



A tool to assess livelihood preparedness for disasters: a study of Kaikōura earthquake in New Zealand

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Received: 22 January 2021 / Accepted: 9 March 2022 / Published online: 26 March 2022
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Abstract

Over the past decade, the cost of disasters on lives and livelihoods has increased many folds. However, there are few tools available that can be used to measure the level of livelihood preparedness for disruptions caused by natural hazards. By studying the experience and perceptions of communities affected by the 2016 Kaikōura earthquake in New Zealand, this paper aims to develop an assessment tool for measuring livelihood preparedness. Results from a survey of 140 residents in Kaikōura who lived through the earthquake and its aftermath identified four indicators of livelihood preparedness, namely (1) resource accessibility, (2) individual adaptive capacity, (3) livelihood diversity, and (4) the effectiveness of disaster risk reduction (DRR) measure. Structural equation modelling approach was used to establish the quantification of these four indicators, and as a result, a numerical model was developed that can be used as a tool to assess livelihood preparedness at an individual level. It is hoped that this tool will be used by policymakers and individuals living in hazard prone locations to evaluate livelihood preparedness prior to a disaster to facilitate improvement or as a forensic tool post disaster.

Keywords Individual livelihoods · Indicators · Preparedness · Kaikōura · New Zealand

1 Introduction

It is often argued by genealogies that livelihood thinking emerged in 1992 from a publication by Chambers and Conway (1992); however, its origins can be traced back by at least 50 years to the fields of agriculture and developmental studies (Scoones 2009). Nonetheless, after decades of academic research on the livelihood related subject, there seems to be a diverse array of methods developed to index livelihoods (Angelsen et al. 2011; Jemimah Njuki et al. 2011a). In part this may be due to the multidisciplinary nature of livelihood studies spanning from agriculture Nkala et al. (2011), developmental studies Sagir et al. (2013); Scoones (2009) to disaster risk reduction and sustainability (Farrington 1999).

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At its core, livelihood reflects the capability of people to meet their basic needs by drawing on a diverse array of resources at their disposal (Bobrowsky 2013; Luqman et al. 2018). Current indicators on livelihood are focussed on measuring the ability of individuals or communities to meet their needs in the event of a crisis (Aker 2012; Donohue and Biggs 2015; Lin and Polsky 2016). However, due to the increased cost of disasters CRED (2021), there is an additional need to measure the extent to which individuals have prepared their livelihoods during and after a disaster. Disaster preparedness in itself are actions undertaken prior to a disaster in order to mitigate, respond to and recover faster from disaster incidents (Tierney et al. 2001). It encourages prevention, protection and promotion endeavours (Chang-Richards et al. 2013). Hence individual livelihood preparedness can be defined in this research as a state of readiness of livelihood in the face of potential disasters. It may well entail actions taken by individuals to prepare their means of earning a living from unforeseen circumstances.

Prior to the study by Kwazu and Chang-Richards (2020), livelihood preparedness indicators and frameworks proposed by Li et al. (2020); Pandey et al. (2017) have often been a derivative of the sustainable livelihood index proposed by Scoones (1998) or livelihood resilience (Folke 2006). Frameworks based on the sustainable livelihood index Scoones (1998) place emphasis on livelihood assets, strategies, outcomes, institutional investments and vulnerability context (Kamaruddin and Samsudin 2014). On the other hand, current measures of resilience seemed to be focused on coping or adaptation (Nyamwanza 2012).

It could be argued that both approaches provide a holistic view of livelihoods in the face of disruption. However, this is not without criticisms. Critics of the sustainable livelihood index have argued that greater attention was given to the micro-level at the expense of macro-influences and power dynamics that could exist between people of different social strata (De Haan 2012). On the other hand, the ubiquitous use and ambiguous definition of resilience Folke (2006) might have impacted on livelihood indicators and frameworks designed to measure livelihood resilience. Hence, depending on the context under examination, livelihood resilience indicators have varied slightly across different livelihood and disaster-focused literature (Ifejika Speranza et al. 2014; Nyamwanza 2012; Sina et al. 2019).

This study will attempt to compensate for the shortcoming of frameworks designed using the sustainable livelihood index as highlighted by De Haan (2012) while limiting the ambiguity associated with defining resilience in livelihood and disaster research. With the input of individuals recovering from the 2016 earthquake in Kaikōura, this study aimed.

1. To identify the indicators perceived by residents affected by the Kaikōura earthquake as important for their livelihood preparedness.
2. To develop a tool for measuring livelihood preparedness in Kaikōura.

The next section (section two) will highlight livelihood preparedness indicators, while section three would deliver a summary of the livelihood impacts of the 2016 Kaikōura earthquake in New Zealand. This will be followed by the methodology employed to conduct this research in section four. Section five will illustrate the results obtained, while section six will propose a mathematical equation for measuring livelihood preparedness. Section seven discusses our findings followed by conclusions in section eight.

2 Livelihood preparedness and indicators

The ever-increasing cost of disasters on lives and livelihood CRED (2021) highlights the need to prepare individuals for potential disruptions to their way of life. Livelihood and disaster preparedness may be uniquely important because it could shorten the time spent on recovery (Cannon 2006). Individual livelihood encompasses a person's capacities, assets and activities embarked upon to earn a living (Lloyd-Jones and Rakodi 2014). Hence the formulation and application of livelihood indicators could facilitate the evaluation and monitoring of individual or communal livelihoods through the provision of vital information to policymakers and individuals alike (Niedritis et al. 2011; Njuki et al. 2011b). An individual's ability to access resources, adapt to changing circumstances and willingness to diversify livelihoods while incorporating disaster risk reduction measures all combined in one framework could be used to measure livelihood preparedness (Kwazu and Chang-Richards 2020).

As highlighted by Chambers and Conway (1992) and affirmed by Scoones (1998), resource accessibility is of vital importance to individual livelihood; hence as an indicator of livelihood preparedness, it aims to measure the collection of assets and resources available to an individual in the advent of a disaster. On the other hand, an individual's adaptive capacity assesses their ability to adjust their lives and livelihood options to thrive during and after disasters (Anushka et al. 2018). Similarly, livelihood diversity as an indicator of livelihood seeks to measure the extent of interdependence and variance between different livelihood strategies adopted by an individual. It could be perceived as an adaptation strategy Le Dé et al. (2018) or a hedging tool (Ning et al. 2014). The effectiveness of disaster risk reduction measures seeks to assess preparedness measure in place to mitigate or eliminate disaster impacts on lives and livelihoods (Gebrehiwot and van der Veen 2015; Kumar et al. 2013; Løvholt et al. 2014).

3 Livelihood impacts of the 2016 Kaikōura earthquake in New Zealand

On the 14th of November 2016 at 12.02 AM, a magnitude 7.8 earthquake occurred along the east coast of upper South Island ((McDonald et al. 2017; Ministry of Civil Defence and Emergency Management 2017) (See Fig. 1). The earthquake originated in the Waiiau Plains, but significant destruction was recorded in most areas of North Canterbury, Marlborough and Wellington (Dizhur et al. 2019). The 2016 earthquake resulted in the destruction of the regional economy with livelihood implications.

According to Deloitte (2017) at least 1.25 million NZD (approx. 850,000 USD in 2016) in GDP value was lost every week sequel to the earthquakes, as businesses in wellington where required to vacate their office building for safety evaluations. In most cases, employers and employees alike were required to bear the cost of recovering lost productivity through wage cuts because certain costs could not be passed to the consumer (Sampson et al. 2017). Similarly, 5.3 million litres of wine and 20% of the total wine storage capacity was lost in the Marlborough region an area that accounted for 70% of New Zealand total wine production Dizhur et al. (2019); Stevenson et al. (2016) and employs at least 4% of the Marlborough region workforce (Infometrics 2019). Nonetheless, the disruption of transportation infrastructure was perhaps the greatest impact of the earthquake on individual livelihoods, especially in Kaikōura.

