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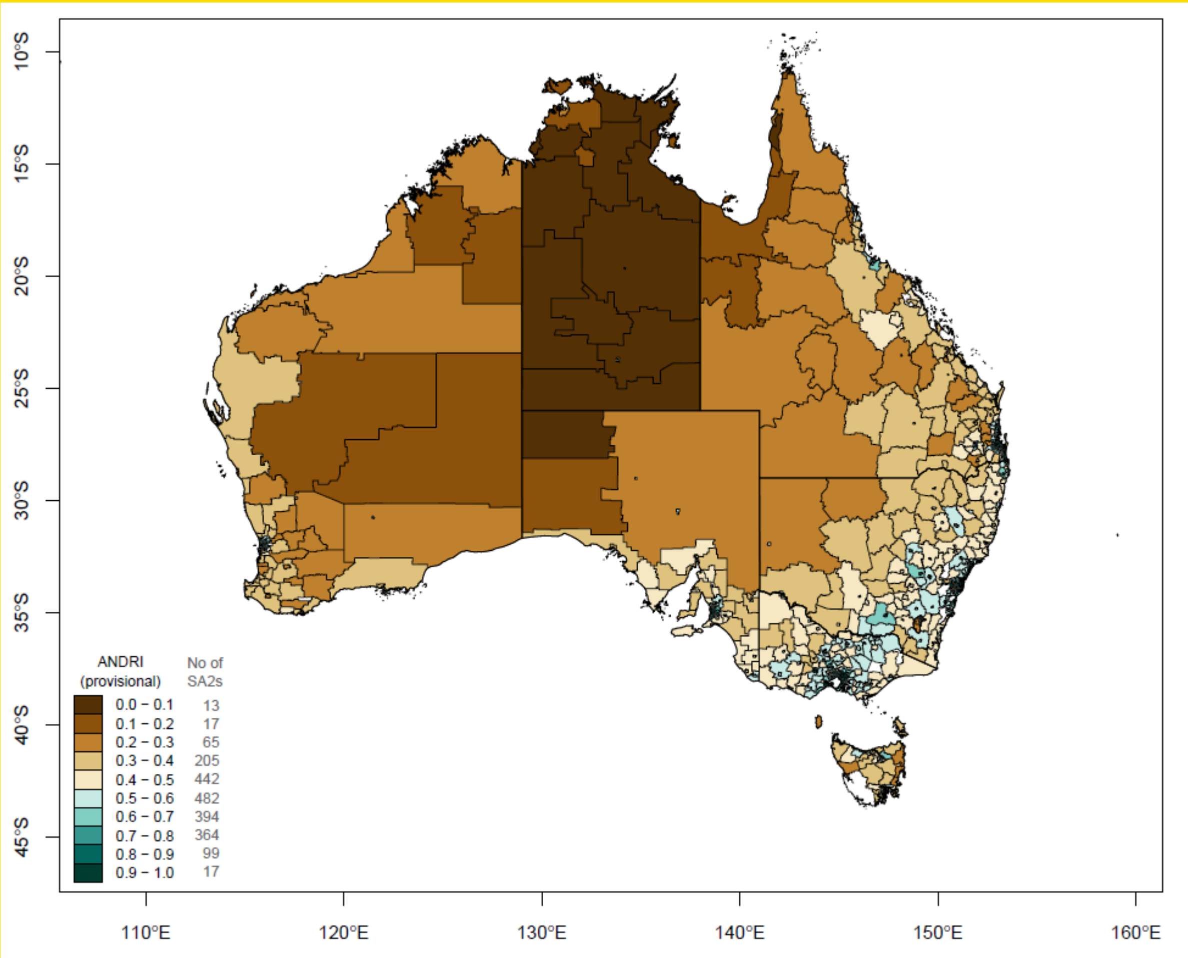
THE AUSTRALIAN NATURAL DISASTER RESILIENCE INDEX

Annual Project Report, 2017-18

Melissa Parsons, Ian Reeve, James McGregor, Sonya Glavac, Richard Stayner, Judith McNeill, Peter Hastings, Graham Marshall and Phil Morley
University of New England, Armidale, NSW.



Version	Release history	Date
1.0	Initial release of document	00/00/2018
1.1	Example Only - Minor corrections in Section 3.1 - DELETE THIS ROW IF NOT REQUIRED	00/00/2018
1.2	Example Only - Addition of Section 3.4 to provide further information on something - DELETE THIS ROW IF NOT REQUIRED	00/00/2018
2.0	Example Only - Major rewrite of report to include data from further field studies. - DELETE THIS ROW IF NOT REQUIRED	00/00/2018

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

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Publisher:
Bushfire and Natural Hazards CRC

ISBN: 000000 (if required)

July 2018

Citation: Insert citation if required

Cover: Provisional Australian Natural Disaster Resilience Index, May 2018 (subject to change)

CONTENTS

ACKNOWLEDGMENTS

The Australian Natural Disaster Resilience Index has been co-designed by project end-users. We thank the many end-users and other supporters who have contributed their thoughts, time and expertise to the project so far:

- Sandra Barber, Tasmania Fire Service
- Gwynne Brennan, Country Fire Authority Victoria
- Trent Curtin, Metropolitan Fire Brigade, Melbourne
- Karen Enbom, Country Fire Authority Victoria
- Tony Jarrett – NSW Rural Fire Service
- Paul Fletcher – Metropolitan Fire Service, SA
- Suellen Flint – Department of Fire and Emergency Services WA
- Holly Foster – Emergency Management Victoria
- Tamara Beckett – Department of Environment, Land, Water and Planning, VIC
- Andrew Richards – State Emergency Service, NSW
- Colleen Ridge - State Emergency Service, Tasmania
- Amanda Leck – Australian Institute of Disater Resilience
- Members of the AFAC Community Engagement Technical Group
- Anthony Bradstreet – NSW Rural Fire Service
- Rachel Armstrong – Department of Fire and Emergency Services, WA
- Stef Russell – Country Fire Authority, Victoria

And many others who have contributed through Research Advisory Forum workshops and the AFAC Community Engagement Technical Group.

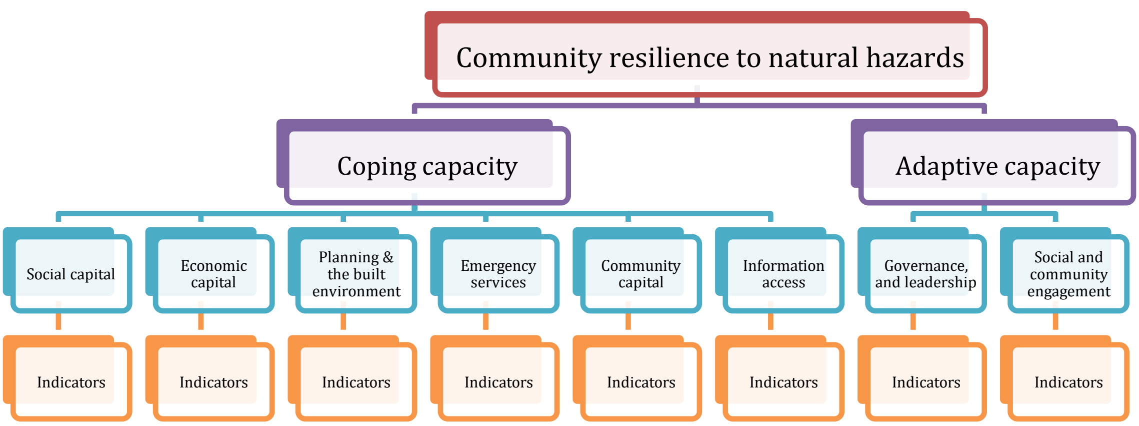
EXECUTIVE SUMMARY

Natural hazard management policy directions in Australia – and indeed internationally – are increasingly being aligned to ideas of resilience. However, the definition and conceptualization of resilience in relation to natural hazards is keenly contested within academic literature (Klein et al., 2003; Wisner et al., 2004; Boin et al., 2010; Tierney, 2014). Broadly speaking, resilience to natural hazards is the ability of individuals and communities to cope with disturbances or changes and to maintain adaptive behaviour (Maguire and Cartwright, 2008). Building resilience to natural hazards requires the capacity to cope with the event and its aftermath, as well as the capacity to learn about hazard risks, change behaviour, transform institutions and adapt to a changing environment (Maguire and Cartwright, 2008).

The Australian Natural Disaster Resilience Index is a tool for assessing the resilience of communities to natural hazards at a large scale. Using a top down approach, the assessment will provide input to macro-level policy, strategic planning, community planning and community engagement activities at National, State and local government levels. First, it is a snapshot of the current state of natural hazard resilience at a national scale. Second, it is a layer of information for use in strategic policy development and planning. Third, it provides a benchmark against which to assess future change in resilience to natural hazards. Understanding resilience strengths and weaknesses will help communities, governments and organizations to build the capacities needed for living with natural hazards.

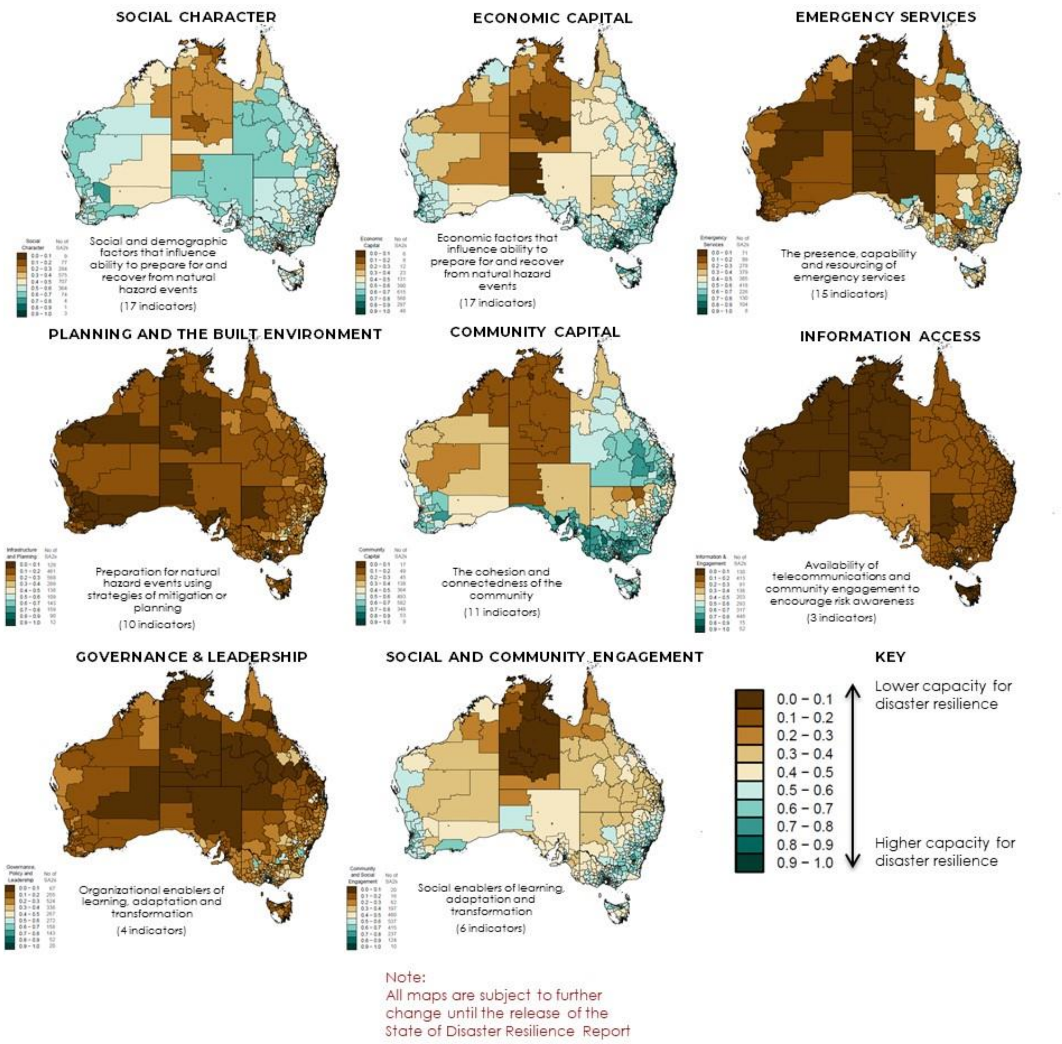
Design of the Australian Natural Disaster Resilience Index

The Australian Natural Disaster Resilience Index will assess resilience based on two sets of capacities – coping capacity and adaptive capacity. We have used a hierarchical structure for the Australian Natural Disaster Resilience Index. Indicators provide the data for a theme – together the indicators measure the status of the theme. We collected approximately 90 indicators across the eight coping and adaptive capacity themes. Indicators were collected at Statistical Area 2 (SA2) resolution where possible.



