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PLANNING AND CAPABILITY REQUIREMENTS FOR CATASTROPHIC AND CASCADING DISASTERS

Final project report

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RISK FRONTIERS

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EXECUTIVE SUMMARY

BACKGROUND

Planning and capability requirements for catastrophic and cascading disasters was a three-year research project focusing on the research questions of:

- What is the nature of catastrophic disasters and how are they conceptualised in the Australian context?
- What has been the historical frequency of compound disasters in Australia?
- What are the most appropriate practices to plan and prepare for catastrophic disasters?
- How can businesses and community organisations best be incorporated into planning and preparedness arrangements for catastrophic disasters?

The research was based on literature reviews; interviews with representatives from emergency management organisations, businesses and community organisations; analysis of historical disaster loss data and content analysis of previous business contributions to disaster responses.

FINDINGS

While a truly catastrophic disaster is by definition unmanageable, emergency managers can still help reduce loss of life and property and assist in sustaining the continuity of affected communities (Harrald, 2006). However, business-as-usual response strategies that work for smaller, more frequent events will not cut it in truly catastrophic circumstances. Often the success of the response is reliant upon the capacities already present in communities. Emergency managers must look to bolster these extant capacities.

Emergency services need to conceptualise how their service delivery models will have to adjust to the overwhelming demand for services and the complexity of catastrophes, including how they will anticipate and work with community first responders. Emergency management organisations must define capabilities they are best able to deliver in support of wider community efforts. For other capabilities, planners should look to community-based sources to supplement those available within government and consider altering service delivery standards.

Our results support existing well defined principles for disaster planning and risk reduction (Alexander, 2005): however, we found they are not effectively implemented to develop plans that consistently inform decision making. Planning is being inhibited by cultural, knowledge and resource constraints dominated by reactive response-oriented approaches.

There is a lack of knowledge regarding collective capability requirements and gaps to manage severe-to-catastrophic disasters. Unlike the defence forces, emergency services collectively lack a long-term view of capability

requirements. There is need for a collective national view of future capability requirements to inform investment.

Severe-to-catastrophic disasters will require resources beyond the impacted jurisdiction. Although resources are already shared between jurisdictions, there is a need to bolster approaches for jurisdictions to work seamlessly together, including investments to enhance interoperability and to strengthen mechanisms of national coordination. The Commonwealth's role must also be defined by Commonwealth emergency management legislation as has previously been recommended (Eburn et al., 2019).

The need for strengthening national coordination arrangements is reinforced by analysis of historical compound disasters, which shows that it is possible for numerous concurrent or sequential severe disasters to occur across multiple jurisdictions, resulting in potential resource conflicts across jurisdictions.

Our research ultimately supports the principle of shared responsibility. The whole-of-community approach recognises that any severe-to-catastrophic disaster will involve whole-of-society responses. Despite the recognition of the value of businesses and community organisations in the National Strategy for Disaster Resilience, emergency management approaches are based on an inadequate view of community organisation and business capabilities and the culture remains largely government-centric.

Governments, whilst considering the lessons of previous disasters, must be proactive, forward looking and risk-based. Capability and capacity requirements for severe-to-catastrophic disasters will likely evolve into the future due to societal, environmental and technological changes. Technology offers significant opportunities to enhance capabilities.

Ultimately, our research supports the need for further efforts to mitigate disaster risk and build resilience, similar to recommendations of the Productivity Commission and APRA.

UTILISATION

The project adopted a collaborative approach with end-users assisting to define research questions and utilisation outputs. A key utilisation output from the research has been an emergency management capability maturity assessment tool that can be utilised by jurisdictions and organisations to better understand potential capability gaps in the context of severe-to-catastrophic disaster scenarios. Through utilisation funding provided by the Bushfire and Natural Hazards Cooperative Research Centre, this tool will be promoted for use across all jurisdictions.

Following analysis of emergency management legislation, a model Commonwealth Emergency Management Act was drafted for consideration by end-users.

Outcomes of the research were presented as evidence to the Royal Commission into National Natural Disaster Arrangements.