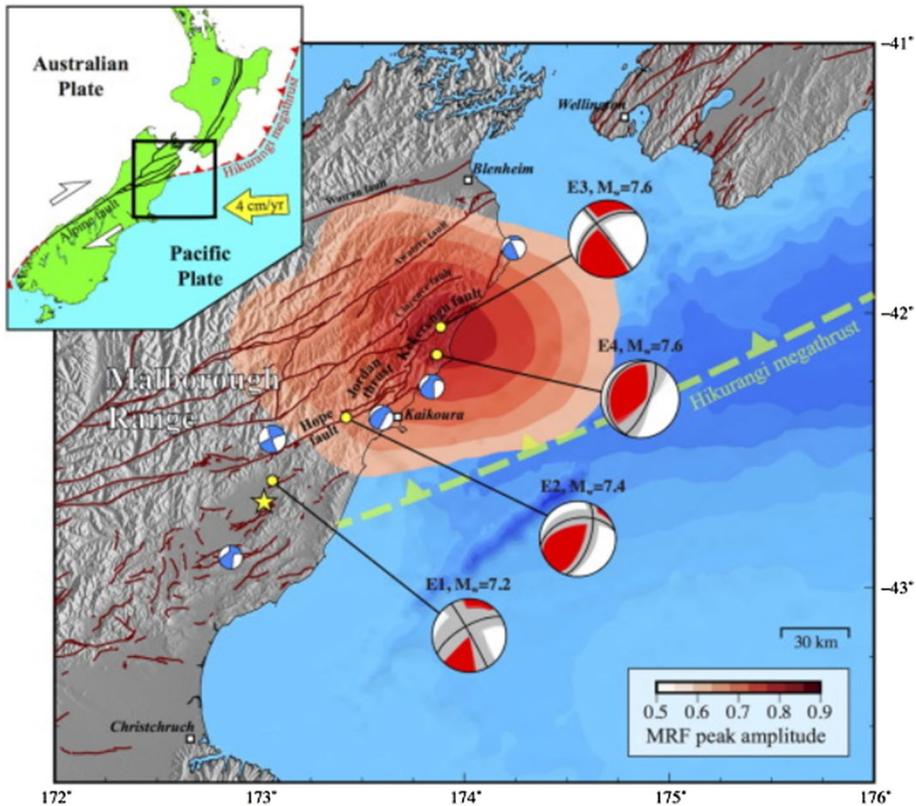


Fig. 1 Kaikōura earthquake in 2016. Source: Duputel and Rivera (2017)

In addition to the destruction of other basic infrastructure (power, water, communication and sewage facilities), Kaikōura was isolated from the rest of the country both from land and the sea for the first two days (Ministry of Civil Defence and Emergency Management 2017). Subsequently, the disruption to the easy flow of people, goods and services affected the hospitality and tourism industry as well as primary industries (Stevenson et al. 2016). These employ over 50% of Kaikōura workforce (Infometrics 2018). Tourist in Kaikōura at the time of the earthquake had difficulty returning to their destination while those that planned to visit cancelled their booking for fears of being stuck in Kaikōura (Kwazu et al. 2019). With regard to the primary industry, the transport disruption interrupted animal breeding and increased the challenge of sourcing livestock feed (Stevenson et al. 2016). In addition to the disruption of waterways due to uplifts, marine habitats were impacted. This led to restrictions on fishing in order for the aquatic animal population to recover, thereby adding a temporal strain to individual livelihoods dependent on fishing and marine tourism (Ministry of Civil Defence & Emergency Management 2017; Stevenson et al. 2016).

Even though the long-term impacts of the Kaikōura earthquake are uncertain, the loss of market share by businesses and livelihoods affected by the earthquake were raised in literature (Stevenson et al. 2016). Furthermore, due to the seismic nature of the region Massey and Dellow (2018) chances are that individual lives and livelihood are in danger of potential future disruption. Consequently, the ability to measure the preparedness of individual

livelihoods for unforeseen events may be an invaluable asset. Nevertheless, the first step in this process is to validate indicators of livelihood preparedness from the perspective of individuals recovering from the 2016 earthquake in Kaikōura. The next section will highlight the methodology employed for this research.

4 Methodology

4.1 Data collection, sampling and study location

At the preliminary stage of the study, interviews were conducted to highlight the livelihood lessons learned from the 2016 Kaikōura earthquake (Kwazu et al. 2019). The interview focused on 16 randomly selected residents of Kaikōura who lived through the earthquake. Subsequently, indicators derived through a systematic review of literature by Kwazu and Chang-Richards (2020) were used to formulate a questionnaire for working people (and those that were in the labour market in 2016 who lived through and are currently recovering from the 2016 earthquake). Ethics for data collection were approved by the University of Auckland Human Participants Ethics Committee with reference number 014782.

As of 2019, the total population of Kaikōura district stood at 3912 individuals, 66.5% of which are within the working age in New Zealand (15–64) years (Statistics New Zealand 2020). From our observations during the preliminary studies Kwazu et al. (2019), a significant portion of the working population in Kaikōura lived and worked in Kaikōura town. Due to the extent of disruptions in Kaikōura town and concentration of businesses within the city centre, data collection for this research will focus on Kaikōura town. Figure 2 is a pictorial overview of our study location in Kaikōura.

Table 1 highlights four questions framed to test the validity of each derived indicator as well as their overall importance to the people of Kaikōura.

Preliminary drafts of the questionnaire were distributed to a test population of 20 random individuals for validation. This step was necessary to ensure that each question conveyed the right message; hence, some explanation was provided for each indicator as suggested by our preliminary test participants. They also affirmed the applicability of our formulated indicators in Kaikōura. Although Leung (2011) advocated for an 11-point Likert scale to increase sensitivity and normality of data, a 5-point Likert scale was applied instead as it was discovered at the validation stage that some individuals became confused with higher scales, hence less willing to complete the questionnaire.

For flexibility reasons, the questionnaire was distributed on paper and in an online format using Qualtrics. Like the paper version, the digital draft was also transmitted to a sample population of 20 individuals with different skill-level on the use of digital technology. This step was needed to test the ease of answering our questionnaire in digital format. Responses from the participants assisted in the optimisation of the digital copy of our questionnaire. The questionnaire was distributed randomly to individuals through door-to-door visits of homes and businesses in Kaikōura town. From the perspective of Kelly et al. (2003), random sampling provided generalisable results, hence the reason for its adoption in this research. Our target population were working individuals living in Kaikōura at the time of the 2016 earthquake.

To improve flexibility and ease the data collection process on the sample population, individuals were offered a choice between the paper questionnaire and the digital format that can be accessed on a phone or a computer. While either option was accepted in



Fig. 2 Pictorial overview of Kaikōura town. Adopted from Google earth

equal measure, over 97% of the responses (137 individuals) came from the paper-based version. This may be attributed to the fact that most paper response were collected at a pre-specified date by the research team. Additionally, with the paper option, people could be reminded and persuaded to complete the survey; however, it was difficult to do the same for the online version. Data were collected in Kaikōura from the 30th of June to the 30th of September 2019. Three feedbacks were received through Qualtrics; hence, to ease the process of data cleaning before analysis, the paper responses were carefully entered into Qualtrics and then exported to SPSS. SPSS version 25 was used to analyse collated data.

Table 1 Questionnaire to identify indicators

Question: On a scale of 1–5 (where 1 indicates not important and 5 indicates very important) how important are these steps to improving your ability to earn a living and meet your basic needs in the event of a disaster

Indicators	Explanation used in the questionnaire
Resource accessibility	Having access to cash, loans, affordable insurance, family, friends and other assets
Livelihood diversity	Having multiple sources of income or having several different ways of earning a living
Individual adaptive capacity	Being able to adapt to changes and/or new circumstances
Effectiveness of individual disaster risk reduction measures	Implementation of measures to mitigate risks or reduce disaster impacts (e.g. fastening items in the house to prevent them from falling over in the event of an earthquake)

4.2 Data analysis

Preliminary analysis was conducted to determine the reliability of the scale. This delivered a Cronbach's alpha of 0.650 which is within the marginally adequate value suggested by Yockey (2016) but lower than the value indicated by (Field 2009). However, Field (2009) noted that Cronbach alpha values are sensitive to the number of items in a scale, as scales with more items could have higher alpha values and vice versa. Since there were 4 items in our scale, Briggs and Cheek (1986) supported by Pallant (2011) suggested the assessment of mean inter-item correlation for scales with fewer than 10 items. They were of the view that mean inter-item correlation of 0.2–0.4 also showed the reliability of the scale. A mean inter-item correlation of 0.321 was obtained for this research.