Results of the Australian Natural Disaster Resilience Index

The results and initial trends in the eight themes of the Australian Natural Disaster Resilience Index are presented below. It should be noted that these interpretations and maps are subject to further change as the State of Disaster Resilience Report is developed. What is presented here is an overview of the pattern of index values. In all maps, lower index values in brown represent lower disaster resilience and higher index values in green represent higher disaster resilience. Each of the sections is an SA2 division of the ABS.



The next stage of the project is to interpret the Australian Natural Disaster Index results as a State of Disaster Resilience Report. The interpretation takes a strengths based approach that highlights areas of strength in disaster resilience and opportunities for improvement.

END-USER STATEMENT

John Schauble, *Emergency Management Victoria, Vic*

What makes a community resilient to natural disasters is in large measure the same as makes it resilient to other shocks and stressors. Put simply, strong and connected communities are inherently resilient. The task for emergency managers is to ensure that whatever they do builds upon this rather than builds dependency. The Australian Natural Disaster Resilience Index has significant potential to assist in this process of identifying the resilience of communities to natural hazards at scale. This will assist government and agencies to plan and resource activities that further enhance resilience, in terms of planning, response and recovery. Living in a hazard rich environment does not mean developing learned helplessness, particularly in urban environments. Understanding communities and their relationship to the environment and the natural hazards local to them will help in addressing resilience shortfalls and building the strengths to overcome them. The out workings of this project have the potential to deeply influence that dialogue and its outcomes.

INTRODUCTION

Natural hazard management policy directions in Australia – and indeed internationally – are increasingly being aligned to ideas of resilience. However, the definition and conceptualization of resilience in relation to natural hazards is keenly contested within academic literature (Klein et al., 2003; Wisner et al., 2004; Boin et al., 2010; Tierney, 2014). Broadly speaking, resilience to natural hazards is the ability of individuals and communities to cope with disturbances or changes and to maintain adaptive behaviour (Maguire and Cartwright, 2008). Building resilience to natural hazards requires the capacity to cope with the event and its aftermath, as well as the capacity to learn about hazard risks, change behaviour, transform institutions and adapt to a changing environment (Maguire and Cartwright, 2008).

However, an assessment of the current of resilience is needed to able identify problems and plan future resilience building actions. There are two principal approaches to assessing disaster resilience. Bottom-up approaches are locally based and locally driven and are qualitative self-assessments of disaster resilience (Committee on Measures of Community Resilience, 2015). Bottom-up approaches survey individuals or communities using a scorecard consisting of indicators of disaster resilience such as preparation, exposure to specific hazards, community resources and communication (e.g. Arbon, 2014). In contrast, top-down approaches are often intended for use at broad scales by an oversight body (Committee on Measures of Community Resilience, 2015) and use secondary spatial sources such as census data to quantitatively derive indicators that describe the inherent characteristics of a community that contribute to disaster resilience (Cutter et al., 2010).

The Australian Natural Disaster Resilience Index will be a tool for assessing the resilience of communities to natural hazards at a large scale. Using a top down approach, the assessment will provide input to macro-level policy, strategic planning, community planning and community engagement activities at National, State and local government levels. First, it is a snapshot of the current state of natural hazard resilience at a national scale. Second, it is a layer of information for use in strategic policy development and planning. Third, it provides a benchmark against which to assess future change in resilience to natural hazards. Understanding resilience strengths and weaknesses will help communities, governments and organizations to build the capacities needed for living with natural hazards.

DESIGN OF THE AUSTRALIAN NATURAL DISASTER RESILIENCE INDEX

The Australian Natural Disaster Resilience Index will assess resilience based on two sets of capacities – coping capacity and adaptive capacity:

- Coping capacity enables people or organizations to use available resources and abilities to face adverse consequences that could lead to a disaster (sensu UNISDR, 2009). In a practical sense, coping capacity relates to the factors influencing the ability of a community to prepare for, absorb and recover from a natural hazard event.
- Adaptive capacity is the ability of a system to modify or change its characteristics or behaviour to cope with actual or anticipated stresses (Folke et al., 2002). Adaptive capacity entails the existence of institutions and networks that learn and store knowledge and experience, create flexibility in problem solving and balance power among interest groups (Folke et al., 2002). In a practical sense, adaptive capacity relates to the factors that enable adjustment of responses and behaviours through learning, adaptation and transformation.

Together, these coping and adaptive capacities form the core of our assessment of resilience to natural hazards (Parsons et al. 2016). Coping capacity and adaptive capacity help to answer the question 'How able is a community to prepare for, respond to and recover from a natural hazard event and return to a satisfactorily functioning state in a timely manner, and to strategically learn and adapt to improve its resilience to future natural hazard events?'

INDEX STRUCTURE

We have used a hierarchical structure for the Australian Natural Disaster Resilience Index (Figure 1). A hierarchical structure allows levels with similar concepts, processes and spatial/temporal organization to emerge. Lower levels can be summarized into higher levels, and higher levels constrain the elements of levels sitting within it. The first level in our hierarchy is made up of the adaptive capacities and coping capacities that make up our conceptual premise of disaster resilience. The second level in our hierarchy is made up of themes that convey the components of adaptive capacity and coping capacity. The third level is comprised of indicator sets that measure the status of a theme. It is possible that one indicator is relevant across different themes or capacities.

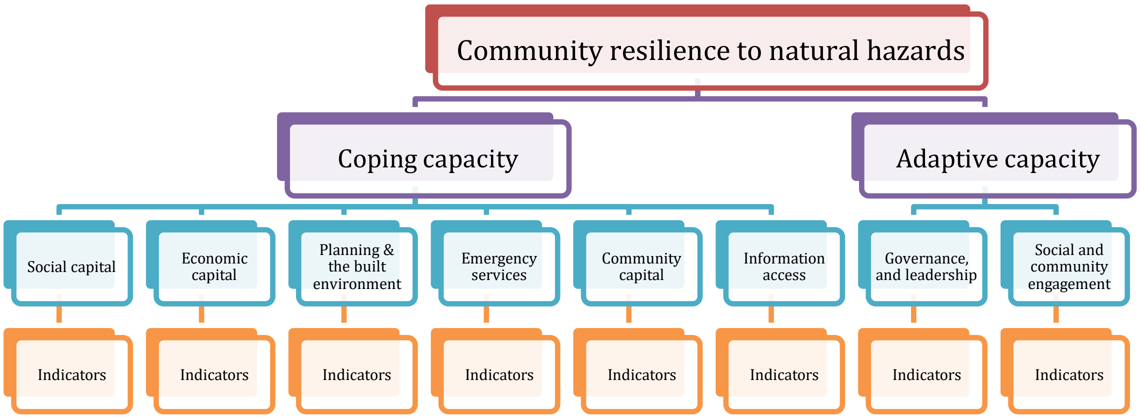


Figure 1. The hierarchical structure of the Australian Natural Disaster Resilience Index.

INDICATORS

Indicators provide the data for a theme – together the indicators measure the status of the theme. Many indicators have a basis in the literature and have demonstrated relationships with aspects of natural hazards or disasters. For example, there is a documented relationship between income, housing type and gender and the ability to prepare for and respond to natural hazard events (Morrow, 1999). Selecting indicators is both an art and a science, and there are tradeoffs that need to be made among the availability and quality of data at a national coverage, the latent construct of disaster resilience represented by the data and the statistical character of the indicator. Broadly, the data set contains two different types of indicators:

a) Quantitative indicators – indicators collected or compiled from exiting data sets such as census data, economic data, health data, telecommunications, infrastructure databases. These indicators are mostly continuous numbers.

b) Semi-quantitative indicators – indicators derived from assessment of policies, plans, legislation, or other reports. These indicators may be partly composed of assessments of quantitative data, such as the State of the Public Service Survey. These indicators are mostly ordinal numbers and as such have a small number of integer values.

The data collection phase of the project was completed in 2017. We collected approximately 90 indicators across the eight coping and adaptive capacity themes. Indicators were collected at Statistical Area 2 (SA2) resolution where possible. Data collected at other resolutions (e.g. local government areas, regions, States) were disaggregated to SA2 resolution. The indicators used to compute the Australian Natural Disaster Index for each theme are listed in Table 1a – 1h.

Table 1a. Indicators used in the social character theme of the Australian Natural Disaster Resilience Index.

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Immigration	% population arrived in Australia 2001 onwards	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable YARRP (Year of arrival in Australia)
Internal migration	% of total households with all or some residents not present a year ago	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable MV1D (Household 1 year mobility indicator)
Language proficiency	% speaks English not well or not at all	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable ENGLP (Proficiency in spoken English/Language)
Need for assistance	% population with a core activity need for assistance	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable ASSNP (Core activity need for assistance)
Family composition	% one parent families	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable CDCF (Count of dependent children in family)
	% households with children	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable HCFMD (Family household composition – dwelling)

Table 1a (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Household composition	% lone person households	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable HCFMD (Family household composition – dwelling)
	% group households	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable HCFMD (Family household composition – dwelling)
Sex	Sex ratio	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable SEXP (Sex) as the ratio of males to females
Age	% population aged over 75	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable AGEP (Age)
	% population aged below 15	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable AGEP (Age)

Table 1a (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Education	Ratio of certificate/postgrad attainment to year 8-12 attainment	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable HEAP (Level of highest educational attainment) as the ratio of persons with certificate through postgraduate level qualifications to persons with high school qualifications
Employment and occupation	% of labour force unemployed	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable LFHRP (Labour force status and hours worked not stated)
	% not in labour force	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable LFHRP (Labour force status and hours worked not stated)
	% managers and professionals	SA2	No disaggregation - ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable OCCP (Occupation)

Table 1b. Indicators used in the economic capital theme of the Australian Natural Disaster Resilience Index.

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Home ownership	% residents owning their home outright	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from the ABS community profile B32 (Tenure and Landlord Type by Dwelling Structure) as the total number of dwellings owned outright/total dwellings
	% residents owning their home with a mortgage	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from the ABS community profile B32 (Tenure and Landlord Type by Dwelling Structure) as the total number of dwellings owned with a mortgage/total dwellings
	% residents renting their home	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from the ABS community profile B32 (Tenure and Landlord Type by Dwelling Structure) as the total number of dwellings rented under any arrangement/total dwellings
	Median weekly rent ($)	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	ABS community profile B02 (Selected means and averages)
	Median monthly mortgage repayment ($)	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	ABS community profile B02 (Selected means and averages)

Table 1b (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Income	Median weekly personal income ($)	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	ABS community profile B02 (Selected means and averages)
	Median weekly family income ($)	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	ABS community profile B02 (Selected means and averages)
	% families with less than $600 p.w. income	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from the ABS community profile B26 (Total family income (weekly) by family composition) as the Sum of total families with income less than $600 p.w./Total family households
	% families with more than $3,000 p.w. income	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from the ABS community profile B26 (Total family income (weekly) by family composition) as the Sum of total families with income more than $3000 p.w./Total family households
Economy	% employment in largest single sector	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from the ABS community profile B43c (Industry of employment by age by sex) as the largest sector of employment/total employed persons aged 15 years and over

Table 1b (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
	Economic Diversity Index	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from the ABS community profile B43c (Industry of employment by age by sex) using the method of Stenekes et al. 2012
	% businesses employing 20 or more people	SA2	No disaggregation – ABS data at SA2	ABS Counts of Australian Businesses	Computed from ABS Counts of Australian Businesses, including Entries and Exits, June 2010 to June 2014, using June 2014 data. The indicator is Businesses employing 20-199 people + businesses employing >200 people/ total businesses)
	Retail and or commercial establishments per 1,000 people	SA2	No disaggregation – ABS data at SA2	ABS	Computed from ABS Counts of Australian Businesses, including Entries and Exits, June 2010 to June 2014, using June 2014 data and the ABS community profile B04 (Total population) The indicator is total number of businesses/total population/1000

Table 1b (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
	% population change 2001 to 2011	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from the ABS community profile T03c (Age by sex) as Total Persons 2011 Census/Total Persons 2001 Census
	Local government grant per capita	SA2	LGA	Department of Infrastructure and Regional Development	Data from the Local Government National Report, 2013-14

Table 1c. Indicators used in the emergency services theme of the Australian Natural Disaster Resilience Index.