END-USER PROJECT IMPACT STATEMENT

Roger Mentha, *Fire and Rescue NSW*

The *Planning and Capability Requirements for Catastrophic and Cascading Events* project has undertaken research to explore opportunities to enhance planning for severe-to-catastrophic disasters. A major achievement of the project has been the development of a capability maturity assessment tool now being used by the NSW Capability Development Sub-Committee and which will be promoted nationally through a series of upcoming workshops.

Other key achievements have included the many publications and research reports exploring different aspects of catastrophic disaster planning, including opportunities for legislative reform and recommendations to enhance the involvement of community organisations and businesses in disaster management. In 2020 the team has also completed a world-first study into the historical frequency of compound disasters in Australia utilsing disaster loss databases.

Throughout the research, the team has reached several thousand practitioners through conference presentations and other forums. During the last 12 months, significant media coverage has seen key research findings widely promoted.

I congratulate the project team for the completion of the research and the end-user engagement that has been achieved. The research and other outputs are already being used to inform state risk assessments and capability. I look forward to seeing further utilisation of the many outputs this project has been able to produce.

PRODUCT USER TESTIMONIALS

Danielle Meggos, *Resilience NSW*

The NSW SEMC Capability Development Sub-Committee has been working with the research team to utilise the capability maturity assessment tool to conduct a capability maturity assessment for the NSW emergency management sector. The process has included the facilitation of a series of scenario-based workshops involving stakeholders from across NSW government. The tool has been used to provide criteria to rate and record the maturity of specific capabilities identified in the Capability Development Framework for the NSW emergency management sector. Workshop participants have expressed positive feedback in the process with an interim report presented to the Capability Development Sub-Committee identifying capability gaps for further enhancement and investment.

The tool and process delivered by Risk Frontiers provides a straight-forward approach to assess capability maturity which could be utilised by other jurisdictions and organisations, at a local, regional or state level.

Joe Buffone, *Emergency Management Australia, Home Affairs*

Home Affairs through Emergency Management Australia have been completing a package of scenario-based workshops regarding preparedness and planning for severe-to-catastrophic disasters. The BNHCRC *Planning and Capability Requirements for Catastrophic and Cascading Disasters* project provided a valuable resource to compare and validate many of the practical perspectives that were being raised when developing the Australian Disasters Preparedness Framework and from the outcomes of the scenario-based workshops. We will now look to further utilise knowledge and tools from the research in the implementation phase of the framework and policy development to prepare and plan for severe-to-catastrophic disasters.

INTRODUCTION

Natural disasters are a significant risk globally (World Economic Forum, 2018). The extreme end of possible disasters, so called catastrophic disaster risks, however, attract limited attention compared with either more frequent smaller and thus manageable events, or previous historical events. This is certainly the case in the context of the Australian emergency management sector, which remains strongly response-focused.

Numerous reviews have concluded that Australia is ill prepared to cope with a truly catastrophic disaster (Council of Australian Governments, 2002, Smith, 2008, Government of Western Australia, 2017). The 2005 review of Australia's preparedness for a catastrophic event concluded that planning has been seen as an extension of existing emergency management arrangements rather than a specific focus in its own right. Other limitations identified included cross-jurisdictional planning, interoperability of communications, transportability of professional qualifications, predictive modelling, research and understanding of events, long term community support and recovery, the coordination of international support and aid and the engagement of the private sector (Catastrophic Disasters Emergency Management Capability Working Group, 2005).

Crosweller (2015), in his capacity of Director-General Emergency Management Australia, argued for enhacements to national capability knowledge and intelligence systems, acknowledgement of business sector capabilities and enhanced training to address challenges created by severe-to-catastrophic disasters.

In 2016, based upon consultation with jurisdictions, the Australian Government published a capability road map focused on reducing potentially catastrophic impacts through strengthening capability and capacity. Key proposed actions included development of a national capability and planning framework, review of existing national and jurisdictional plans to ensure adequate consideration of catastrophic events, improvement of information and intelligence systems, development of crisis leadership capabilities, improving catastrophic disaster knowledge, exercising and stress testing of plans and systems, developing a rapid expansion model, developing supply chain partnerships and enhancing communications and warnings capabilities (Australian Government, 2016).

