively with the Overall resilience rating, that is, a town with a higher proportion identifying as Māori was less likely to rate themselves as resilient. Here over-interpretation of causal linkages should be avoided. The analysis shows only a correlation; it does not explain any causative effects. One explanation is that, while Māori institutions are working to improve community resilience, tangata whenua (indigenous Māori people) are significantly more likely than non-Māori to have poorer social and economic outcomes. For example, the average life expectancy for non-Māori is 7.1 years higher than for tangata whenua (Statistics New Zealand, 2015). The Māori employment rate in 2016 was 60.3 per cent compared to 66.2 per cent for all ethnicities (Statistics New Zealand, 2017). The overrepresentation of tangata whenua in poor social outcomes means that communities with more people who identify as Māori are also more likely to be less resilient at a given point in time. The underlying causes of this divide are beyond the scope of this research, but the relationship between self-report resilience and indicators related to iwi, tangata whenua, te reo and Māori institutions requires further study.

Operationalising some form of community resilience framework does not come without significant risks. A major epistemological question relates to the quantifiability of community resilience. As has previously been discussed, the resilience of particular place-based communities may not adequately recognise the processes operating at other scales and as such communities cannot develop their own adaptive capacity divorced from national and international forces (MacKinnon & Derickson, 2013; Robinson & Carson, 2015). In an attempt to overcome this significant criticism in framing the measurement of the resilience of communities, the framework proposed here is bounded by the external factors of influence (see Figure 1). These concerns are recognised but the potential to utilise such a framework to understand the strengths and weaknesses of a community through measurement and enquiry, in order to celebrate and improve where possible, will provide benefits that outweigh postulation regarding the various contexts within which the community operates (McCrea, Walton, & Leonard, 2014; Steiner & Markantoni, 2014).

6. Conclusion

The research was a pilot study, so the main goal was to demonstrate that the method was feasible. A secondary goal was to generate initial findings, which the study has done, although with considerable caveats. There are several ways in which the research can be strengthened. The most obvious way is to pursue a large study that would capture more data and support better analysis. There are several dimensions to extend: the study could recruit more people per community with either workshop or survey techniques; it could increase the number or communities studied, and include more regions in New Zealand including regions in the South Island and even communities in other countries; and it could increase the number of indicators assessed in order to develop a more complete understanding of the links between indicators and ratings.

A second avenue for further work, once more data were available, would be to analyse the resilience threshold more closely. In the present research, the threshold effect was estimated based on a 50 per cent probability for the binary indicator. Although the resilience indicator is a binary variable, there is no reason that the threshold needs to be 50 per cent. An alternative is to use a similar process of expert judgement to assign communities a resilience status, and then estimate thresholds based on a probability of 30 per cent or 70 per cent. Using a consistent threshold would still enable researchers to align the different indicators with each other based on values that support resilience and values that do not. This avenue of work would still accept the resilience description and the idea of thresholds.

A third way to extend the work would be to develop other metrics for the idea of resilience. In the present study, resilience was measured in two ways; expert judgement and the results of community workshops. Other methods could be developed for creating an independent assessment of resilience (that is, independent from the official statistics used to investigate various thresholds). That binary assessment, or some categorical assessment, could then be compared to official statistics or community opinion. This extension would essentially expand on the method of identifying resilient and not-resilient communities.

The research confirmed three ideas about resilience presented in the resilience framework from Fielke, et al. (2017). It confirmed the idea that resilience can be quantified, and that the dimensions of resilience can be quantified separately. It did this through the selection of indicators across each of the dimensions that can be meaningfully compared to the subjective opinions of experts and community members. It also confirmed the second idea that total resilience is a function of the separate dimensions of resilience. The way the different dimensions interact to form total resilience is still not defined, and future research could explore how individuals weight different dimensions onto overall resilience. This work does, however, show that each of the dimensions contribute in various ways to the total resilience of a community. Finally, the work confirmed the idea of thresholds of resilience. It demonstrated that it is possible to find thresholds within indicators wherein a community will cross from resilient to not-resilient (or vice versa). This analysis defined the threshold at a 50 per cent probability of a town being resilient and from there found the range of values for each indicator at which a town is resilient and not-resilient.

This work confirmed that it is possible to test the concept of resilience by comparing subjective opinions with official statistics. The results from this pilot study may not be representative of the true resilience status of these towns, nor are these results necessarily able to be applied to other rural communities in New Zealand. The analysis, however, provides a method for conducting this type of research and lends itself to expansion in a number of ways. Any extension of this work will allow for a greater understanding of resilience and the ways in which it can be measured in rural communities.