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Health response workforce	Medical practitioners per 1000 population	SA2	SA3	Australian Institute of Health and Welfare: 2011 National Health Workforce Dataset	Per capita workforce computed using ABS Estimated Resident Population: 2011, SA3
	Registered nurses per 1000 population	SA2	SA3	Australian Institute of Health and Welfare: 2011 National Health Workforce Dataset	Per capita workforce computed using ABS Estimated Resident Population: 2011, SA3
	Psychologists per 1000 population	SA2	SA3	Australian Institute of Health and Welfare: 2011 National Health Workforce Dataset	Per capita workforce computed using ABS Estimated Resident Population: 2011, SA3
	Welfare support workers per 1000 population	SA2	SA4	ABS 2011 Census of Population and Housing	Computed from census variable OCCP (Occupation) Per capita workforce computed using ABS Estimated Resident Population: 2011, SA4
	Available hospital beds per 1000 population	SA2	States by ABS remoteness categories	Australian Institute of Health and Welfare: 2013-14 Hospital Resources	Table 2.10: Average available beds and beds per 1,000 population by remoteness area, public hospitals, states and territories, 2013–14.

Table 1c (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Emergency response workforce	Ambulance officers and paramedics per 1000 population	SA2	SA4	ABS 2011 Census of Population and Housing	Computed from census variable OCCP (Occupation) Per capita workforce computed using ABS Estimated Resident Population: 2011, SA4
	Fire and emergency workers per 1000 population	SA2	SA4	ABS 2011 Census of Population and Housing	Computed from census variable OCCP (Occupation) Per capita workforce computed using ABS Estimated Resident Population: 2011, SA4
	Police per 1000 population	SA2	SA4	ABS 2011 Census of Population and Housing	Computed from census variable OCCP (Occupation) Per capita workforce computed using ABS Estimated Resident Population: 2011, SA4
Emergency response funding	Fire and emergency services and SES organisations_Cost per 1000 population	SA2	State	Productivity Commission Report on Government Services, 2014-15	Volume D, Emergency Management, Table DA.3 Per capita funding computed using ABS Estimated Resident Population: 2015, State
	Ambulance organisations_Cost per 1000 population	SA2	State	Productivity Commission Report on Government Services, 2014-15	Volume D, Emergency Management, Table DA.3 Per capita funding computed using ABS Estimated Resident Population: 2015, State
Volunteer workforce	Fire service volunteers per 1000 population	SA2	State	Volunteer numbers as reported in fire service and state emergency service agency annual reports, 2014-15	Per capita volunteer numbers computed using ABS Estimated Resident Population: 2015, State

Table 1c (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
	SES volunteers per 1000 population	SA2	State	Volunteer numbers as reported in fire service and state emergency service agency annual reports, 2014-15	Per capita funding computed using ABS Estimated Resident Population: 2015, State
Remoteness	Distance to medical facility (km)	SA2	LGA	Regional Australia Institute [In]Sight	Computed by Regional Australia Institute as the average distance to medical facility, using a GIS

Table 1d. Indicators used in the planning & the built environment theme of the Australian Natural Disaster Resilience Index.

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Buildings	% caravan & improvised dwellings	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable STRD (Dwelling structure)
	% residential dwellings built post 1981	SA2	SA1	National Exposure Information System (NEXIS) – Geoscience Australia	
Emergency planning	Emergency planning assessment score	SA2	LGA	Derived from systematic evaluation of emergency plans	
Planning for natural hazards	Full time equivalent (FTE) council staff 2014-15	SA2	LGA	Various local government sources	Includes all staff categories within the council
	Council area per FTE council staff	SA2	LGA	Various local government sources	LGA (km^2)/FTE council staff
	LGA population per FTE council staff	SA2	LGA	Various local government sources	LGA population/FTE council staff

Table 1d (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
	Roads per FTE council staff	SA2	LGA	Various local government sources	Total road length in LGA (km)/FTE council staff
	Number of dwellings per FTE council staff	SA2	LGA	Various local government sources Compiled by James	Number of dwellings in LGA/FTE council staff
	New dwellings (2012-16) as a proportion of 2011 dwellings	SA2	LGA	Various local government sources Compiled by James	New dwellings in LGA (2012-16)/ total number of dwellings in LGA (2011) x100
	New dwellings per week (2015 - 16)	SA2	LGA	Various local government sources Compiled by James	Number of new dwellings approved in the 2015-2016 year/52
	Planning assessment score	SA2	LGA	Derived from systematic evaluation of local and regional planning documents	

Table 1e. Indicators used in the community capital theme of the Australian Natural Disaster Resilience Index.

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Crime and safety	Offences against person_Per 100,000 population	SA2	Various - police districts, LGA, suburbs	State and Territory crime statistics, 2011-12	Offences against person include assault, homicide, robbery, sexual offences, abduction.
	Offences against property_Per 100,000 population	SA2	Various - police districts, LGA, suburbs	State and Territory crime statistics, 2011-12	Offences against property include burglary, arson, theft, property damage. Driving, drug and liquor offences are not included.
	Safe walking in neighbourhood_ASR per 100 population	SA2	LGA	PHIDU Social Health Atlas of Australia	Age standardised number of people per 100 population of persons aged 18 years and over who feel very safe/safe walking alone in local area after dark. This indicator is the Social Health Atlas variable - Persons aged 18 years and over who feel very safe/safe walking alone in local area after dark (modelled estimates), derived from the ABS General Social Survey, 2010. For the disaster resilience index, LGAs with missing data (for very remote areas and areas with <1000 population) were imputed from surrounding areas. ASR = Age standardized rate

Table 1e (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Household support	Support in crisis_ASR per 100 population	SA2	LGA	PHIDU Social Health Atlas of Australia	Age standardised number of people per 100 population of persons aged 18 years and over who are able to get support in times of crisis from persons outside the household. This indicator is the Social Health Atlas variable - Persons aged 18 years and over who are able to get support in times of crisis from persons outside the household (modelled estimates), derived from the ABS General Social Survey, 2010. For the disaster resilience index, LGAs with missing data (for very remote areas and areas with <1000 population) were imputed from surrounding areas. ASR = Age standardized rate

Table 1e (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
	Raise 2000 in week_ASR per 100 population	SA2	LGA	PHIDU Social Health Atlas of Australia	Age standardised number of people per 100 population of Persons aged 18 years and over whose household could raise $2,000 within a week. This indicator is the Social Health Atlas variable - Persons aged 18 years and over whose household could raise $2,000 within a week (modelled estimates), derived from the ABS General Social Survey, 2010. For the disaster resilience index, LGAs with missing data (for very remote areas and areas with <1000 population) were imputed from surrounding areas. ASR = Age standardized rate

Table 1e (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Access to services	Difficulty accessing services_ASR per 100 population	SA2	LGA	PHIDU Social Health Atlas of Australia	Age standardised number of people per 100 population of persons aged 18 years and over who had difficulty accessing services. This indicator is the Social Health Atlas variable - Persons aged 18 years and over who had difficulty accessing services (modelled estimates), derived from the ABS General Social Survey, 2010. For the disaster resilience index, LGAs with missing data (for very remote areas and areas with <1000 population) were imputed from surrounding areas. ASR = Age standardized rate
	% households with no motor vehicle	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable VEHD (Number of motor vehicles).

Table 1e (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Wellbeing	Poor self-assessed health_ASR per 100 population	SA2	LGA	PHIDU Social Health Atlas of Australia	Age standardised number of people per 100 population of the estimated population, aged 15 years and over, with fair or poor self-assessed health. This indicator is the Social Health Atlas variable - Estimated population, aged 15 years and over, with fair or poor self-assessed health, derived as modelled estimates from the ABS Australian Health Survey, 2011-13. For the disaster resilience index, LGAs with missing data (for very remote areas and areas with <1000 population) were imputed from surrounding areas. ASR = Age standardized rate
Place attachment	% residents in same residence > 5 years	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable MV5D (Household five year mobility indicator)
Volunteering	% population undertaking voluntary work	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable VOLWP (Voluntary work for an organization or group)
Unemployment	% jobless families	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable LFSF (Labour force status of parents/partners in families)

Table 1f. Indicators used in the information access theme of the Australian Natural Disaster Resilience Index.

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Internet and mobile phone coverage	% area with excellent or good ADSL cover	SA2	Computed from raster layers	MyBroadband ADSL availability, Department of Communications, 2016	Between 60-80 (good) or 81-100 (excellent) per cent of premises have access to at least one fixed broadband technology
	% area with mobile phone coverage	SA2	Computed from raster layers	Telstra coverage map, 2016	The area within the SA2 that has access to Telstra 3G or 4G mobile phone network for device only
Community engagement and hazard education	Community engagement score	SA2	State	Derived from systematic assessment of community engagement policy and activity	

Table 1g. Indicators used in the social and community engagement theme of the Australian Natural Disaster Resilience Index.

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Social engagement	Percent population with life satisfaction scale 70 and above	SA2	No disaggregation – NATSEM data at SA2	AURIN and NATSEM	Life Satisfaction in 3 Groups (Synthetic Data) 2011. The data is calculated using a spatial microsimulation method to estimate small area (SA2) subjective wellbeing in Australia. The procedure uses the Australian Unity Wellbeing Index survey and the 2011 Census data. Subjective Wellbeing Homeostasis proposes that each person has a 'set-point' for personal wellbeing that is internally maintained and defended. This set-point is genetically determined and, on average, causes personal wellbeing to be held at 75 points on a 0-100 scale. Low levels of personal resources weaken homeostasis. For the disaster resilience index, SA2s with missing data were imputed from surrounding SA3 or SA4 values.

Table 1g (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
	Percent population with high generalized trust	SA2	No disaggregation	AURIN	Estimates of generalised trust (Synthetic Data) 2011. Generalised trust estimated from Wave 10 of the HILDA dataset. The question used on HILDA was “To what extent do you agree or disagree with the following statements?- g) Generally speaking, most people can be trusted” and was ranked on a scale of 1 (strongly disagree) to 7, (strongly agree). A spatial microsimulation technique was applied to estimate generalised trust from the HILDA dataset. The indicator was computed as the % population with survey responses agree-strongly agree. For the disaster resilience index, SA2s with missing data were imputed from surrounding SA3 or SA4 values.
	Migration effectiveness ratio 2006-11	SA2	No disaggregation – ABS data at SA2	ABS	This ratio assesses how effective migration has been in redistributing the population.

Table 1g (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Skills for learning	Percentage of population with post school qualification	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from the ABS community profile B40b (Non-school qualification: Level of education)
	People over 15 in further education	SA2	No disaggregation – ABS data at SA2	ABS 2011 Census of Population and Housing	Computed from census variable TYSTAP (Educational institution: attendee status)
	Participation in personal interest learning	SA2	State	ABS 2013 Survey of Work-Related Training and Adult Learning	Percentage of survey respondents aged 15-74 participating in personal interest learning.