The Black Summer Bushfires have provided further focus on Australia's preparedness for severe-to-catastrophic disasters, with numerous inquiries occuring at the time of this report's preparation.

AUSTRALIAN DISASTER MANAGEMENT POLICY CONTEXT

Australia's natural disaster management arrangements cover all three tiers of government, as illustrated in Figure 1. At all levels of government, emegrency management arrangements exist to coordinate activities across the phases of prevention, preparedness, response and recovery.

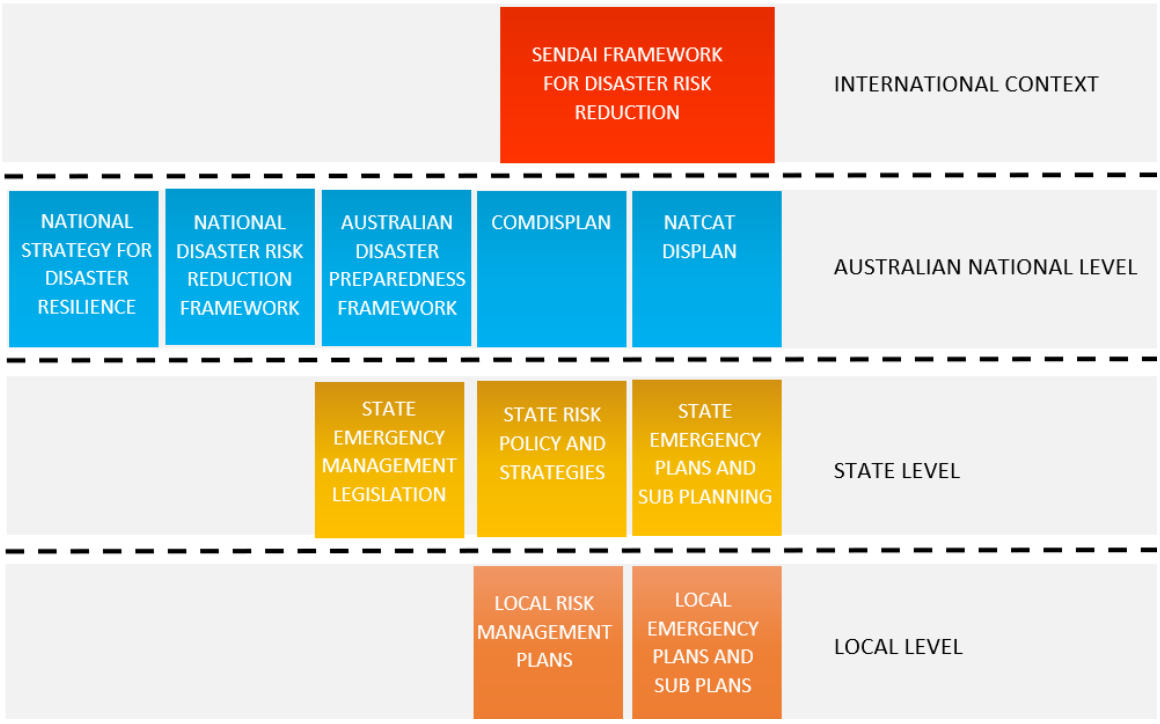

FIGURE 1: AUSTRALIAN NATURAL DISASTER MANAGEMENT ARRANGEMENTS

Emergency management is primarily the accountability of state governments, who have their own legislated emergency management frameworks. Under these frameworks, various risk management, emergency response and recovery plans are developed typically utilising an all-hazards, all-agencies approach. The NSW State Emergency Plan defines this approach as:

> *The all-hazards approach is based on the principle that those systems and methods of operation which work for one hazard are most likely to work for other hazards. It does not, however, prevent the development of specific plans and arrangements for hazards that require specialised approaches.*
>
> *The all-agencies approach recognises that no one agency can address all of the impacts of a particular hazard, either in a proactive or reactive sense. It is necessary for a lead agency to coordinate the activities of the large number of organisations and agencies that are involved. These can be drawn from across all levels of government and non-government and private sectors (NSW Government, 2018; p. 6).*

At the state level, numerous emergency services and functional areas exist to provide emergency management capabilities. Planning is led by state-level emergency management committees.