Using the overall mean value of 4.054, a one-sample T test was conducted to determine the most significant indicator of livelihood preparedness in Kaikōura. Indicators with statistically significant P values ($P < 0.05$) and mean value above the overall mean were considered as critical for livelihood preparedness in Kaikōura. To affirm the applicability of indicators highlighted in Kwazu and Chang-Richards (2020) as well as develop a framework for livelihood preparedness in Kaikōura, a principle component analysis using SPSS version 25 and structural equation modelling using AMOS version 26 were conducted.

SEM is a “class of methodologies that seeks to represent hypotheses about the means, variances and covariances of observed data in terms of a smaller number of ‘structural’ parameters defined by a hypothesised underlying model” (Kaplan 2000, p. 1). It is a combination of different statistical tools comprising multiple regression analysis, path analysis and factor analysis all of which make it a robust and yet complicated modelling tool (Nachtigall 2003). Even though SEM encompasses PCA (a kind of factor analysis), to improve the understanding of the current data set, a separate principal component analysis was also conducted. SEM provides a unifying framework for fitting numerous linear models while accounting for structural and empirical errors (DSSC 2012). However, in addition to its large data requirement for complex models, obtained solutions may not always conform with reality (Nachtigall 2003; Werner and Schermelleh-Engel 2009). It allows for the evaluation of complex model to determine their compatibility with data (Werner and Schermelleh-Engel 2009). Even though SEM is sensitive to data kinds and could generate different unique solutions depending on the restrictions imposed by a researcher, it accounts for latent variables (variables that cannot be easily measured) (Jeon 2015).

Successful execution of SEM is dependent on theory, and in its absence, it would be difficult to identify variables that would be included in a Model (Zou et al. 2018). A systematic review of literature for indicators of livelihood preparedness Kwazu and Chang-Richards (2020) provided the theoretical framework for the structural equation modelling in this research. In this paper, livelihood preparedness serves as the latent variable while resource accessibility, livelihood diversity, individual adaptive capacity and effectiveness of disaster risk reduction are the observed variable. The SEM model will deliver standardised regression values between observed and latent variables. Figure 3 illustrates the hypothesised model for livelihood preparedness.

A reflective and recursive SEM model was hypothesised for livelihood preparedness and its four indicators. In other words, these indicators reflect a prepared livelihood rather than a reason for livelihood preparedness. For instance, an individual may be motivated to diversify their livelihood for economic reasons; however, in doing so and combined with enforcing DRR measures, their livelihoods could be secured in the event of a disruption. Similarly, a self-employed person working from home may undertake a risk reducing measure like the installation of a power backup system to ensure energy security for the family in the event of a grid outage; however, in doing so, they could carry on with their work longer than their peers in the event of a disaster that resulted in a power grid failure. With respect to recursivity, a feedback loop was not expected between indicators in the model; nonetheless, the model was tested for non-recursivity and obtained results were less optimal. The hypothesised model consists of five unobserved variables which include error terms $e1$ – $e4$ and livelihood preparedness as the latent variable. The four indicators of livelihood preparedness are the observed variable. A listwise approach was adopted in the deletion of incomplete data for SEM, as this ensured the analysis of uniform data cases (Kline 2016).

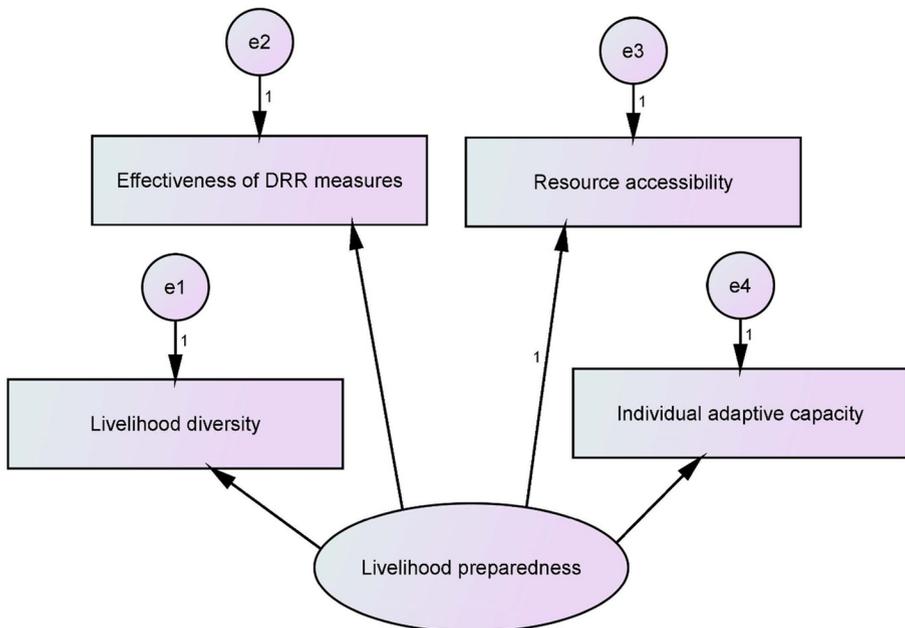


Fig. 3 Hypothesised model for livelihood preparedness

To obtain a solution for SEM, the model needs to be over identified (Beaumont 2015; Kline 2016). Loehlin (1992) suggested the use of over identified models, especially because they allow for testing statistical hypothesis such as global model fit. While our current model is structurally over identified with one degree of freedom, on an initial attempt to run the model, it was discovered that the model was empirically under identified (DSSC 2012; Kline 2016; Nachtigall 2003). Hence following the instruction of DSSC (2012), the estimated regression value of a variable was restricted to 1. At the initial attempt to obtain a solution for the model, the regression value of livelihood diversity was restricted to one. However, the output of the regression estimates highlighted a value > 1 for resource accessibility which was greater than values obtained from other indicators of livelihood preparedness. Hence, for subsequent solutions, estimated regression value for resource accessibility was restricted to one which increased degree of freedom to two and delivered an optimal model.

From the findings at the preliminary stage of the research, the authors saw the need to collect demographic information on sex, education level, ethnicity, sector of employment, age, presence of dependents and views on climate change. Data for the first six variables were collected based on the template used by (Statistics New Zealand 2020). This demographic information served as independent variables while indicators of livelihood preparedness was used as dependent variables to conduct a multivariate analysis of variance (MANOVA). A MANOVA was needed to search for variations in response within different demographics in the sample population. Prior to conducting a MANOVA, the data were tested to ensure that it met the necessary assumptions listed by Pallant (2011), and where necessary, different adjustments were made. These adjustments will be discussed further at the results stage. The next section will illustrate the results obtained from this study.

5 Results

5.1 Information about questionnaire participants

From a sample size of 236 individuals that lived through and are currently recovering from the 2016 Kaikōura earthquake, 140 responses were obtained with regard to how important different indicators are in preparing individual livelihoods for a disaster. Of the 140 responses received, 135 individuals provided 100% feedback and the rest provided less than 50% feedback. Table 2 highlights a breakdown of the demographic data obtained in Kaikōura.

As shown in Table 2, the majority (64%) of survey respondents were females and the rest 36% were males. Many survey respondents are the body-abled working age group between 20 and 64 years. People in the 50–64-year age bracket represented a large number of respondents (34.6%), followed by individuals aged between 35 and 49 (28.7%), 25–34 (18.3%), and 20–24 (11%).

In terms of the level of education, the greatest number of responses was obtained from those with a secondary school certification as their highest formal qualification (32.8%). This was followed by individuals with levels 1–4 certifications at 21.9%. Individuals with levels 5 or 6 diploma represented 19% of the data, while those with level 7 qualification or a bachelor's degree made up 18.2%. People without any formal qualification amounted to 4.4%, and those with postgraduate degree and above constituted 3.7% of total response.