Table 1h. Indicators used in the governance and leadership theme of the Australian Natural Disaster Resilience Index.

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
Research and development	Presence of research organisations	SA2	LGA	Regional Australia Institute	This is the % of research organisations out of all businesses variable from the [In]Sight 2014 Regional Competitiveness Index. Data derived from Innovation Australia – registered research organisation records
Capacity for development	Business Dynamo sub-index	SA2	LGA	Regional Australia Institute	This is the Business dynamo sub-index variable from the [In]Sight 2014 Regional Competitiveness Index. The Business Dynamo sub-index focuses on the new measures of innovation: 1. New business entries as a proportion of total businesses, 2010-2014 2. Owner-managers as a proportion of total employed persons 3. Trademark applications, average annual per 10,000 working age population 4. Knowledge-intensive business services (KIBS), employees per 10,000 working age population

Table 1h (cont.).

Disaster resilience dimension	Indicator name	Final resolution	Disaggregated from	Data source	Note
	Local economic development support	SA2	LGA	Regional Australia Institute	This is the Local economic development support variable from the [In]Sight 2014 Regional Competitiveness Index. Data derived from systematic assessment of the availability of business information and pro-business policies
Emergency service governance environment	Governance, policy & leadership score	SA2	State level	Derived from systematic assessment of emergency service governance elements	

STATISTICAL ANALYSIS

Index calculation is the process of bringing together the indicators to form an index. The generalized process for computing and reporting the Australian Natural Disaster Resilience Index is shown in Figure 2. The transformation (specifically normalizing) and aggregation steps will be the focus of this section.

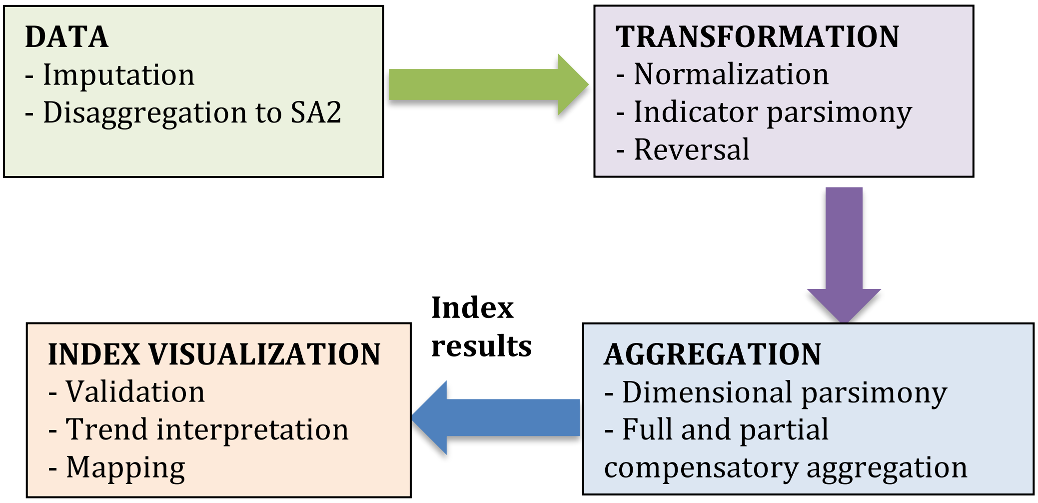


Figure 2. Generalized process of index derivation for the Australian Natural Disaster Resilience Index.

Transformation

The indicators that comprise a composite index are frequently transformed for one or other, or both, of two reasons: to obtain an indicator distribution that meets the assumptions required by a statistical procedure such as Principal Components Analysis (PCA), and to give indicators equal influence in a simple additive composite index (the most common aggregation method for composite indices).

Before proceeding, it is necessary to clarify a number of terms that are used inconsistently in the indicator literature:

> *Normalise*: this can be used to refer to transformations that bring a non-normal distribution closer to a normal distribution (e.g. von Hippel, 2003), or it can refer to rescaling a variable such that it has a range of 0 – 1 (OECD, 2008).
>
> *Standardise*: this can refer to converting the values of a variable to z scores (OECD, 2008; Schmidtlein et al., 2008), or to rescaling to a range of 0 – 1 (Gall, 2007).

There appears to be a belief among some authors (e.g. Jacobs, et al., 2004; Hudrlikova and Kramulova, 2013), that converting the values of a variable to z scores:

- "… imposes a standard normal distribution onto each indicator…" (Jacobs, et al., 2004 p.37), or
- "…converts all indicators to a common scale in which they are assumed to have a normal distribution" (Jacobs, et al., 2004 p.37), or
- "Standardisation (or z-score method) converts data in order to get normal distribution." (Hudrlikova and Kramulova, 2013, p.38)

This is not the case: converting an indicator to z scores simply rescales it to have a mean of 0 and a standard deviation of 1. A skewed indicator will have exactly the same skewness, and a similar departure from normality, after conversion to z scores.

Similar inconsistencies in terminology in the composite index literature have been noted by Heinrich, et al. (in press). In addition to those noted above, "normalisation" can also be used to refer to the aggregation of a number of indicators into a single index. In this report, *normalise* means any transformation of an indicator that aims to bring its distribution closer to a normal distribution. *Rescaling* means a change to the range of an indicator, and/or its mean and standard deviation, without altering the shape of its distribution. Normalising to reduce excessive skewness and kurtosis is a step in many published composite indices (e.g. the Global Innovation Index and the Environmental Sustainability Index – Yang, 2014), and is recommended in methodological guides (e.g. OECD, 2008, Kovacevic, 2011, Hudrlikova, 2013).

There are two reasons for normalising maldistributed indicator descriptions. Firstly, if an indicator distribution is highly skewed, then this has serious consequences when simple additive aggregation is used to form composite indices.

Aggregation methods

Aggregation issues are mostly concerned with arriving at an index that somehow gives expression to the pattern of indicator values, without being unstable or misleading. The central issue, widely discussed in the literature, is compensability between indicators, i.e. whether or not low values of some indicators can be compensated for in the aggregation process by high values of other indicators. A further consideration in aggregation methodology, that has become relevant in recent times with the use of aggregation operators that allow for detailed prescription of levels of compensability between indicators, is the level of expert input required to model the compensability. In general, methods that require extensive efforts by (possibly volunteer) experts are unlikely to be practicable. An enduring issue, despite great improvements in computer processing speeds, is also the length of time required for aggregation calculations. The scoring of options in Multiple Criteria Decision Analysis (MCDA) is mathematically equivalent to constructing indices of resilience to hazards and so allows MCDA methods to be applied to the task of constructing resilience indices. However, resilience indices generally involve large numbers of indicators (MCDA criteria) and geographical units (MCDA options) in the thousands, so that the computational intensity of MCDA methods makes them infeasible for calculating resilience indices.

The hierarchical structure of the ANDRI means that there is more than one methodological choice to be made with aggregation. There are six aggregations required to calculate the various sub-indices that go to make up the Coping Capacity sub-index, and two aggregations required to calculate the sub-indices that comprise the Adaptive Capacity sub-index. This is followed by an aggregation of eight sub-indices to calculate the Coping Capacity sub-index and an aggregation of two sub-indices to calculate the Adaptive Capacity sub-index. Finally, these two sub-indices need to be aggregated to produce the ANDRI.

Having regard to wide range of aggregation methods and their varying assumptions about compensability, there is no reason that different aggregation methods cannot be used in different parts of the hierarchy. In particular, where an aggregation involves only two or three indicators or sub-indices, the demands of specifying compensatory relationships are lessened. In addition, the higher parts of the hierarchy are more conceptual in nature, which opens the possibility of specifying compensatory relationships from theoretical considerations.

Given these characteristics, the ANDRI calculation has used non-compensatory or partially non-compensatory aggregation methods where it is within the project budget to make reasonable estimates of compensatory relationships. Where the aggregation involves just a few indicators or sub-indices, compensatory relationships, if known, can be easily specified. Where there is a larger number of indicators or sub-indices to aggregate, more general methods of managing compensatory relationships can be used, as described below

No weighting at the indicator level is used in the ANDRI calculation. The critique of lack of weighting which has been levelled at fully additive aggregation methods (De Muro et al., 2011), is less applicable to ANDRI, given the efforts made in the methods to take account of compensatory effects as much as possible within the constraints of the project.

There is no single aggregation function that is universally accepted as the correct method for aggregating indicators to calculate a composite index or composite sub-index. Choice of aggregation function depends on the indicator context, on the level of knowledge about possible indicator interactions and upon the mathematical tractability of indicator calculations. Often, a degree of subjectivity is inevitable in indicator aggregation choices. The most widely used aggregation function, the arithmetic mean, is intuitively appealing, but subject to growing criticism in the literature for allowing unconstrained compensation between indicators.

Descriptive details and selected results may include one or more of the following aggregation functions, according to the indicator context and level of understanding of indicator interactions:

- discrete Choquet integral,
- ordered weighted averaging (OWA),
- generalised mean,
- Mazziotta-Pareto index, and

- arithmetic mean.

The discrete Choquet integral requires a reasonable understanding of interactions between indicators and subsets of indicators. It provides a nuanced and mathematically valid aggregation that takes account of these interactions, but becomes intractable in its information requirements when the number of indicators exceeds three. It is rarely used in disaster resilience studies.

The OWA, generalised mean and Mazziotta-Pareto Index methods listed above have all been proposed in the literature as improvements on the arithmetic mean. They have been used in a small number of studies involving composite indices, not necessarily disaster resilience. The arithmetic mean aggregation method has been widely used but is open to serious criticism as to its validity.

The aggregation strategies pursued to obtain tractable measurement models appropriate to the level of understanding of indicator interactions may include simple formative measurement models (the model most commonly used in natural disaster resilience and vulnerability studies), as well as combined reflective and formative models. The former type is ubiquitous in studies involving latent constructs in psychology and social and educational psychology, and has the advantage that aggregation by arithmetic mean is wholly valid.

Aggregation strategies may include reducing the number of indicators if this can be done without serious information loss.

In the reporting of the theme aggregation results, one of the composite subindices and its measurement model will be identified as representing, in our opinion, the most appropriate method given the indicator context. Aggregation results for ordered weighted averaging, generalised mean, Maziotta-Pareto index and the arithmetic mean will be also provided.

The level of uncertainty attaching to the composite sub-indices is expressed through the inter-indicator variation. High inter-indicator variability leads to increased compensatory effects when indicators are aggregated. For aggregation functions other than the discrete Choquet integral, these effects will be largely uncontrolled and their basis in physical reality uncertain. For these reasons, the inter-indicator variability, as expressed by the inter-indicator coefficient of variation, is a measure of composite index uncertainty.

Computing the index

Computation of the sub-index for each theme, the coping and adaptive capacity index and the overall Australian Natural Disaster Resilience Index follows a standard process comprising transformation, correlation, aggregation and mapping steps.

An abridged example of the theme report arising from the computation of the Economic Capital theme is given in the following pages.