Local governments play a key role in emergency management. The accountabilities of local governments vary across jurisdictions depending upon jurisdictional emergency management legislation and plans. Local risk management, emergency and recovery plans are developed to guide emergency management within local government areas. Planning is typically led by local committees, comprising emergency management and functional area representatives.

The role of the Australian Government is to provide support and assistance to jurisdictions. COMDISPLAN and NATCATDISPLAN exist to coordinate Australian Government support to jurisdictions during severe-to-catastrophic disasters. The Commonwealth is also responsible for emergency management in Australia's offshore territories.

In collaboration with jurisdictions the Australian Government has developed a series of national policies to guide Australian approaches to disaster risk management. These include:

- **National Strategy for Disaster Resilience** outlines a shared vision for a disaster-resilient Australia. The strategy adopts the principle of collective responsibility for resilience, stating that disaster resilience is the collective responsibility of all sectors of society (Council of Australian Governments, 2011).
- **National Disaster Risk Reduction Framework** provides national, whole-of-society guidance on strategies to proactively reduce disaster risk (Australian Government, 2018).
- **Australian Disaster Preparedness Framework** provides guidance on the capabilities to manage severe-to-catastrophic disasters in Australia (Australian Government, 2018).

Arrangements exist between different agencies to provide inter-jurisdictional support. The Australasian Fire and Emergency Service Authorities Council (AFAC) National Resource Sharing Centre assists to coordinate interstate assistance provided by emergency services for hazards such as bushfires, storms and floods. The Commissioner and Chief Officers Strategic Committee, comprising senior emergency service officials from each jurisdiction, exists to provide a forum to coordinate emergency services resources nationally. Other national arrangements exist for health and biosecurity emergencies.

The National Strategy for Disaster Resilience recognises that the involvement of businesses and community organisations is critical to achieving a disaster resilient Australia. The role of business is detailed as:

> *COAG acknowledges that businesses can and do play a fundamental role in supporting a community's resilience to disasters. They provide resources, expertise and many essential services on which the community depends. Businesses, including critical infrastructure providers, make a contribution by understanding the risks that they face and ensuring that they are able to continue providing services during or soon after a disaster (Council of Australian Governments, 2011; p. 5).*

The role of non-government and community organisations is described as:

> *Non-government and community organisations are at the forefront of strengthening disaster resilience in Australia. It is to them that Australians often turn for support or advice and the dedicated work of these agencies and organisations is critical to helping communities to cope with, and recover from, a disaster. Australian governments will continue to partner with these agencies and organisations to spread the disaster resilience message and to find practical ways to strengthen disaster resilience in the communities they serve (Council of Australian Governments, 2011; p. 5).*

METHODOLOGY

RESEARCH QUESTIONS

The research was focused on answering the following questions:

- What is the nature of catastrophic disasters and how are they conceptualised in the Australian context?
- What has been the historical frequency of compound disasters in Australia?
- What are the most appropriate practices to plan and prepare for catastrophic disasters?
- How can businesses and community organisations be best incorporated into planning and preparedness arrangements for catastrophic disasters?

The methodology followed to answer these research questions is set out below.

CATASTROPHIC DISASTERS LITERATURE REVIEW

A search of global literature was conducted between October 2017 and February 2018 using Google Scholar and Google internet search engines. The search utilised a combination of keywords including: catastrophic disaster, catastrophe, black swan, grey swan, disaster preparedness, emergency preparedness, emergency management preparedness, disaster planning, emergency planning, emergency management planning, disaster readiness, emergency readiness, critical infrastructure preparedness, capability planning and critical infrastructure protection. Articles identified in this manner inevitably stimulated further reading and the exploration of other literature and concepts. Specific jurisdictional websites were searched regarding emergency plans.

The literature review assisted in establishing a summary of the existing research evidence regarding better practice approaches for planning and preparedness in the context of catastrophic disasters.