Table 2 Demographic data about survey participants

Category	Items	Values (%)
Gender	Male	36
	Female	64
Age group	15–19	1.5
	20–24	11
	25–34	18.3
	35–49	28.7
	50–64	34.6
	64+	5.9
Education level	Secondary	32.8
	Level 1–4*	21.9
	Level 5–6**	19
	Level 7***	18.2
	Postgrad+	3.7
Ethnicity	No formal education	4.4
	European	79.4
	Māori	7.3
	Asia	5.8
	Africa/Middle East and Americas	2.9
	Pacific Islands	2.9
Family type (with and without dependents ¹)	Mixed	4.6
	Couple with dependents	35
	Couple without dependents	30
	Single parents	25
	Single individuals without dependents	10
Job sector of respondents	Hospitality and tourism	31.2
	Wholesale and retail trading	22.5
	Healthcare workers	9.4
	Education and training	8
	Construction	5.8
	Primary industry	5.1
	Utilities	2.9
	Housing and real estate	2.9
	Financial services and insurance	2.9
	Information and media telecommunication	2.9
	Civil servant	2.9
	Manufacturing	1.4
	Logistics	0.7

1: Dependents: Children (individuals below 15 (Statistics New Zealand 2016)) and/or older adults above 65 years and the disabled

*Certificate; **Diploma; ***Degree (New Zealand Qualifications Authority 2020)

Majority of survey respondents identified their ancestry as European (79.4%). Those of Māori and Asian linkages constituted 7.3% and 5.8%, respectively. About 65% of respondents reported that they are part of a family unit (35% have dependents and the other 30%

Table 3 Eigen values and variances for different components

Component	Eigen values	Variance
1	1.991	49.780
2	0.860	21.506
3	0.641	16.022
4	0.508	12.691

Table 4 Component matrix derived from SPSS

Component one	
Indicators	Loading factor
Resource accessibility	0.804
Livelihood diversity	0.507
Individual adaptive capacity	0.730
Effectiveness of individual disaster risk reduction measures	0.754

without dependents). Single people who have no dependents and single parents were represented by 25% and 10%, respectively.

With regard to jobs, responses were obtained for 13 different sectors in Kaikōura. Hospitality and tourism as well as wholesale and retail trading had the highest representation at 31.2% and 22.5%, respectively. Healthcare workers and those who classified their job sector as others were represented by 9.4% and 1.4%, respectively. Responses obtained from individuals working in the construction sector and those whose livelihood depend on the primary industry represented 5.8% and 5.1%, respectively. Utilities, housing and real estate, information and media communication, financial and insurance services, public administration as well as education and training individually accounted for 2.9% of the obtained data. Manufacturing as well as logistics were least represented at 1.4% and 0.7%, respectively.

5.2 Principal component analysis and T test

The analysis results delivered a Bartlett test of sphericity of 80.635 and an associated significance level of 0.000 which demonstrates that the correlation matrix is not an identical matrix. The value of the Kaiser-Mayer-Olkin measure of sampling adequacy is 0.699, which is greater than the minimum value of 0.5 proposed by Field (2009); Pallant (2011) for factor analysis. The principal component analysis generated a single component solution with an eigenvalue greater than one. This is illustrated in Table 3.

While component one had an eigenvalue of 1.991, components two to four had an eigenvalue of < 1 rendering them less viable (Field 2009; Pallant 2011; Tabachnick & Fidell 2007). Since only one component could be derived the result could not be rotated using any of the rotational options on SPSS. Nonetheless, each variable had a loading value > 0.5 on component one. Table 4 shows the component matrix derived from SPSS.

Resource accessibility had a greatest loading value of 0.804 on component one, while individual livelihood diversification had the least weight on component one.

Table 5 Correlation matrix

Indicators and correlation values				
Indicators	Resource accessibility	Livelihood diversity	Individual adaptive capacity	Effectiveness of individual disaster risk reduction measures
Resource accessibility	1.000	0.263	0.418	0.489
Livelihood diversity	0.263	1.000	0.223	0.179
Individual adaptive capabilities	0.418	0.223	1.000	0.376
Effectiveness of individual disaster risk reduction measures	0.489	0.179	0.376	1.000

Table 5 illustrates the correlation among different components of livelihood preparedness in Kaikōura. Resource accessibility recorded the highest correlation value with other indicators, especially the effectiveness of individual disaster risk reduction measures as both had a correlation value of 0.489. Similarly, effectiveness of individual disaster risk reduction measures and individual adaptive capabilities recorded relatively higher correlation values with each other at 0.376. However, livelihood diversity had the lowest correlation value with other indicators of livelihood preparedness with a value of 0.179 recorded between livelihood diversity and effectiveness of individual disaster risk reduction measures.

Table 6 illustrates the results of the one-sample t test as well as the mean value obtained for each indicator of livelihood preparedness. The overall mean score stood at 4.05 which is higher than the values obtained for all indicators except individual adaptive capacity.

Perhaps this could be attributed to the fact that the least response obtained for Individual adaptive capacity was a ranking of two. Similarly, effectiveness of individual disaster risk reduction measures was slightly below the overall mean at 4.04 as a relatively greater number of individuals (totalling 107) rated it as at least a four on a five-point scale as important for livelihood preparedness. On the other hand, individual livelihood diversity recorded the lowest mean value at 3.83. In addition to two missing values, this indicator was perceived by greatest number of individuals (four individuals) as not important and somewhat important (nine individuals) to livelihood preparedness in Kaikōura.

Ning et al. (2014) noted that individuals could diversify their livelihood either in the same sector (internal diversification) or into a different sector (external diversification); hence, an attempt was made to ascertain people's perspective on internal and external diversification. For either option, majority of individuals (> 70%) either were indifferent or ranked it as important. However, a slightly greater percentage of people felt it was very important to diversify in the same sector (7.9%) as opposed to externally (7.1%).

Table 6 One-sample t test for indicators of livelihood preparedness in Kaikōura

No	Indicators	Mean	T	P-value
1	Resource accessibility	3.96	- 1.210	0.228
2	Livelihood diversity	3.83	- 2.686	0.008
3	Individual adaptive capacity	4.37	4.559	0.000
4	Effectiveness of DRR measures	4.04	- 0.222	0.825
Overall mean value = 4.054				

Both individual adaptive capacity and livelihood diversity recorded statistically significant $p < 0.05$; however, for this research, only individual adaptive capacity would be regarded as the critical indicator for livelihood preparedness in Kaikōura as a relatively high mean value was also obtained for it.

5.3 Results of structural equation modelling

According to Kline (2016); Nachtigall (2003), SEM is sensitive to abnormal or incomplete dataset. Hence to limit potential simulation errors, incomplete data were eliminated which reduced the data size to 137 responses. DSSC (2012) supported by Bentler and Chou (1987) believed 15 responses per unobserved variable were reasonable for a SEM analysis. Given that there are 4 unobserved variable and 137 responses, our current sample size should be enough to run a SEM analysis. At a minimum discrepancy value (CMIN/DF) of 0.361 and two degrees of freedom, a Chi-square value of 0.722 with a P value of 0.697 was obtained.

The model delivered a goodness-of-fit value (GFI) of 0.997 and a root mean square error value of approximation (RMSEA) of 0.000. An adjusted goodness of fit index (AGFI) value of 0.987 was obtained with a comparative fit index (CFI) value of 1.00. A normed fit index (NFI) and Tucker Lewis index (TLI) values of 0.991 and 1.052 were obtained, respectively. A modification index was conducted to obtain a better fit; however, optimum value was obtained with current model in Fig. 3. According to DSSC (2012); Kline (2016), with the exception of the CMIN/DF figure, obtained fitness values suggest a model fit between current dataset and hypothesised livelihood preparedness model proposed in Fig. 3. Figure 4 illustrates a structural equation model for livelihood preparedness with standardised regression estimates and variance.