Abridged theme report: Economic capital

Transformation

Transformation details

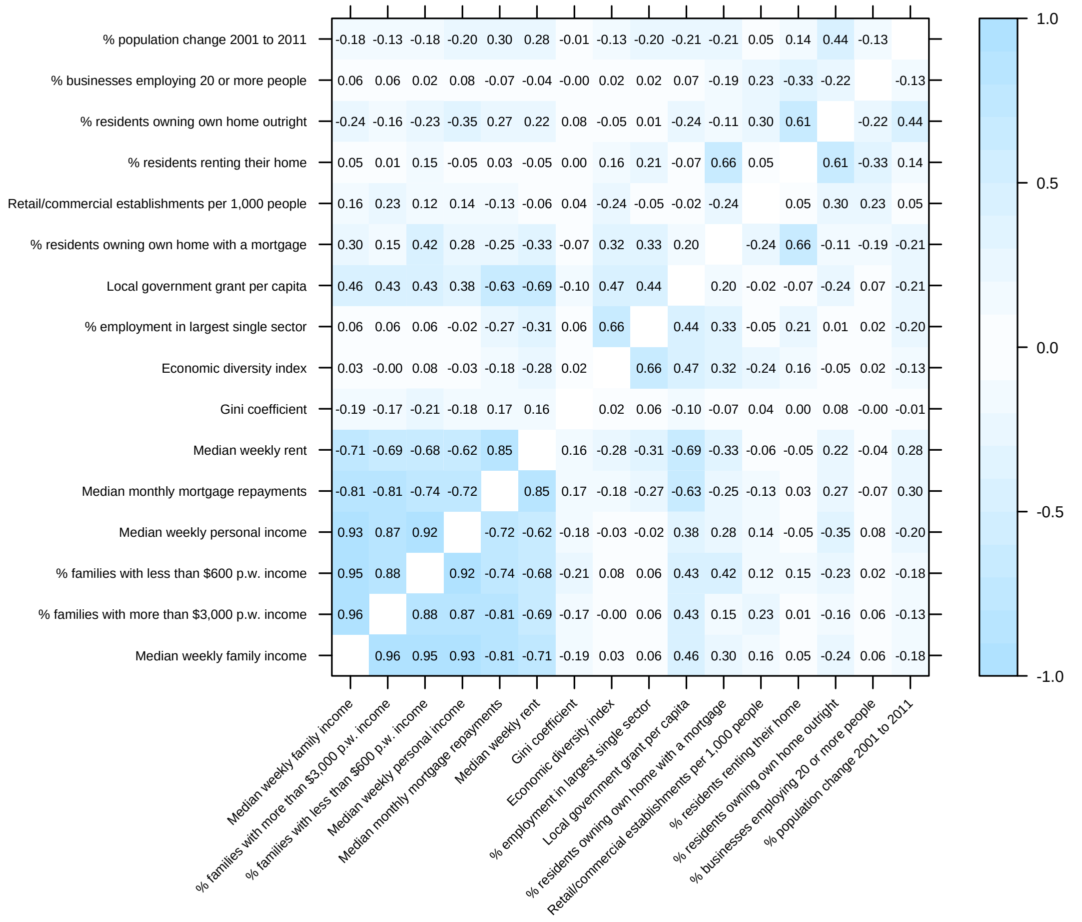
Indicator	Transformation details		
	Skewness transform	Exponent	Coefficient for kurtosis transform
% residents owning own home outright	No transform	-	-
% residents owning own home with a mortgage	Power transform	0.86	0.23
% residents renting their home	Power transform	0.32	0.13
Median weekly rent	Power transform	0.82	0.12
Median monthly mortgage repayments	Power transform	1.04	0.16
Median weekly personal income	Power transform	0.28	0.18
Median weekly family income	Power transform	0.35	0.02
% families with less than $600 p.w. income	Power transform	0.40	0.05
% families with more than $3,000 p.w. income	Power transform	0.23	0.02
% employment in largest single sector	Power transform	0.12	0.26
Economic diversity index	Power transform	6.44	0.00
% businesses employing 20 or more people	Power transform	0.43	0.29
Retail and/or commercial establishments per 1,000 people	Power transform	0.23	0.34
% population change 2001 to 2011	Power transform	0.05	0.44
Gini coefficient	Power transform	0.73	0.44
Local government grant per capita	Power transform	0.07	0.29

Transformation results

Indicator	Raw data pre-transform			Post-transform		
	Skewness	Kurtosis	Outliers	Skewness	Kurtosis	Outliers
% residents owning own home outright	-0.43	-0.09	0	-0.43	-0.09	0
% residents owning own home with a mortgage	0.27	0.83	4	0.05	0.00	0
% residents renting their home	1.43	3.27	27	-0.01	-0.00	2
Median weekly rent	0.29	1.32	5	0.03	0.00	2
Median monthly mortgage repayments	-0.07	1.15	17	0.01	0.00	2
Median weekly personal income	1.47	4.33	16	0.06	-0.00	2
Median weekly family income	0.71	-0.11	1	0.01	0.00	3
% families with less than $600 p.w. income	1.10	3.53	13	0.00	-0.00	6
% families with more than $3,000 p.w. income	1.15	0.79	8	0.01	0.00	2
% employment in largest single sector	2.27	5.80	34	-0.16	-0.00	2
Economic diversity index	-1.46	1.07	0	0.00	-1.29	0
% businesses employing 20 or more people	7.94	126.83	13	-0.07	-0.00	5
Retail and/or commercial establishments per 1,000 people	9.85	155.17	14	0.02	-0.00	8
% population change 2001 to 2011	30.68	1073.36	6	-0.15	-0.00	7
Gini coefficient	1.08	9.71	32	-0.04	0.00	10
Local government grant per capita	10.77	164.01	23	-0.30	-0.00	1

Correlation

Correlation plot



The correlation plot has the indicators in the order given by the sorted loadings table from principal components analysis (PCA). The correlation plot is for transformed indicators with reversals carried out where appropriate. For some correlations the negative value is a consequence of one indicator having been reversed and the other not reversed. For example, Median monthly mortgage repayments is negatively correlated with % families with more than $3,000 p.w. income. Without reversals these would be positively correlated, but Median monthly mortgage repayments is reversed since it is believed to have a negative effect on resilience. On the other hand, Median monthly mortgage repayments is negatively correlated with % families with less than $600 p.w. income, and both the indicators have been reversed to reflect the belief that they both have a negative influence on resilience. It is this second type of negative correlation between indicators that has implications for aggregation.

The correlation plot shows a number of groups of reasonably well correlated indicators, consistent with a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.77. The scree plot was inconclusive as to the number of components, and a solution based on the number of eigenvalues greater than one gave a number of uninterpretable components. After examining a number of possible solutions, a three component solution provided some guidance for the aggregation strategy. The sorted loadings table for the three component solution is shown below.

Indicator	C1	C2	C3
Median weekly family income	0.98		
% families with more than $3,000 p.w. income	0.95		
% families with less than $600 p.w. income	0.95		
Median weekly personal income	0.93		
Median monthly mortgage repayments	-0.86		
Median weekly rent	-0.77	-0.39	
Gini coefficient			
Economic diversity index		0.83	
% employment in largest single sector		0.79	
Local government grant per capita	0.49	0.57	
% residents owning own home with a mortgage	0.31	0.54	0.46
Retail and/or commercial establishments per 1,000 people		-0.42	
% residents renting their home			0.92
% residents owning own home outright			0.77
% businesses employing 20 or more people			-0.51
% population change 2001 to 2011		-0.39	0.41
Cumulative % of variance	34.29	50.50	64.13

Since these indicators were chosen for their known influence on resilience, causation flows from the indicators to the measure of resilience, and a formative measurement model is appropriate. There is moderately strong multi-factor structure as evidenced by the proportion of variance explained by the components and the relatively high KMO measure.

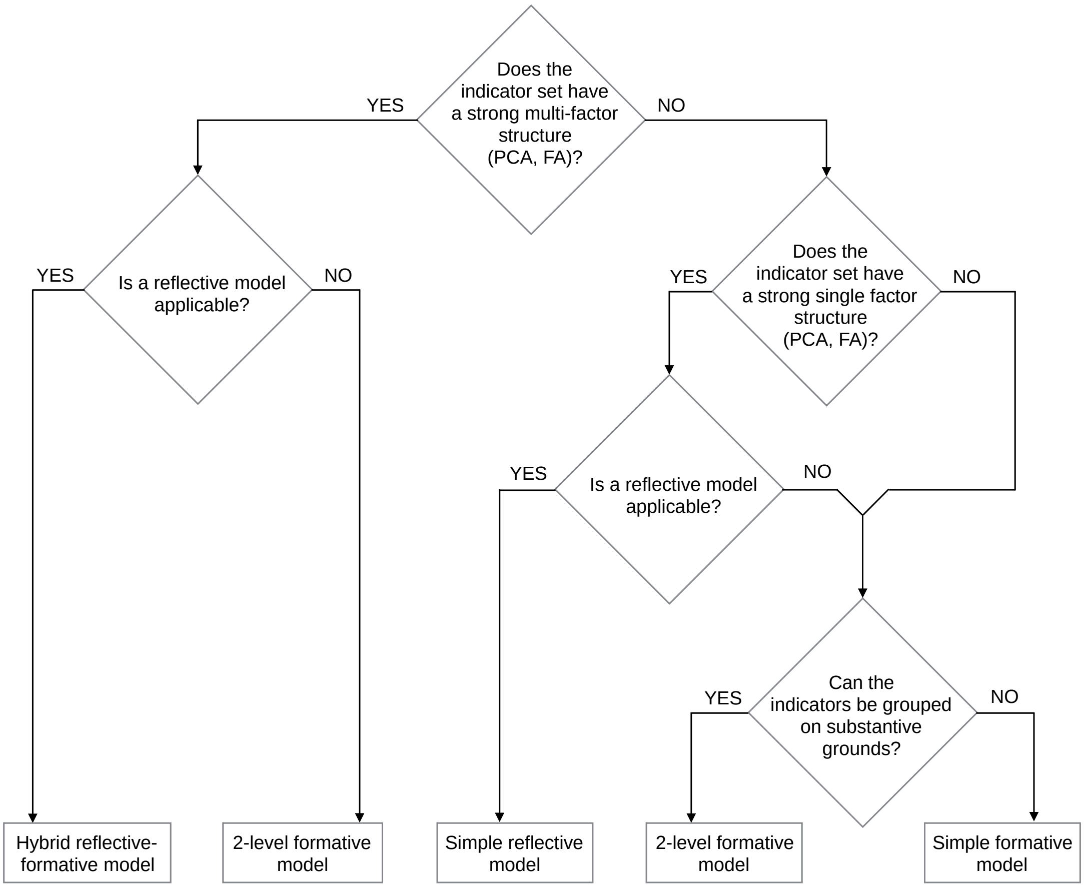
Regression analysis

Indicator denoted the dependent variable in the regression	R^2
Median weekly family income	0.98
% families with more than $3,000 p.w. income	0.95
% families with less than $600 p.w. income	0.94
% residents renting their home	0.92
Median weekly personal income	0.92
% residents owning own home with a mortgage	0.89
% residents owning own home outright	0.86
Median monthly mortgage repayments	0.85
Median weekly rent	0.78
Local government grant per capita	0.60
Economic diversity index	0.57
% employment in largest single sector	0.55
Retail and/or commercial establishments per 1,000 people	0.35
% population change 2001 to 2011	0.30
% businesses employing 20 or more people	0.20
Gini coefficient	0.06

Regressions between each indicator as dependent variable and the remaining indicators as independent variables show that many of the indicators are well predicted by the remaining indicators. However, the correlation plot shows that there are a number of negative correlations and for this reason, as outlined in section 1.2.6 of the Methodology Report, no indicators were discarded.

Measurement model

Since the 16 Economic Capital indicators had a strong multi-factor structure, but were not suited to a reflective measurement model, a two-level formative model for aggregation was chosen, following the ANDRI decision tree for aggregation strategy shown below.