7. Appendices

Appendix A – Index ranges for official indicator data

Table 9: Index key converting variables to a number between 1 and 5, where 1 = most vulnerable and 5 = most resilient

Categorical value:	**1**	**2**	**3**	**4**	**5**
Social indicators[6]					
Annual Pop. Change (2006-2013) %	loss of 2% or more	loss of under 2%	stable or growing less than 1%	1.01-2% growth	2.01% growth or more
Dependency ratio	70% or more	60-69.99%	55-59.99%	50-54.99%	less than 50%
Education level (finished secondary) %	less than 40%	40-49.99%	50-59.99%	60-69.99%	70% or more
Education level (finished tertiary)%	less than 5%	5-9.99%	10-19.99%	20-29.99%	30% or more
Access to phone %	less than 60%	60-69.99%	70-79.99%	80-89.99%	90% or more
Access to internet %	less than 50%	50-59.99%	60-69.99%	70-79.99%	80% or more
Volunteering (%)	0%	0.01-5%	5.01-10%	10.01-20%	20% or more
Economic indicators					
Unemployment rate %	15% or more	10-14.99%	7-9.99%	3-6.99%	less than 3%
Median income	less than $20000	$20001-22,500	$22501-27500	$27501-34999	more than $35000
Industry diversity ANZSIC06 no industries employing over 10% of workers	7	5 or 6	3 or 4	1 or 2	0
Occupation diversity ANZSCO count of occupations with over 20% of workers	4	3	2	1	0
Cultural indicators					
Spiritual affliation %	less than 40%	40-44.99%	45-49.99%	50-59.99%	60% or more
Māori % population	less than 15%	15-25%	25.01-35%	35.01-45%	45.01% or more
Te reo %	less than 5%	5-10%	10.01-15%	15.01-25%	25.01% or more

[6] Ranges were established by examining the variation across rural communities and dividing the range into five categories. If a greater range of communities is included, the values associated with each variable will need to be adjusted accordingly.

Born overseas %	less than 10%	10-15%	15.01-20%	20.01-25%	25.01% or more
Institutional indicators					
Court convictions (local court per capita Census pop %)	5% or more	3-4.99%	2-2.99%	1-1.99%	less than 1%
Local election voter turnout (district) 2016 %	less than 30%	30-34.99%	35-39.99%	40-49.99%	50% or more
State owned households 2013 %	20% or more	15-19.99%	10-14.99%	5-9.99%	less than 5%
Self rated health (regional council) 2012 poor %	20% or more	15-19.99%	10-14.99%	5-9.99%	less than 5%
Environmental indicators					
Soil erosion ton/year/person 2012/3	75 ton or more	50-74.99 ton	25-49.99 ton	10-24.99 ton	less than 10 ton
Indigenous vegetation cover % 2012/3	less than 10%	10-19.99%	20-24.99%	25-29.99%	30% or more
Air quality exceedances MfE state of our air (% of sites exceeding 2 day PM10 concentration) 2012	more than 50%	25.01-50%	10.01-25%	0.01-10%	0
Bacteria (E.Coli) indicator comparing sites in NZ	worst 25%	worst 50%	median	best 50%	best 25%

Appendix B – Model results of resilience as a function of indicators

Table 10. Test 5: Models of binary resilience as functions of indicators

Model / Indicator	**Intercept parameter (st. error)**	**Indicator parameter (st. error)**	**Pr(>|z|) for Indicator parameter**
Overall rating	-10.5 (4.69)	0.161 (0.0701)	0.0214
Population change	1.49 (2.23)	0.231 (0.287)	0.420
Secondary school qualifications	-178 (304)	5.33 (9.13)	0.559
Tertiary qualification	-1.72 (35.0)	0.243 (4.93)	0.961
Phone access	-2.24 (19.0)	0.0302 (0.257)	0.906
Internet access	-4420 (8180000)	82.2 (152000)	1
Volunteering	572 (249000)	-31.7 (13800)	0.998
Unemployment rate	-2.43 (4.39)	0.206 (0.363)	0.571
Median income	-11.1 (21.2)	0.146 (0.277)	0.6
Religious affiliation	0.919 (11.2)	-0.0171 (0.207)	0.934
Māori population	579 (927000)	-11.3 (17900)	0.999
Te reo speakers	4.025 (5.68)	-0.299 (0.403)	0.457
Born overseas	4.23 (8.03)	-0.438 (0.827)	0.596
Voter turnout	0.229 (5.02)	-0.00542 (0.116)	0.963
State owned houses	1.10 (2.45)	-0.0716 (0.143)	0.617
Self-rated poor health	1.082e-14 (15.9)	-9.654e-16 (1.45)	1

Appendix C – Thresholds for resilience found

Table 11. Thresholds for each indicator, with actual values for each town

Indicator	**Threshold**	**Huntly**	**Te Kuiti**	**Taumarunui**	**Dannevirke**
Overall rating	64.94	67.5	61.67	56.25	73.75
Population change (% change 2006 – 2013)	-6.47	0.09	-5.29	-11.01	-9.08
Tertiary qualification (%)	7.10	7.14	6.81	7.38	7.07
Phone access (%)	74.14	69.00	75.20	72.61	79.73
Median income (% of national median)	76.36	73.68	78.95	71.75	81.05
Te reo speakers (%)	13.43	16.00	14.06	14.97	7.77
Born overseas (%)	9.64	10.40	11.33	8.65	8.21
State-owned houses (% of households)	15.32	23.46	18.56	15.71	3.08

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