The highest standardised regression estimate value was obtained between livelihood preparedness and resource accessibility at 0.74. This suggests that within the current structure represented in Fig. 4, a change of one standard deviation in resource accessibility will result in a 0.74 change in the standard deviation of individual livelihood preparedness in Kaikoura (Grace & Bollen 2005). This is relatively higher when compared to a shift in

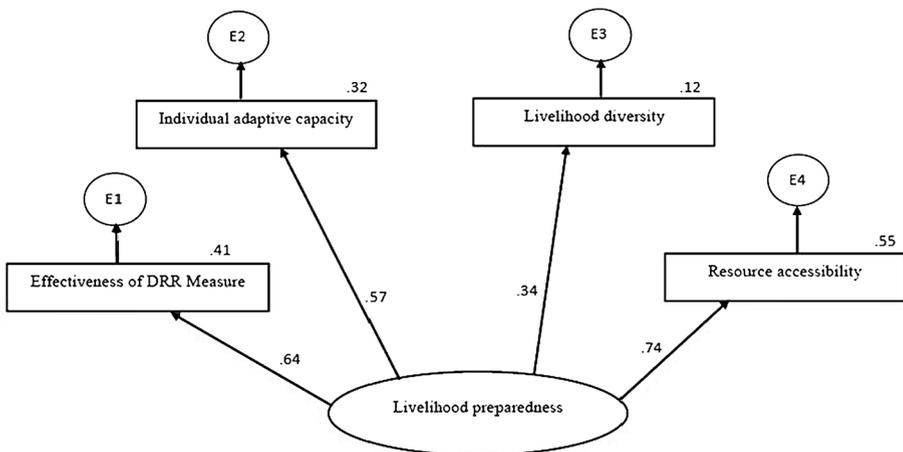


Fig. 4 Structural equation model for livelihood preparedness with standardised estimates

livelihood preparedness standard deviation of 0.64 attributed to effectiveness of individual disaster risk reduction, 0.57 linked to Individual adaptive capacity and 0.34 propagated by livelihood diversity.

Similarly, resource accessibility exacts relatively higher variance at 0.55 on the SEM shown in Fig. 4 when compared to other indicators of livelihood preparedness. This is followed by effectiveness of DRR at 0.41 and individual adaptive capacity at 0.32. Livelihood diversity exacts the least variance to the livelihood preparedness SEM at 0.12. In all, significantly higher standardised regression value and variance obtained for resource accessibility suggest that a change in resources accessible to individuals in Kaikōura could have a relatively higher effect on livelihood preparedness when compared to other indicators.

5.4 Results of a significance tests across different demographics in Kaikōura

A one-way MANOVA was performed to ascertain any potential variance among different demographic groups. Using gender as the independent variable while the indicators of livelihood preparedness which include resource accessibility, livelihood diversity, individual adaptive capacity and effectiveness of individual disaster risk reduction measures; there were no statistically significant differences between males and females on the combined dependent variables $F(4, 132) = 1.44$, $P = 0.225$; Wilks' Lambda = 0.96; partial eta squared = 0.042.

Another one-way MANOVA was carried out using age as the independent variable. However, responses from the 15–19 age group were ignored as it did not satisfy the sample size assumption highlighted by Tabachnick and Fidell (2007) and affirmed by Pallant (2011). Nonetheless, there was no statistically significant difference between the age groups on the combined variables, $F(16, 386) = 1.014$, $P = 0.441$; Wilks' Lambda = 0.88; partial eta squared = 0.031.

Like the last two demographics, no statistically significant difference was identified between different levels of educational qualifications on the combined dependent variable, $F(20, 425) = 1.15$, $P = 0.298$; Wilks' Lambda = 0.84; Partial eta squared = 0.958.

With regard to ethnicity, no statistically significant difference was identified among various ethnicities in Kaikōura on the combined variables, $F(20, 422) = 1.03$, $P = 0.426$; Wilks' Lambda = 0.85; Partial eta squared = 0.039. Similarly, no statistically significant difference was detected among people with and without dependents in Kaikōura on the combined variables, $F(12, 336) = 0.567$, $P = 0.868$; Wilks' Lambda = 0.948, Partial Eta Squared = 0.971.

Regarding people's perception on the effects of climate change, like other demographic data evaluated so far, no statistically significant difference was detected irrespective of their perceptions on a changing climate. The MANOVA delivered a combined variable $F(8, 262) = 0.776$, $P = 0.624$; Wilks' Lambda = 0.954, Partial Eta Squared = 0.023.

These sectors (manufacturing and logistics) will be exempted from the MANOVA as they do not meet the sample size condition. No statistically significant difference was detected among individuals from different job sectors on the combined variable $F(44, 457) = 1.08$, $P = 0.336$; Wilks' Lambda = 0.684, Partial Eta Squared = 0.090.

In all, no significant difference was detected across all seven demographic groups assessed by a MANOVA, some of which were unexpected. For instance, the absence of statistically significant difference between those who believed climate change would affect their livelihoods and those that were unsure about climate change or thought differently

was in contrast with the findings of Muringai et al. (2020) which highlighted that individual livelihoods were significantly affected by the impact of a changing climate.

Further research will be required to explain the absence of any statistical difference between people who believed climate change would have an impact in Kaikōura and others who are not sure of what the impact would be and those that do not believe it will pose any effect to lives and livelihood in Kaikōura.

A similar trend also repeated among people working in different job sectors. It was expected that those working in primary industries as well as other sectors vulnerable to climate change might have recorded a statistically significant values different from other groups. Nonetheless, absence of statistically significant difference between people of different educational level was expected as most people in Kaikōura had basic education; if the situation was reverse, perhaps the results will be different.

6 A framework for measuring livelihood preparedness

Due to a relatively high model fitness obtained from SEM of livelihood preparedness indicators, the framework for measuring livelihood preparedness in Kaikoura will be based on obtained standardised regression values (SRV), variance (V) and response obtained from the Likert scale (LK) for different indicators (IND) plus the summation of all the error terms associated with each observed variable. Thus, the equation is as follows:

$$\text{Livelihood preparedness (LP)} = \sum ((\text{SRV}_{\text{IND}})(\text{V}_{\text{IND}})(\text{LK}_{\text{IND}})) + \sum E \quad (1)$$

The standardised regression values were included because they represented the extent of deviation in livelihood preparedness for one standard deviation in the indicators. Given the absence in statistical differences between groups, it is assumed that variance values obtained for each indicator will be constant across the population in Kaikoura, hence its inclusion in Eq. 1. The Likert scale value in Eq. 1 is an individual’s input upon which the calculation of their level of preparedness will be based. The summation of the error terms was included to account for both structural and systematic errors associated with the observed variables. Among all the parameters, the value of the error term will be challenging to determine hence would require further research.

Thus, substituting the regression values and variances into Eq. 1 results in Eq. 2

$$\text{LP in Kaikoura} = (0.04\text{LK}_{\text{LD}} + 0.26\text{LK}_{\text{IDRR}} + 0.39\text{LK}_{\text{RA}} + 0.18\text{LK}_{\text{IAC}})/0.87 + \sum E \quad (2)$$

Discounting for the error terms, on a 5-point Likert scale, the maximum obtainable value for an individual in Kaikoura would be 5 which suggests an optimally prepared livelihood. While a minimal value of 1 could be obtained from Eq. 2 which would be indicative of a livelihood vulnerable to disasters. Values between 1 and 5 would imply that there could be room for improvement. It is important to note that the accuracy of values obtained from Eq. 2 is dependent on objective choices an individual makes on the Likert scale. Equation 2 could be developed into a mobile application to ease the process of implementation.

7 Discussion

As suggested by Field (2009) and Pallant (2011) using the eigenvalues in Table 3 as well as the loading factors in Table 4, resource accessibility, livelihood diversity, individual adaptive capacity and effectiveness of individual disaster risk reduction measures were validated as indicators of livelihood preparedness. An overall mean value of 4.05 on a five-point scale affirmed their value as a measure of livelihood preparedness in Kaikōura.

Even though individual adaptive capacity was depicted as the most significant indicator by the *t* test in Table 6, it may not be the most valued indicator of livelihood preparedness in Kaikōura. The relatively higher standardised regression value of resource accessibility in Fig. 4, its loading value in Table 4 and its high correlation with other indicators in Table 5 portray it as the most valuable indicator of livelihood preparedness. Lack of assets would limit an individual's ability to adapt to changing conditions for livelihood preparedness (Cannon 2006; Newport et al. 2016; Rampengan et al. 2014). Compared to other indicators, the highest correlation values were obtained between resource accessibility and effectiveness of individual disaster risk reduction measures which is in line with the findings of Vatsa Krishna (2004) as assets are vital to mitigate against risk and associated vulnerability.