Aggregation

Aggregation method

The two-level formative model, guided by the PCA results, comprised three subindices:

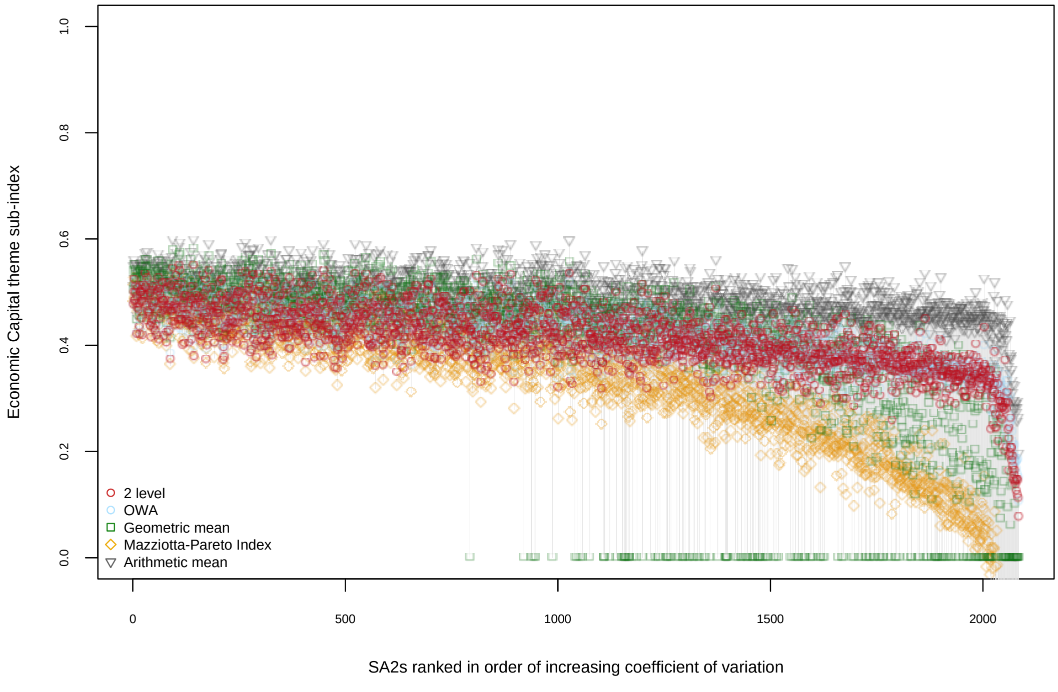
> *Disposable income* – median weekly family income, % families with more than $3,000 p.w. income, % families with less than $600 p.w. income, median weekly personal income , median monthly mortgage repayments, median weekly rent;
> *Ownership* – % residents renting their home, % residents owning own home with a mortgage, % residents owning own home outright; and
> *Economy* – economic diversity index, % employment in largest single sector, local government grant per capita, % population change 2001 to 2011, retail and/or commercial establishments per 1,000 people and % businesses employing 20 or more people.

Since the correlation plot showed the Gini coefficient to have very low correlations with any of the remaining indicators, the effect on the Economic Capital theme sub-index of omitting the Gini coefficient was tested. The correlation between the theme sub-indices with and without the Gini coefficient was 0.99, which was considered grounds for omitting this indicator.

Because Disposable Income includes indicators that are strongly negatively correlated, some consideration needs to be given to compensability issues, since with such indicators, very high values of some indicators will be aggregated with very low values of other indicators. For example, will low numbers of families with less than $600 p.w. income (higher resilience) compensate for high median monthly mortgage repayments (lower resilience) in determining the resilience of a community and vice versa? Since there is little information in the natural disaster resilience literature to answer these questions precisely, the choice was made to use ordered weighted averaging (OWA) rather than the arithmetic mean. With an orness of 0.375, OWA provides moderate restraint on compensatory effects which would otherwise be unrestrained with the arithmetic mean.

OWA with an orness of 0.375 was also used to aggregate the four sub-indices to produce the Social Character sub-index. This orness value was chosen in the absence of any evidence that Household Factors, Socio-Economic Advantage, Familiarity with Locality and Infirmity could not substitute for each other to a moderate extent.

Comparison of aggregation methods



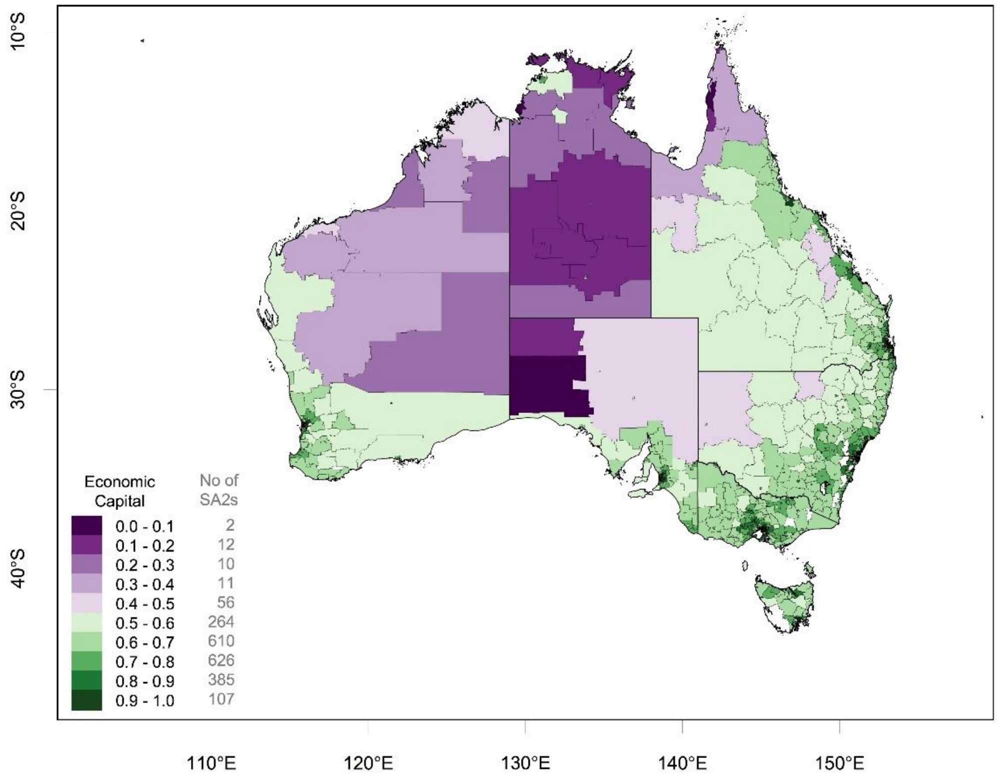
The comparison of aggregation methods, above, shows the results for the two level formative model (OWA-OWA) and single level models with aggregation by OWA, geometric mean, Mazziotta-Pareto Index and arithmetic mean. As expected, the use of OWA with its constraints upon compensatory effects results in the Economic Capital theme sub-index taking values lower than are obtained with the arithmetic mean. There is not a lot difference between the two level and single level models with aggregation by OWA (in the diagram the single level OWA is obscured behind the two level OWA), although two level OWA retains the capacity for a more nuanced accounting for compensatory effects if required. The geometric mean gives approximately similar values of the sub-index as the arithmetic mean, but falls to zero as soon as the coefficient of variation of the constituent indicators for an SA2 is high enough to be the result of one or more zero indicators. The Mazziotta-Pareto Index, with its fixed unbalance penalisation, severely reduces the value of the sub-index when the coefficient of variation for the indicators is high.

Examples of SA2s with high and low coefficient of variation

The example SA2s in the table below show that a high coefficient of variation across the 16 indicators results in a larger difference between the two-level model using OWA and the simple arithmetic mean of the indicators. This is a consequence of OWA restraining the extent to which high values on some indicators can compensate for low values on other indicators.

Indicator	Rescaled transformed Indicator values	
	High c.v. (Thamarrurr)	Low c.v. (Currumbin Waters)
% residents owning own home outright	0.00	0.59
% residents owning own home with a mortgage	0.00	0.57
% residents renting their home	0.01	0.42
Median weekly rent	0.93	0.55
Median monthly mortgage repayments	1.00	0.54
Median weekly personal income	0.00	0.58
Median weekly family income	0.00	0.62
% families with less than $600 p.w. income	0.00	0.44
% families with more than $3,000 p.w. income	0.37	0.59
% employment in largest single sector	0.15	0.33
Economic diversity index	0.00	0.56
% businesses employing 20 or more people	0.00	0.39
Retail and/or commercial establishments per 1,000 people	0.00	0.58
% population change 2001 to 2011	0.27	0.49
Local government grant per capita	0.19	0.42
Economic Capital theme sub-index (2 level OWA)	0.08	0.48
Economic Capital theme sub-index (Arithmetic mean)	0.19	0.51
Coefficient of variation	1.58	0.17

Mapped Economic Capital Theme Sub-index



Indicator relationships with composite index

National level

The correlations at national level between individual indicators and the Economic Capital theme sub-index are shown in the table below. The magnitude of the correlation gives guidance as to which indicators have the most influence on the value of the Economic Capital theme sub-index. Correlations and scatter plots show that, nationally, the Economic Diversity Index and % residents renting their home have the most influence on the value of the Economic Capital theme sub-index. The first indicator has a positive influence, while the second has a negative influence on the Economic Capital theme sub-index. So where, for example, the sub-index has a low value, it is likely that this could be caused by low diversity in the local economy and a high proportion of residents renting their home.

The opposite is likely to be the case when the Economic Capital theme sub-index has a high value. However, there will be exceptions to this pattern when smaller regions are considered.

Indicator	Correlation with Economic Capital theme sub-index
Economic diversity index	0.62
% residents owning own home with a mortgage	0.59
% residents owning own home outright	0.43
Median weekly rent	0.32
Median monthly mortgage repayments	0.28
Median weekly family income	0.19
% families with more than $3,000 p.w. income	0.09
Median weekly personal income	0.00
Retail and/or commercial establishments per 1,000 people	-0.04
% population change 2001 to 2011	-0.08
% businesses employing 20 or more people	-0.15
Local government grant per capita	-0.33
% families with less than $600 p.w. income	-0.45
% employment in largest single sector	-0.57
% residents renting their home	-0.75

Regional level

Disaggregation of the correlations between indicators and sub-index to SA4 level (larger geographic areas containing around 20 SA2s) reveals that the regional differences in the patterns of correlations between indicators results in corresponding differences in the relationships between indicators and the Economic Capital theme sub-index. The group of points with a remoteness score of 1 or close to 1 are the metropolitan SA4s, including inner city and suburban areas. The points with remoteness scores of 2 through to 5 represent the SA4s ranging from inner regional Australia to very remote Australia. Taking all the indicator correlations the following conclusions can be drawn about spatial variation in the influence of the indicators on the Economic Capital theme sub-index.

- % residents renting their own home is a strong negative influence on the sub-index in metropolitan areas and remote areas, but less so in regional areas.
- % residents owning their home outright is a moderate positive influence on the sub-index in metropolitan and remote areas, but in regional areas this indicator is more likely to be a negative influence on the sub-index.
- The indicators that have a strong influence on the sub-index in many of the regional SA4s are % residents owning own home with a mortgage (positive), median weekly rent (positive), % employment in largest single sector (negative), Economic Diversity Index (positive) and local government grant per capita (negative). This strong influence extends to metropolitan and remote areas for % employment in largest single sector and Economic Diversity Index which is consistent with the national results tabulated above.

- % businesses employing 20 or more people generally has little influence on the sub-index, regardless of the region.

These results highlight the importance examining individual indicator values when interpreting the sub-index value for an individual SA2.

RESULTS OF THE AUSTRALIAN NATURAL DISASTER RESILIENCE INDEX

In this section, we discuss the results and initial trends in the Australian Natural Disaster Resilience Index. It should be noted that these interpretations and maps are subject to further change as the State of Disaster Resilience Report is developed. What is presented here is an overview of the pattern of index values. In all maps, lower index values in brown represent lower disaster resilience and higher index values in green represent higher disaster resilience. Each of the sections is an SA2 division of the ABS.

THEME INDEXES

Social character

Social character embodies the social and demographic factors that influence the ability to prepare for and recover from natural hazard events. The social character dimension of disaster resilience ranges from low to high (Figure 3). Areas with higher capacity for disaster resilience through social character tend to be concentrated around the more populated coastal areas, and lower areas in remote Northern Australia. Although not visible in Figure 3, there are also areas of lower capacity for disaster resilience through social character in metropolitan areas, such as the Western Suburbs of Sydney.