PERSPECTIVES OF AUSTRALIAN AND INTERNATIONAL EMERGENCY MANAGERS

Interviews

Interviews were undertaken with serving and retired senior emergency managers from Australia and overseas to obtain their views regarding preparedness for dealing with catastrophic disasters. Interviews were conducted in a semi-structured manner both via face-to-face interactions and telephone. The interview guide comprised questions regarding the definition of catastrophic disasters, strengths and weaknesses of existing arrangements, the risk appetite to inform planning and capability requirements and perceptions of the involvement of other actors such as businesses and NGOs. Interviews with international emergency managers tapped into a broader knowledge base and involved respondents who had been involved in large-scale disasters. Australian respondents were from all jurisdictions apart from the Australian Capital Territory.

International respondents were from the United States, New Zealand and the United Kingdom (n=7).

Forty-four interviews were undertaken, each about one hour in length. Interviews were recorded and transcribed to assist with analysis. Thematic analysis was undertaken utilising a deductive approach. A coding framework was established based around emerging themes identified through an initial review of the transcripts. Coding included catastrophe definition, conceptualisation, strengths, weaknesses, planning, plan application, capability, collaboration, non-traditional actors, international assistance and community.

Online survey

An on-line Survey Monkey questionnaire of Australian and international emergency managers was undertaken in April 2018. The questionnaire comprised 99 questions structured using the Likert scale and open answer questions. The questionnaire was promoted through emergency management Linked-In and Facebook forums, via the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC) twitter page and through direct distribution to Australian emergency services. Questions were structured around disaster preparedness elements -- risk assessment, planning, capability development, exercising, training and lessons learnt – in order to test the extent to which certain preparedness elements exist in practice. A definition endorsed by the peak Australian emergency management committee was provided to respondents to allow for a consistent interpretation of the context of the questionnaire. The definition was:

> *A catastrophic disaster is an event that is beyond our current arrangements, thinking and experience: i.e., that has overwhelmed our technical, non-technical and social systems, resources and has degraded or disabled governance structures and strategic operational decision-making functions.*

Some 339 respondents participated in the survey, 251 of which completed at least one section of the questionnaire. This sub-group comprised 130 respondents from Australia and 121 from overseas. Australian respondents were from all jurisdictions. Almost 80% of international respondents were from the United States. The seniority of respondents varied but most often were managers (n=61), team leaders (n=49) and senior managers (n=41). The majority of the sample had over 11 years emergency management experience.

LEGAL ANALYSIS

Analysis of existing Australian legislation and case law was undertaken to answer the specific research question: in the absence of legislation, what is the role in, and more importantly what power might the Commonwealth have, when responding and recovering from a catastrophic disaster?

COMMUNITY ORGANISATION INVOLVEMENT IN DISASTER MANAGEMENT

Interviews

Interviews with senior stakeholders from community organisations were performed. Interviews covered:

- Nature of their organisation.
- Role in disaster preparedness, response and recovery.
- Previous experiences.
- Motivations for involvement.
- Perceptions of the roles of business, government and other community organisations.
- Experiences of collaborating with businesses, government and other community organisations.
- Involvement in government-led emergency planning.
- Internal disaster management preparations.
- Appetite to be further involved in disaster management.

Interviews were conducted in a semi-structured manner and were conducted via telephone. Interviews lasted for around one hour. Interviews were recorded and transcribed to assist with analysis to identify key themes.

Twenty-seven interviews were undertaken with twenty-six different organisations. Organisations were recruited based on their previous involvement in disaster management activities.

Thematic analysis was undertaken utilising a deductive approach. A coding framework was established based around emerging themes identified through an initial review of the transcripts and the interview guide. Coding included roles before, during and after disasters, perceived roles of other organisations; motivations for involvement; strengths, weaknesses, opportunities and risks; collaboration and areas for improvement.

Online survey

An online survey was undertaken targeting community organisations during the second half of 2019. The purpose of the survey was to collect quantitative data to support interview responses.

The survey questionnaire was designed in consultation with representatives of the community sector and was distributed nationally through peak membership organisations including VCOSS and Linkwest. Individual service providers were also encouraged to promote the survey. The survey was also distributed through LinkedIn and Twitter. In total, some 181 organisations responded to the survey.