On the other hand, livelihood diversity had the least loading value in Table 4 and correlated poorly with other indicators in Table 5 especially effectiveness of individual disaster risk reduction measures. These combined with a relatively higher inclination to diversify within the same sector as their current livelihood strategy might be indicative of a people less willing to deviate from their usual way of life. This was evident as well at the preliminary stage of the study, as most people (especially those in decision making positions) admitted the need to diversify the economy of the community as well as their livelihoods but are reluctant to make any changes in fears that diversification could harm the environment and their way of life (Kwazu et al. 2019).

Additionally, due to the unpredictable nature of geological disasters USGS (2019), greater focus has been on effectiveness of individual disaster risk reduction measures to prepare individual livelihoods vulnerable to geological hazards (Suri 2018; Wilkinson 2011). However, a comparatively high significant level obtained for individual adaptive capacity suggests a heightened interest by individuals in Kaikōura to adapt their livelihoods. Timing of the data collection might be partly responsible for this result as data was collected at the recovery stage of the disaster. Nonetheless, greater emphasis on individual adaptive capacity especially for geological hazards is positive as it could fasten recovery and potentially protect individual livelihoods from future disasters (Armijos et al. 2017).

The absence of any statistically significant difference in the response obtained from various demographic groups could be explained by several factors, first of which is our sample size. According to Holland (2019); Pallant (2011); Tabachnick and Fidell (2007), *P* values can be misleading because they are highly dependent on sample size. An increased sample size amplifies the likelihood of obtaining statistically significant results. Even though we had a response rate of over 50%, perhaps a larger sample size and response rate might have delivered statistically significant results.

Similarly, the lack of evidence for social inequality in Kaikōura might justify the absence of variations obtained from different genders and ethnic groups. Social inequality between men and women or among people of different ethnic origins leads to unequal distribution of assets and limited tools to prepare individual livelihoods for a disaster (Baf-foe and Matsuda 2018; Zhang et al. 2012). The probable absence of social inequality could

result in men and women from different ethnic backgrounds sharing similar perspectives on indicators of livelihood preparedness.

The absence of variations in results obtained with respect to age, dependents, job sector and climate change warrant further research as these deviates from previous studies. Since the older generation tend to be more experienced in livelihood endeavours Mabuku et al. (2019) but less flexible to change Barclay et al. (2015), it was expected that responses from individuals 50 years and above would differ from the rest. Similarly, a variation was also expected among single individuals and those with dependents as indicated by (He et al. 2018). Individuals with dependents will have to take cognisance of their wards in taking preparedness measures which could make their perception of the livelihood indicators different.

Lastly, although unlikely, the lack of a statistically significant difference among different demographic groups may be because all the respondents experienced the same disaster in 2016. Nevertheless, there is a need to study potential factors that would influence these indicators of livelihood preparedness as they could provide more insight into the results obtained from this research.

8 Conclusions

Due to an ever-rising cost of disasters on lives and livelihoods, it is imperative to have indicators that can measure the preparedness of individual livelihoods for disruption. Through a survey of 140 working individuals in Kaikōura, who lived through and are currently recovering from the 2016 earthquake, this research developed a livelihood preparedness assessment tool which contains quantification of four livelihood preparedness indicators, namely resource accessibility, livelihood diversity, individual adaptive capacity and the effectiveness of individual disaster risk reduction (DRR) measures.

By performing a principal component analysis (PCA) on the obtained data using SPSS, the validity of above indicators was affirmed within the Kaikōura context. Resource accessibility emerged as the most valued indicator of livelihood preparedness (even though no statistically significant difference was obtained in the *t* test,) as the workability of other indicators is dependent on assets accessible to an individual. Although individuals in Kaikōura highlighted the need to adapt their current livelihoods, livelihood diversification was viewed with less optimism out of fears that it could affect the environment and compromise their current way of life. Hence a concerted effort of policymakers, business owners and individuals alike will be required to ensure that the right array of assets are accessible to individuals most especially in hazard prone locations.

The livelihood preparedness framework proposed in this study is a combination of the standardised regression values (SRV), variance (*V*) and response obtained from the Likert scale (LK) for different indicators (IND) plus the summation of all the error terms associated with each observed variable. Standard regression values for each indicator are proportional to the change in the standard deviation of individual livelihood preparedness in Kaikōura. Indicators with a relatively higher standardised regression value and variance are expected to have a greater influence on livelihood preparedness. Hence, an increase in resource accessibility within Kaikōura is expected to significantly improve individual livelihood preparedness. Discounting the error terms that are yet to be determined in future studies, the livelihood preparedness equation proposed in this study could be developed

into a mobile phone application which can be downloaded by individuals to assess their livelihood preparedness level.

Current study reaffirms the importance of an individual's access to a diverse array of resources for livelihood preparedness. This may be particularly true for relatively isolated communities prone to a variety of hazards capable of disrupting individual livelihoods. Access to the right array of resources before and after a disaster could have a significant effect in limiting losses and enhancing recovery. Similarly, even though current data used in formulating the current framework placed a relatively lower emphasis on livelihood diversity, this could be different in future disaster contexts.

Within the Kaikōura context, policymakers and Kaikōura residents alike may need to formulate a sustainable diversification strategy capable of protecting individual livelihoods while fostering economic growth in the community. Prior to a disaster, the proposed framework could serve as a livelihood assessment tool and in a post disaster setting, it could be applied as a forensic tool by individuals and policymakers alike. Using the proposed livelihood preparedness assessment framework, a numeric value for individual livelihood preparedness could be obtained. This could provide an overview of the overall readiness level of a people's livelihood and potentially highlight areas that might require improvement. By facilitating increased individual livelihood preparedness, the framework proposed in this research could enhance disaster risk reduction thereby increasing livelihood resilience among individuals and across a community.

Lastly, due to the varying mechanism of different disasters propagated by different hazards and varying livelihood contexts and policies associated with location, the proposed framework might be applicable only to Kaikōura and its environs. However, the guiding principle of the framework could be applicable to other locations; hence, the value attached to these indicators should be tested in other geolocations and different hazard settings. Further studies will be conducted to reaffirm the results obtained from this study.

Funding Open Access funding enabled and organized by CAUL and its Member Institutions. No funding was received for this research.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The ethics for data collection was approved by the University of Auckland Human Participants Ethics Committee with reference number 014782.