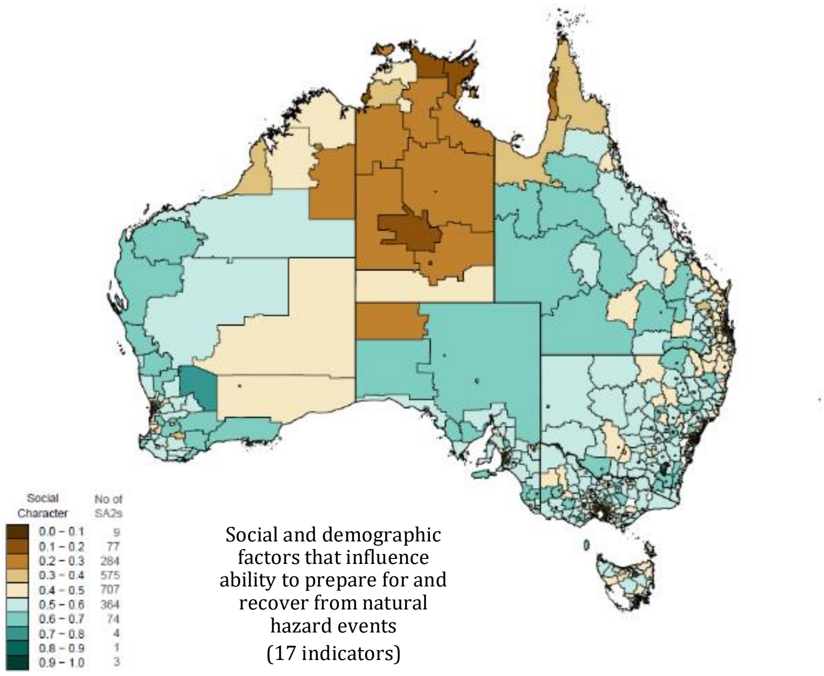


Figure 3. Results of the Social Character theme. This map is subject to change as the State of Disaster Resilience Report develops and should not be reproduced.

Economic capital

Economic capital embodies the economic factors that influence ability to prepare for and recovery from natural hazard events. The economic capital dimension of disaster resilience ranges from low to high (Figure 4). Areas with higher capacity for disaster resilience through economic capital tend to be concentrated around the more populated coastal areas, and lower areas in remote Australia. Although not visible in Figure 4, there are also areas of high capacity for disaster resilience through economic capital in metropolitan areas, such as the Eastern Suburbs of Sydney.

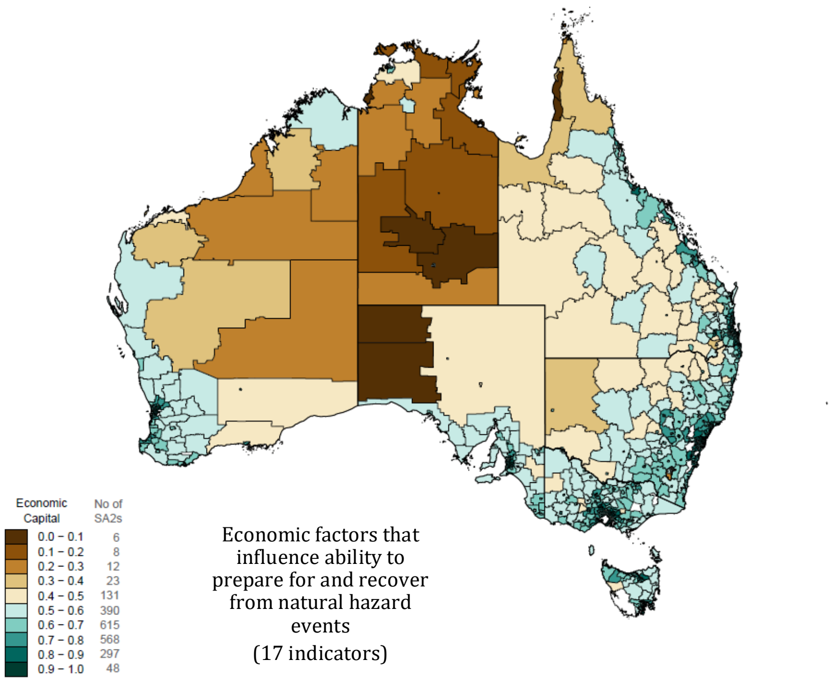


Figure 4. Results of the Economic Capital theme. This map is subject to change as the State of Disaster Resilience Report develops and should not be reproduced.

Emergency services

Emergency Services embodies the presence, capability and resourcing of emergency services. The emergency services dimension of disaster resilience ranges from low to high (Figure 5). Areas with higher capacity for disaster resilience through emergency services tend to be concentrated around the more populated eastern coastal areas. Regional and remote parts of Australia have lower capacity for disaster resilience through emergency services, driven by the lower emergency service capability per capita that occurs in these less populated areas.

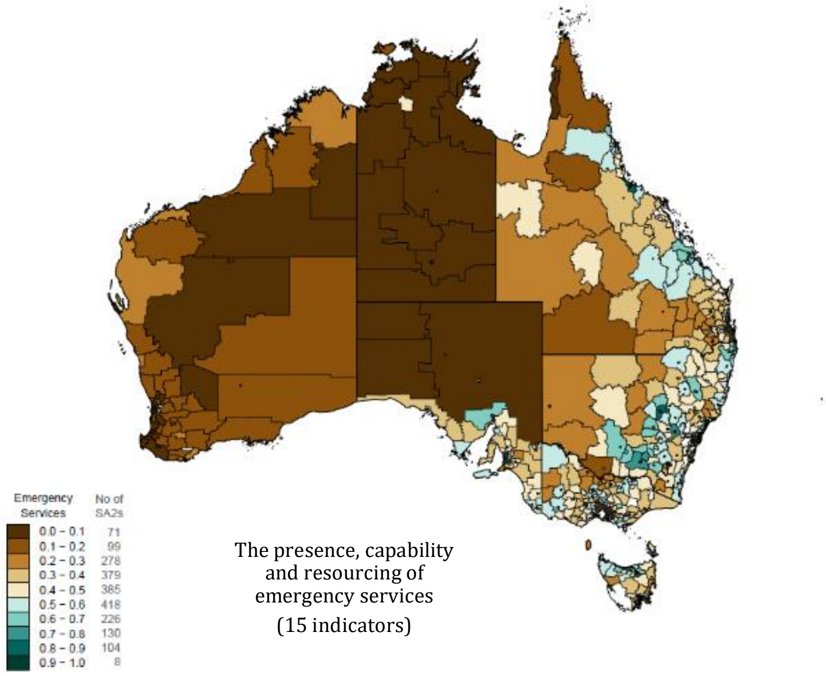


Figure 5. Results of the Emergency Services theme. This map is subject to change as the State of Disaster Resilience Report develops and should not be reproduced.

Planning and the built environment

Planning and the built environment embodies preparation for natural hazard events using strategies of mitigation or planning. The planning and the built environment dimension of disaster resilience ranges from low to high, but is generally in the lower half of the range (Figure 6). Although not visible on the map, areas with higher capacity for disaster resilience through planning and the built environment tend to be concentrated around the more populated metropolitan areas, associated with well-resourced councils. Regional and remote parts of Australia have lower capacity for disaster resilience through planning and the built environment.

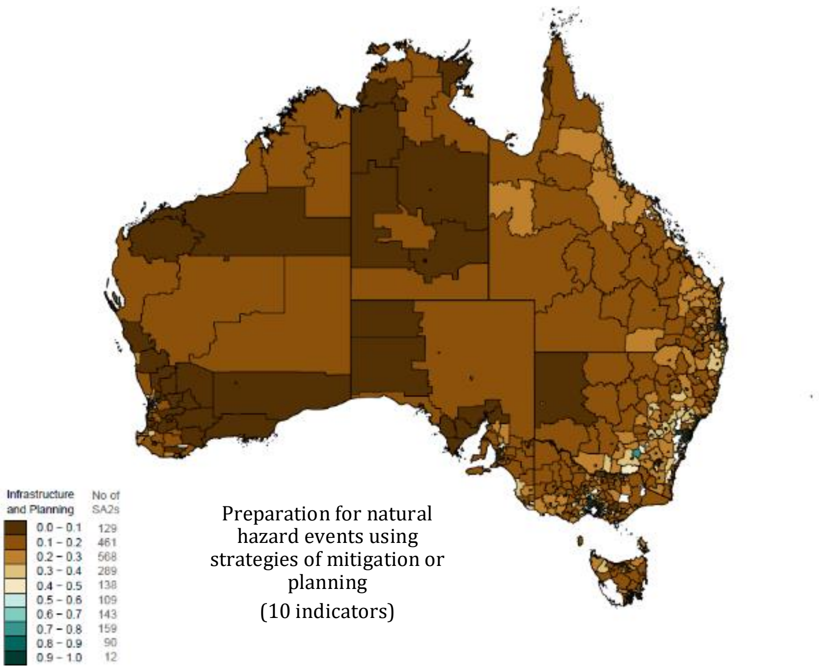


Figure 6. Results of the Planning and the Built Environment theme. This map is subject to change as the State of Disaster Resilience Report develops and should not be reproduced.

Community capital

Community capital embodies the cohesion and connectedness of the community. The community capital dimension of disaster resilience ranges from low to high (Figure 7). Areas with higher capacity for disaster resilience through community capital tend to be concentrated around the more populated areas, although some rural and remote areas also have higher capacity for disaster resilience through community capital.

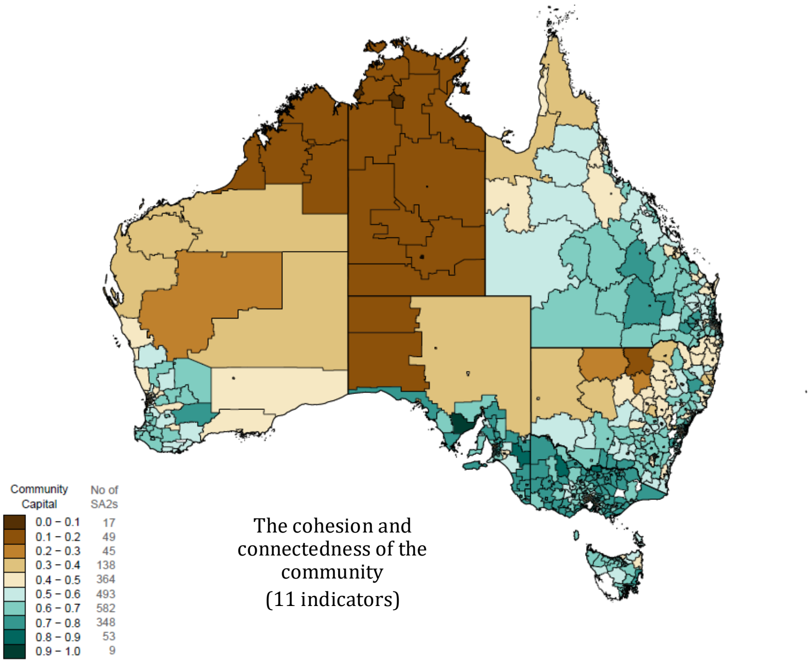


Figure 7. Results of the Planning and the Built Environment theme. This map is subject to change as the State of Disaster Resilience Report develops and should not be reproduced.

Information access

Information access embodies the availability of telecommunications and community engagement to encourage risk awareness. The information access dimension of disaster resilience ranges from low to high but is generally in the lower half of the range (Figure 8). Although not visible on the map, areas with higher capacity for disaster resilience through information access tend to be concentrated around the more populated metropolitan areas, associated with better telecommunications access.