Respondents represented a wide variety of service providers, with the most frequent services provided including health services; information, advice and

referral and family and relationship services. The types of services provided by respondents is summarised in Table 1:

TABLE 1: PROFILE OF ORGANISATIONS

Type of service	Number of respondents
Health services	66
Information, advice and referral	57
Family and relationship services	54
Disaster aid	46
Disability support	40
Migrant, refugee and asylum seeker support	32
Aged care services	29
Youth services	28
Advocacy	28
Housing and homelessness services	28
Legal services	20
Community development	15
Mental health services	6
Other	49

Respondents were recorded from all jurisdictions apart from Tasmania and the Northern Territory. The breakdown of respondents by jurisdiction is shown in Table 2.

TABLE 2: LOCATION OF ORGANISATION

State	Number of respondents
NSW	32
QLD	11
ACT	1
VIC	70
WA	43
NT	0
SA	5
National	8

BUSINESS INVOLVEMENT IN DISASTER MANAGEMENT

Interviews

Interviews with senior stakeholders from large businesses and peak bodies were performed. Interviews covered:

- Nature of their organisation.
- Role in disaster preparedness, response and recovery.
- Previous experiences.
- Motivations for involvement.
- Perceptions of the roles of business, government and other community organisations.
- Experiences of collaborating with community organisations, government and other businesses.
- Involvement in government-led emergency planning.
- Internal disaster management preparations.
- Appetite to be further involved in disaster management.

Interviews were conducted in a semi-structured manner and were conducted via telephone or face-to-face. Interviews lasted for around one hour. Interviews were recorded and transcribed to assist with analysis to identify key themes.

Twenty-eight interviews were undertaken. Organisations were recruited based mainly on their previous involvement in disaster management activities, as derived from Van Leeuwen and Gissing (2019).

Tables 3 and 4 provide an outline of the organisations involved in the interviews.

TABLE 3: TYPE OF ORGANISATION

Type of organisation	Number of respondents
Agriculture, forestry and fishing	1
Mining	2
Manufacturing	1
Electricity, gas, water and waste services	4
Construction	2
Wholesale trade	1
Retail trade	1
Accommodation and food services	4
Transport, postal and warehousing	1
Information media and technology	1
Financial and insurance services	5
Rental, hiring and real estate services	1
Professional, scientific and technical services	3
Administrative and support services	0
Public administration and safety	0
Education and training	0
Health care and social assistance	0
Tourism	1

TABLE 4: ORGANISATIONAL SIZE

Employees on a full-time equivalent basis	Number of respondents
None	0
Between 1 and 5	0
Between 6 and 20	2
Between 21 and 100	0
Between 101 and 1000	2
Between 1001 and 10000	14
Between 10001 and 100000	6
Over 100000	2
Note stated	2

Online survey

An online survey was undertaken, targeting business in the second half of 2019, with a focus on small business. The purpose of the survey was to collect quantitative data to support interview responses.

The survey questionnaire was distributed nationally through LinkedIn groups and peak small business groups. In total, 155 businesses responded to the survey. Some respondents represented overseas businesses and were removed from the sample, leaving 142 businesses.

Respondents represented a wide variety business types, with *retail trade* and *professional, scientific and technical services* being the most frequently selected descriptions. The types of businesses respondents represented are shown in Table 5.

TABLE 5: BUSINESS TYPE

Type of business	Number of respondents
Agriculture, forestry and fishing	10
Mining	1
Manufacturing	3
Electricity, gas, water and waste services	2
Construction	9
Wholesale trade	4
Retail trade	30
Accommodation and food services	13
Transport, postal and warehousing	3
Information media and technology	5
Financial and insurance services	9
Rental, hiring and real estate services	6
Professional, scientific and technical services	20
Administrative and support services	3
Public administration and safety	5
Education and training	4
Health care and social assistance	8
Tourism	1
Other (please specify)	6

Most businesses (87%) employed less than 20 employees, as shown in Table 6.