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References

- Akter S (2012) *Investigating Livelihood Security in Poor Settlements in Bangladesh* 86th Annual Conference of the Agricultural Economics Society. University of Warwick, United Kingdom
- Angelsen A, Larsen HO, Olsen CS (2011) *Measuring Livelihoods and Environmental Dependence*. Routledge, New York
- Anushka S, Amy D, Georgina GG, Tristram RD (2018) Perceptions of cyclone preparedness: assessing the role of individual adaptive capacity and social capital in the Wet Tropics. *Aust Sustain* 10(4):1165. <https://doi.org/10.3390/su10041165>
- Armijos MT, Phillips J, Wilkinson E, Barclay J, Hicks A, Palacios P, Mothes P, Stone J (2017) Adapting to changes in volcanic behaviour: formal and informal interactions for enhanced risk management at Tungurahua volcano, Ecuador. *Glob Environ Chang* 45:217–226. <https://doi.org/10.1016/j.gloenvcha.2017.06.002>
- Baffoe G, Matsuda H (2018) An empirical assessment of rural livelihood assets from gender perspective: evidence from Ghana. *Sustain Sci* 13(3):815–828. <https://doi.org/10.1007/s11625-017-0483-8>
- Barclay J, Haynes K, Houghton B, Johnston D (2015) Social processes and volcanic risk reduction. In: Sigurdsson H, Houghton B, McNutt S, Rymer H, Stix J (eds) *The encyclopedia of volcanoes*. Academic Press, US, pp 1203–1214
- Beaumont, R. (2015). *Health Science Statistics Using R and R Commander*. Scion. <https://books.google.co.nz/books?id=NljBoQEACAAJ>
- Bentler PM, Chou C-P (1987) Practical issues in structural modeling. *Sociol Method Res* 16(1):78–117. <https://doi.org/10.1177/0049124187016001004>
- Bobrowsky P (2013) *Encyclopedia of Earth Sciences Series*. Springer International Publishing, New York
- Briggs SR, Cheek JM (1986) The role of factor analysis in the development and evaluation of personality scales. *J Pers* 54(1):106–148. <https://doi.org/10.1111/j.1467-6494.1986.tb00391.x>
- Cannon T (2006) Vulnerability analysis, livelihoods and disasters. In: Ammann WJ, Dannenmann S, Vulliet L (eds) *Risk 21: Coping with risks due to natural hazards in the 21st century*. Taylor & Francis, pp 41–49
- Chambers, R., & Conway, G. (1992). *Sustainable rural livelihoods: practical concepts for the 21st century* (Vol. 296).
- Chang-Richards, A. Y., Seville, E., Wilkinson, S., & Walker, B. (2013). *Building natural disaster response capacity: Sound workforce strategies for recovery and reconstruction*. Asia-Pacific Economic Cooperation. <http://hdl.handle.net/10092/10481>
- CRED. (2021). *Center for research on disaster epidemiology*. Retrieved February 6, 2019 from https://www.emdat.be/emdat_db/
- Deloitte. (2017). *The forgotten impact Kaikoura earthquake: Wellington still paying the price*. <https://www2.deloitte.com/content/dam/Deloitte/nz/Documents/about-deloitte/nz-en-Kaikoura-earthquake-Wellington-impact-report.pdf>
- Dizhur, D., Giarretton, M., & Ingham, J. M. (2019). Damage observations following the M_w 7.8 2016 Kaikoura earthquake. In R. Rupakhetty, S. Olafsson, & B. Bessonon (Eds.), *Proceedings of the International Conference on Earthquake Engineering and Structural Dynamics* (Vol. 47). Springer International, New York
- Donohue C, Biggs E (2015) Monitoring socio-environmental change for sustainable development: developing a multidimensional livelihoods index (MLI). *Appl Geogr* 62:391–403
- DSSC. (2012). *Structural Equation Modeling Using AMOS: An Introduction*. Division of Statistics and Scientific computation
- Duputel Z, Rivera L (2017) Long-period analysis of the 2016 Kaikoura earthquake. *Phys Earth and Planet Inter* 265:62–66
- Farrington, J. (1999). *Sustainable Livelihoods in Practice: Early Applications of Concepts in Rural Areas*. <https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/2877.pdf>
- Field A (2009) *Discovering statistics using SPSS*, 3rd edn. SAGE, US
- Folke C (2006) Resilience: The emergence of a perspective for social-ecological systems analyses. *Glob Environ Change* 16(3):253–267
- Gebrehiwot T, van der Veen A (2015) Farmers prone to drought risk: why some farmers undertake farm-level risk-reduction measures while others not? *Environ Manage* 55(3):588–602. <https://doi.org/10.1007/s00267-014-0415-7>
- De Haan LJ (2012) The livelihood approach: a critical exploration. *Erdkunde* 66(4):345–357
- Grace JB, Bollen KA (2005) Interpreting the results from multiple regression and structural equation models. *Bull Ecol Soc Am* 86(4):283–295. [https://doi.org/10.1890/0012-9623\(2005\)86\[283:ITRFMR\]2.0.CO;2](https://doi.org/10.1890/0012-9623(2005)86[283:ITRFMR]2.0.CO;2)

- He L, Aitchison JC, Hussey K, Wei Y, Lo A (2018) Accumulation of vulnerabilities in the aftermath of the 2015 Nepal earthquake: Household displacement, livelihood changes and recovery challenges. *Int J Dis Risk Reduct* 31:68–75. <https://doi.org/10.1016/j.ijdr.2018.04.017>
- Holland SM (2019) Estimation, not significance. *Paleobiology* 45(1):1–6. <https://doi.org/10.1017/pub.2018.43>
- Ifejika Speranza C, Wiesmann U, Rist S (2014) An indicator framework for assessing livelihood resilience in the context of social–ecological dynamics. *Glob Environ Change* 28:109–119
- Infometrics. (2019). *MARLBOROUGH REGION ECONOMIC PROFILE*. Retrieved 13 November from <https://ecoprofile.infometrics.co.nz/Marlborough%2bRegion/Employment>
- Infometrics. (2018). *Kaikoura District economic profile*. New Zealand Government. Retrieved November 13, 2019 from <https://ecoprofile.infometrics.co.nz/kaikoura%20district>
- Jeon J (2015) The strengths and limitations of the statistical modeling of complex social phenomenon: focusing on SEM, path analysis, or multiple regression models. *World Acad Sci, Eng Technol, Int J Soc, Behav, Educat, Econ, Bus Indust Eng* 9:1634–1642
- Kamaruddin R, Samsudin S (2014) The sustainable livelihoods index: a tool to assess the ability and preparedness of the rural poor in receiving entrepreneurial project. *J Soc Econ Res* 1(6):108–117
- Kaplan D (2000) *Structural Equation Modeling: Foundations and Extensions*. SAGE, US
- Kelly K, Clark B, Brown V, Sitzia J (2003) Good practice in the conduct and reporting of survey research. *Int J Qual Health Care* 15(3):261–266. <https://doi.org/10.1093/intqhc/mzg031>
- Kline RB (2016) *Principles and Practice of Structural Equation Modeling*, 4th edn. The Guilford Press, New York
- Kumar, A., Seran, P., Juveanendiran, S., & Senthees, T. (2013). *Community based disaster risk reduction in Sri Lanka - A compendium of good practices*. Oxfam International. <https://policy-practice.oxfam.org.uk/publications/community-based-disaster-risk-reduction-in-sri-lanka-a-compendium-of-good-pract-301546>
- Kwazu GC, Chang-Richards A (2020) A metric of indicators and factors for assessing livelihood preparedness: a systematic review. *Int J Dis Risk Reduct*. <https://doi.org/10.1016/j.ijdr.2020.101966>
- Kwazu GC, Chang-Richards A, Wilkinson SJ (2019) *Disrupting the status quo: Reconstruction, recovery and resisting disaster risk creation*. Gainesville, FL
- Le Dé L, Rey T, Leone F, Gilbert D (2018) Sustainable livelihoods and effectiveness of disaster responses: a case study of tropical cyclone Pam in Vanuatu. *Nat Hazards* 91(3):1203–1221. <https://doi.org/10.1007/s11069-018-3174-6>
- Leung S-O (2011) A comparison of psychometric properties and normality in 4-, 5-, 6-, and 11-point likert scales. *J Soc Serv Res* 37(4):412–421. <https://doi.org/10.1080/01488376.2011.580697>
- Li H, Nijkamp P, Xie X, Liu J (2020) A new livelihood sustainability index for rural revitalization assessment—a modelling study on smart tourism specialization in China. *Sustainability* 12(8):3148
- Lin K-HE, Polsky C (2016) Indexing livelihood vulnerability to the effects of typhoons in indigenous communities in Taiwan. *The Geogr J* 182(2):135–152
- Lloyd-Jones T, Rakodi C (2014) *Urban Livelihoods: A People-centred Approach to Reducing Poverty*. Taylor & Francis, UK
- Loehlin JC (1992) *Latent variable models: An introduction to factor, path, and structural analysis*, 2nd edn. Lawrence Erlbaum Associates, USA
- Løvholt F, Setiadi NJ, Birkmann J, Harbitz CB, Bach C, Fernando N, Kaiser G, Nadim F (2014) Tsunami risk reduction – Are we better prepared today than in 2004? *Int J of Dis Risk Reduct* 10:127–142. <https://doi.org/10.1016/j.ijdr.2014.07.008>
- Luqman A, Oluwafunmilayo A, R.I., K. (2018) Perceived Effect of Climate Change on Forest Dependent Livelihoods in Oyo State. *Nigeria J Agric Ext* 22(2):169–179
- Mabuku MP, Senzanje A, Mudhara M, Jewitt GPW, Mulwafu WO (2019) Strategies for coping and adapting to flooding and their determinants: a comparative study of cases from Namibia and Zambia. *Phys Chem Earth, Parts a/b/c* 111:20–34. <https://doi.org/10.1016/j.pce.2018.12.009>
- Massey, C., & Dellow, S. (2018). *Landslide inventory and landslide dam assessments* (GNS Science Report 2018/19, Issue. N. H. R. Platform. https://www.gns.cri.nz/static/download/NHRP/NHRP_Kaikoura_Massey.pdf
- McDonald, G., Smith, N., Ayres, M., Kim, J. H., & Harvey, E. (2017). *Economic impact of the 2016 Kaikoura earthquake: A report prepared for the Ministry of Transport, New Zealand*. Ministry of Business, Innovation & Employment. <http://www.mbie.govt.nz/publications-research/publications/economic-development/economic-impact-2016-kaikoura-earthquake.pdf>
- Ministry of Civil Defence & Emergency Management. (2017). *Kaikōura earthquake and tsunami: 14 November 2016 post event report (MCDEM response)*. <https://www.civildefence.govt.nz/assets/Uploads/publications/Kaikoura-earthquake-and-tsunami-post-nov-2016-post-event-report.pdf>