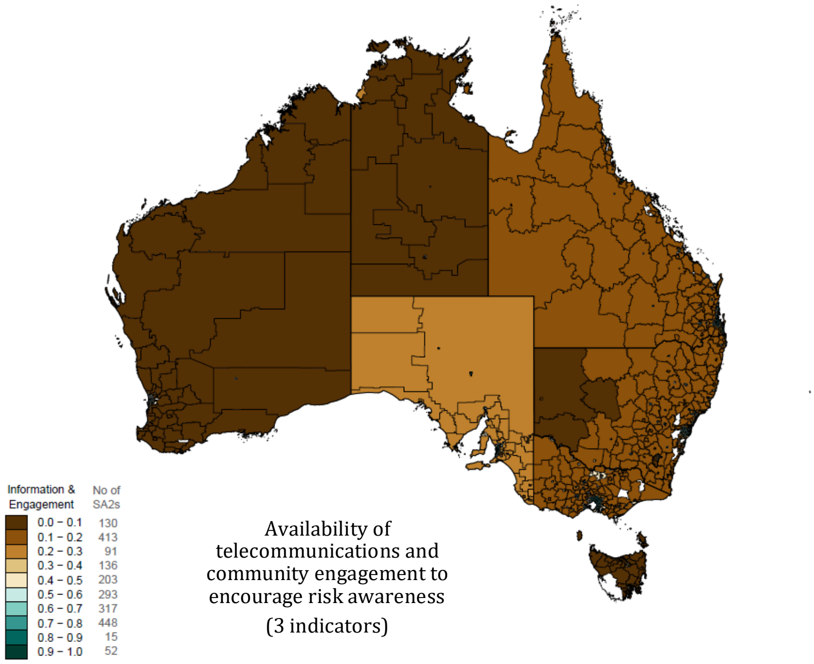


Figure 8. Results of the Information Access theme. This map is subject to change as the State of Disaster Resilience Report develops and should not be reproduced.

Social and community engagement

Social and community engagement embodies the social enablers of learning, adaptation and transformation. The social and community engagement dimension of disaster resilience ranges from low to high (Figure 9). Areas with higher capacity for disaster resilience through social and community engagement tend to be concentrated around the more populated eastern coastal areas. Regional and remote parts of Australia have lower capacity for disaster resilience through social and community engagement.

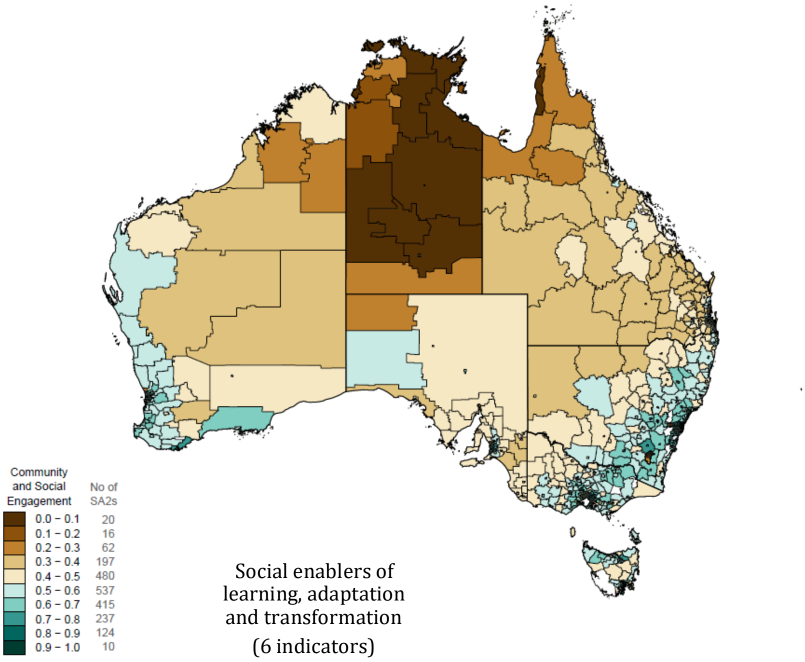


Figure 9. Results of the Social and Community Engagement theme. This map is subject to change as the State of Disaster Resilience Report develops and should not be reproduced.

Governance and leadership

Governance and leadership embodies the organizational enablers of learning, adaptation and transformation. The governance and leadership dimension of disaster resilience ranges from low to high but is generally in the lower half of the range (Figure 10). Although not visible on the map, areas with higher capacity for disaster resilience through governance and leadership tend to be concentrated around the more populated metropolitan areas, associated with research and technology infrastructure.

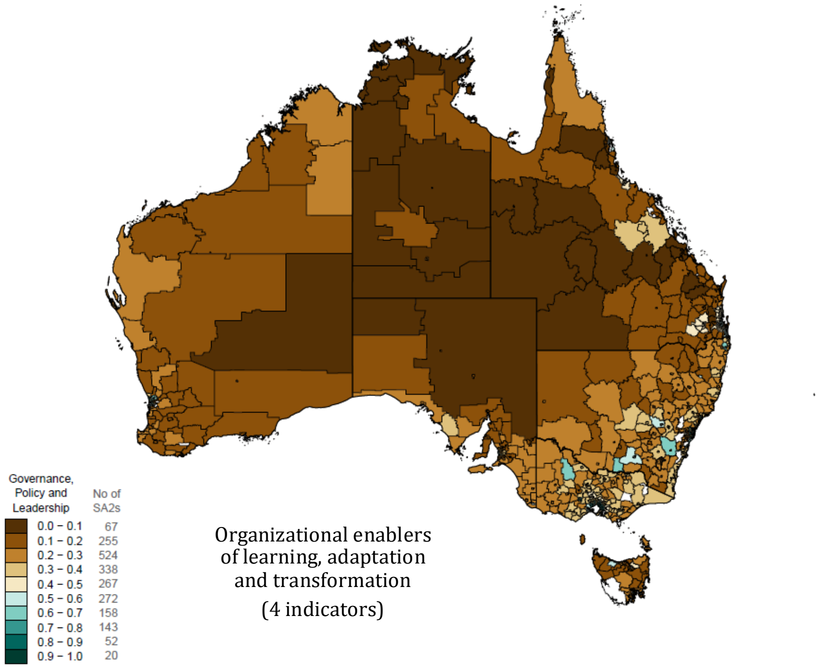


Figure 10. Results of the Governance and Leadership theme. This map is subject to change as the State of Disaster Resilience Report develops and should not be reproduced.

OVERALL INDEX OF DISASTER RESILIENCE

The eight themes are formed into an index of disaster resilience that shows the overall status of disaster resilience across Australia. The provisional index findings are shown in Figure 11. Areas of higher overall disaster resilience tend to be concentrated in metropolitan areas, with lower resilience in more regional and remote areas.

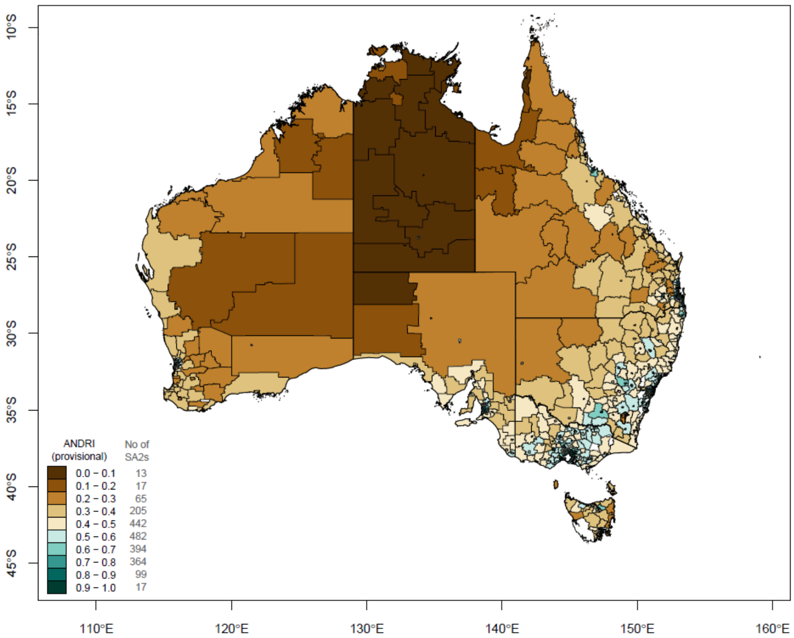


Figure 11. Provisional Australian Natural Disaster Resilience Index. This map is subject to change as the State of Disaster Resilience Report develops and should not be reproduced.

THE STATE OF DISASTER RESILIENCE REPORT

The next stage of the project is to interpret the Australian Natural Disaster Index results as a State of Disaster Resilience Report. The interpretation takes a strengths based approach that highlights areas of strength in disaster resilience and opportunities for improvement. The stregths based narration is based on the following principles, developed in conjunction with end-users:

1) Conceptual and statistical robustness
2) Transparency of methods, indicators, gaps and limitations
3) Strengths based interpretation of resilience
4) Needs to link back to previous research
5) Baseline for comparison through time
6) Local validation
7) Guidance on how to use the report, by whom and for what purpose
8) Don't use traffic light colours (possible single colour scale)
9) Individual commentaries interpreting LGAs
10) Think about archetype approach / behavioural segmentation

DESIGN OF THE STATE OF DISASTER RESILIENCE REPORT

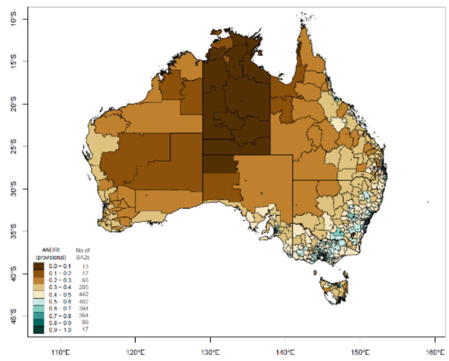
Three elements comprise the State of Disaster Resilience Report (Figure 12).

First, the State of Disaster Resilience Report will interpret the trends and patterns in disaster resilience through the hierarchal levels of the index (Figure 1). The interpretation is a strengths based approach (Principle 3) with data presented as maps with a purple-green palette (Principle 8). The project team are currently investigating a typology approach to interpreting the index results (Principle 10).

Second, a substantial technical volume will accompany the State of Disaster Resilience Report (Principle 1 and Principle 2). This technical volume will contain details of:

1) The design of the index and spatial resolution
2) Indicators, including data sources, disaggregation techniques and relationships to disaster resilience (Principle 4)
3) Statistical methods, including transformation, reversal, correlation & regression, rescaling, aggregation, measurement model and index results
4) Statistical computation results
5) Uncertainty and sensitivity analysis

Third, data products will be developed to suit the needs of end users (Principle 7 and Principle 9). This includes map products, and extraction of results for limited geographical areas (Figure 12).



State of Disaster Resilience Report

Overall strengths based interpretation and narration of the state of disaster resilience in Australia.

2 versions:

- A shorter glossy summary version
- A longer state of disaster resilience report with data and interpretations

Technical volume

Technical details of index computation:

- Index design
- Indicators and indicator data
- Statistical methods
- Theme reports
- Uncertainty and sensitivity analysis

Data products and utilization activities

Socialisation of the State of Disaster Resilience Report with end users, and development of data products:

- GIS layers
- LGA/Regional summaries of index results
- Index roadshow and utilization sessions
- Guidance notes on how to use the index

Peer reviewed academic papers:

- Design of the index (published)
- Composite index statistics
- Results of the Australian assessment of disaster resilience
- Assessment of planning for hazards in Australia

Figure 12. Elements in the development of the State of Disaster Resilience Report.

PUBLICATIONS LIST

Project outputs

Parsons, M., Glavac, S., Hastings, P., Marshall, G., McGregor, J., McNeill, J., Morley, P., Reeve, I. and Stayner, R. 2016. Top-down assessment of disaster resilience: A conceptual framework using coping and adaptive capacities. International Journal of Disaster Risk Reduction, 19: 1-11.

Parsons, M., Foster, H. and Redlich, S. (2018). Case study: the Victorian Emergency Management Community Resilience Index. Australian Journal of Emergency Management, 33: 21-22.

Parsons, M. and Morley, P. (2017). The Australian Natural Disaster Resilience Index. Australian Journal of Emergency Management, 32: 20-22.

Parsons, M., Morley, P., Marshall, G., Hastings, P., Glavac, S., McGregor, J., Stayner, R., McNeill, J. and Reeve, I. (2015). The Australian Natural Disaster Resilience Index: Conceptual framework and indicator approach. Bushfire and Natural Hazards Cooperative Research Centre, Melbourne, Australia.

Affiliated work

Parsons, M. and Thoms, M.C. 2018. From academic to applied: Operationalizing resilience in river systems. *Geomorphology,* 305: 242-251.

Parsons, M. (In press). Extreme floods and river values: A social-ecological perspective. *River Research and Applications.*

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