TABLE 6: NUMBER OF EMPLOYEES

Employees on a full-time equivalent basis	Number of respondents
None	28
Between 1 and 5	67
Between 6 and 20	27
Between 21 and 100	9
Between 101 and 1000	6
Between 1001 and 10000	2
More than 10000	2
Unsure	0

COMPANIES IN DISASTER MANAGEMENT

Lists of the top 100 businesses on the Australian Stock Exchange (ASX 100) (as at 1st December, 2016), and the top 100 NZ companies by number of employees from Katalyst Business (as at 12th March 2019) were obtained. Government agencies were removed from the New Zealand list, and merged with the New Zealand Stock Exchange top 50 businesses (NZX 50) (as at 12th March 2019).

Following Johnson et al. (2011), a content analysis was undertaken based on documents found from internet searches for annual reports and press releases of each business. These were examined for any reference to the three events. If any response- or recovery-related activities were identified, the relevant text was copied to a separate document for subsequent classification. A classification schema was produced based on descriptions used by Johnson et al. (2011).

Information included source of support; beneficiaries; details of cash contributions; subtype of support where the contribution was not in cash; category of business making the contribution, based on the Global Industry Classification Standard (GICS) (Australian Securities Exchange 2019), and reasons for making a contribution and any disaster impacts on the business. Data were then reviewed and classified into a single table for analysis in Excel. The table of records was analysed using a script in R to produce cross-tabulation data from which correlations have been drawn.

ANALYSIS OF HISTORICAL COMPOUND DISASTERS UTILISNG DISASTER LOSS DATABASES

Frequency analysis

Fatality data was sourced from the Risk Frontiers' proprietary natural peril database PerilAUS and financial loss data was obtained from the Insurance Council of Australia (ICA) Natural Disaster Event List (hereafter 'ICA Disaster List').

PerilAUS data was cleaned to merge events that were related with each other so as to ensure analysis of independent events having a spatiotemporal

coincidence (de Ruiter et al., 2019). Following the data screening process, some 10,000 events remained to be analysed.

Compound disasters were identified when any two or more of the above occurred within a three-month window. Three months was chosen as a practical compromise, given that event end-dates are not recorded in the underlying datasets and that communities impacted by such events occurring within this window could still be plausibly experiencing significant recovery and re-building.

The ICA Disaster List, maintained by the Insurance Council of Australia, is a database of Australian insurance sector event losses since January 1966. The database covers Australia and is multi-peril in scope, including bushfires; floods; severe storms, including hailstorms and tropical cyclones, and earthquakes. Ninety-four percent of the normalised event losses arise from weather-related hazards (McAneney et al., 2019b). Some 300 events were included in our analysis.

Fields utilised from PerilAUS and the ICA Disaster List included event name and summary, start date, peril type, location (jurisdiction) and event size. Data were reviewed independently by two individuals.

Data were normalised to estimate the impacts of historical events if they were to occur under present day societal conditions. Fatalities were normalised based on the ratio of the 2017 population to that at the event date in the affected jurisdiction sourced from the Australian Bureau of Statistics. Financial losses were extracted from the normalisation of the ICA Disaster List by McAneney et al. (2019b), which process adjusts historical event loses for changes in exposure, wealth and building codes. Data for 2017/18 and 2018/19 were added in a non-normalised form. We follow McAneney et al. (2019b) in employing Australian financial years (12 months from July 1) to separate successive summers, when most but not all disaster events take place.

Analysis was undertaken according to multiple loss thresholds. Loss thresholds chosen for individual events were ten, 50 and 100 normalised fatalities (ND) and $100M, $1B and $5B for normalised insurance losses (NL). These thresholds were analysed individually and in pairs: ten ND and $100M NL, 50 ND and $1B NL and 100 ND and $5B NL. Lower thresholds were not considered to remove any reporting bias introduced by the greater frequency of smaller events reported in PerilAUS and the ICA Disaster List in more recent decades. PerilAUS records were grouped to match with ICA Disaster List records when considering combined thresholds. For these particular analyses, only PerilAUS records from 1966 onwards were considered.