- Muringai RT, Naidoo D, Mafongoya P, Lottering S (2020) The impacts of climate change on the livelihood and food security of small-scale fishers in lake Kariba, Zimbabwe. *J Asian Afr Stud* 55(2):298–313. <https://doi.org/10.1177/0021909619875769>
- Nachtigall C (2003) (Why) should we use SEM? Pros and cons of structural equation modeling. *Method of Psychol Res Online* 8:1–22
- New Zealand Qualifications Authority. (2020). *Understanding New Zealand qualifications*. Retrieved September 1, 2020 from <https://www.nzqa.govt.nz/studying-in-new-zealand/understand-nz-quals/>
- Newport JK, Möller JJ, Newport KJ, Godfrey A, Jawahar GG (2016) Alternate livelihood income plan for vulnerability reduction through community based disaster preparedness. *J Agric Econ Rural Dev* 30(1):60–72
- Niedritis A, Niedrite L, Kozmina N (2011) *Performance Measurement Framework with Formal Indicator Definitions*. Springer, Heidelberg
- Ning W, Muhammad I, Srijana J, Shao-liang Y, Meher SR, Wahid JA (2014) Livelihood diversification as an adaptation approach to change in the pastoral Hindu-Kush Himalayan region. *J Mt Sci* 11(5):1342–1355. <https://doi.org/10.1007/s11629-014-3038-9>
- Njuki, J., Poole, J., Johnson, J., Baltenweck, I., Pali, P. N., Lokman, Z., & Mburu, S. (2011a). *Gender, livestock and livelihood indicators*. <https://hdl.handle.net/10568/3036>
- Njuki, J., Poole, J., Johnson, N., Baltenweck, I., Pali, P., Lokman, Z., & Mburu, S. (2011b). *GENDER, LIVESTOCK AND LIVELIHOOD INDICATORS*. <https://hdl.handle.net/10568/3036>
- Nkala P, Mango N, Corbeels M, Veldwisch GJ, Huising J (2011) The conundrum of conservation agriculture and livelihoods in Southern Africa. *Int Center for Trop Agri (CIAT)* 6(24):5520–5528
- Nyamwanza AM (2012) Livelihood resilience and adaptive capacity: a critical conceptual review. *J Dis Risk Stud*. <https://doi.org/10.4102/jamba.v4i1.55>
- Pallant J (2011) *SPSS survival manual: A step by step guide to data analysis using SPSS*, 4th edn. Allen & Unwin, UK
- Pandey R, Jha SK, Alatalo JM, Archie KM, Gupta AK (2017) Sustainable livelihood framework-based indicators for assessing climate change vulnerability and adaptation for Himalayan communities. *Ecol Indic* 79:338–346
- Rampengan MMF, Boedihartono AK, Law L, Gaillard JC, Sayer J (2014) Capacities in facing natural hazards: a small island perspective. *Int J Dis Risk Sci* 5(4):247–264. <https://doi.org/10.1007/s13753-014-0031-4>
- Sagir B, Kombako D, Kuir-Aiyus D, Banks G (2013) Conceptualizing mining impacts, livelihoods and corporate community development in Melanesia. *Community Dev J* 48(3):484–500. <https://doi.org/10.1093/cdj/bst025>
- Sampson, K., Stevenson, J., Seville, E., Smith, N., MacDonald, G., Ayers, M., & Brown, C. (2017). *The impact of the 2016 Kaikoura Earthquake on government productivity in Wellington (NZ)*. QuakeCoRE. https://www.resorgs.org.nz/wp-content/uploads/2017/11/Wellington_Productivity_Report_171012.pdf
- Scoones I (2009) Livelihoods perspectives and rural development AU - Scoones Ian. *The J Peasant Stud* 36(1):171–196. <https://doi.org/10.1080/03066150902820503>
- Scoones, I. (1998). *Sustainable Rural Livelihoods: A Framework for Analysis*.
- Sina D, Chang-Richards AY, Wilkinson S, Potangaroa R (2019) A conceptual framework for measuring livelihood resilience: relocation experience from Aceh, Indonesia. *World Dev* 117:253–265
- Stevenson J, Becker J, Cradock-Henry N, Johal S, Johnston D, Orchiston C, Seville E (2016) Economic and social reconnaissance: Kaikōura earthquake 2016. *Bull N Z Soc Earthq Eng* 50(2):346–355
- Suri K (2018) Understanding historical, cultural and religious frameworks of mountain communities and disasters in Nubra valley of Ladakh. *Int J Dis Risk Reduct* 31:504–513. <https://doi.org/10.1016/j.ijdr.2018.06.004>
- Tabachnick BG, Fidell LS (2007) *Using multivariate statistics*, 5th edn. Allyn & Bacon, US
- Tierney KJ, Lindell MK, Perry RW (2001) *Facing the Unexpected: Disaster Preparedness and Response in the United States*. The National Academies Press, US
- USGS. (2019). *Can you predict earthquakes*. U.S Government. Retrieved 2 December 2018 from https://www.usgs.gov/faqs/can-you-predict-earthquakes?qt-news_science_products=0#qt-news_science_products
- Vatsa Krishna S (2004) Risk, vulnerability, and asset-based approach to disaster risk management. *Int J Sociol Soc Policy* 24(10/11):1–48. <https://doi.org/10.1108/01443330410791055>
- Werner, C., & Schermelleh-Engel, K. (2009). *Structural Equation Modeling: Advantages, Challenges, and Problems*. 1 - 4. Retrieved 11/11/20, from <http://kharazmi-statistics.ir/Uploads/Public/MY%20article/Structural%20Equation%20Modeling.pdf>

- Wilkinson, E. (2011). *Intergrating disaster risk reduction in livelihoods programming in the northwest of Nicaragua*. Oxfam International. https://www.preventionweb.net/files/22522_drrandlhoxfamnorthwest.pdf
- Yockey RD (2016) *SPSS DEMYSTIFIED A Step-by-Step Guide to Successful Data Analysis*, 2nd edn. Routledge, UK
- Zealand, S. N. (2016). *Family type*. Retrieved May 1, 2020 from <http://archive.stats.govt.nz/methods/classifications-and-standards/classification-related-stats-standards/family-type/definition.aspx#gsc.tab=0>
- Zealand, S. N. (2020). *Topics*. Retrieved 3rd January from <https://www.stats.govt.nz/topics/>
- Zhang H, Zhuang T, Zeng W (2012) Impact of household endowments on response capacity of farming households to natural disasters. *Int J Dis Risk Sci* 3(4):218–226. <https://doi.org/10.1007/s13753-012-0022-2>
- Zou PXW, Xu X, Sanjayan J, Wang J (2018) A mixed methods design for building occupants' energy behavior research. *Energy and Build* 166:239–249

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