The spatial boundary adopted was the whole of Australia, as the region of concern for Australian emergency management agencies. Where compound disasters were identified they were plotted to illustrate their frequency over time and compared with the occurrence of other societal stresses such as recessions (from the Australian Bureau of Statistics), war (from the Australian War Memorial) and pandemics (from US Centres for Disease Control).

Composition analysis

With a view to understanding if there were physical mechanisms that would increase the probability of specific peril combinations, each natural hazard was

classified into one of seven perils: tropical cyclone, flood, storm, bushfire, heatwave, earthquake, or landslide, where flood refers primarily to riverine flooding and storm encompasses all non-tropical cyclone storms including thunderstorm (hail and lightning), east coast low and frontal systems.

All combinations of perils and peril-pair combinations were then identified for all compound disasters within a three-month window. The jurisdiction in which each peril impacted was also recorded to identify any preferred combination of locations.

A bootstrapping approach was then used to explore whether observed peril-pair combination frequencies occur by chance, or might instead be responding to potentially predictable forcing such as interannual climate variability. One thousand synthetic event sets were created where perils retain their probability of occurrence and the time of year and jurisdiction in which they occur. For each year of the synthetic event sets the frequency of each peril was sampled from a Poisson distribution based on its historical mean frequency. To preserve realistic seasonality and timing, this number of perils was then randomly sampled from the observed dataset to obtain the day-of-year and jurisdiction in which they occurred. From the synthetic event sets it was then possible to examine the combinations of event types and locations that would constitute an effectively random compound disaster as a comparison to observed occurrences.

FUTURE CAPABILITY

To identify possible future disaster capability advances, a workshop was held with a variety of technology companies. Participants in the workshop represented companies dealing in information technology, insurance, aviation, defence, building and construction and infrastructure. The workshop included discussion regarding the nature of the problem and potential short and long term solutions.

WHAT IS CATASTROPHE?

Risks with significant consequences have the potential to overwhelm business-as-usual emergency management arrangements, resulting in catastrophe. The Australian and New Zealand Emergency Management Committee defines a catastrophe as a disaster being:

> *… beyond our current arrangements, thinking, experience and imagination (Australian Government, 2018; p.5).*

In other words, a catastrophe is an event so big that it overwhelms existing social systems and resources and degrades or disables governance structures and operational decision-making (Australian Government, 2018).

How emergency managers define catastrophe is dependent upon the context in which they work but must involve the overwhelming of available resources and multiple severe impacts.

The hallmarks of catastrophes are death and destruction, large-scale disruption, displacement of populations and public anxiety. Often these occur with little to no warning (such as large earthquakes), although they may also onset slowly, growing in size and duration, as in the case of droughts, disease and food shortages. Events with the potential to overwhelm the capacity of institutions and the community to cope can result in emergency systems, communications and plans failing and leaving leaders out of touch with what is happening on the ground. Local emergency response personnel may be directly impacted themselves, and thus unable to perform their professional roles. Resources from neighbouring regions may also be impacted or unavailable. Emergency leaders are confronted with overwhelming issues, of a scale of complexity and uncertainty they may never have experienced nor imagined. Information about impacts and needs of affected communities may be limited for days after an event, meaning that decisions will often have to be made in the absence of complete information. The event becomes subject to significant national and international media scrutiny and inevitably, political involvement.

Catastrophic disasters are cascading in nature, escalating in their impacts as interconnected systems fail successively, yielding yet further impacts and making recovery more complex and prolonged. Essential infrastructure -- water, gas, sewage, power, healthcare, banking, transport, food supply, emergency response and communication -- becomes severely disrupted. Restoration may take months and disease and fires may wreak further havoc. In some events, disruptions may reach global proportions.

Catastrophic events will have large footprints and respect neither borders nor geographical boundaries, thereby muddying accountabilities amongst responding agencies and resulting in conflicting public messaging.

The recovery of communities may take many years, with some of the impacted population choosing to re-locate to other areas permanently. Many of those affected may suffer long-lasting psychological trauma. Economic losses can be severe, as industry and agriculture is disrupted and businesses close or make yet further demands on government for recovery support.

CATASTROPHE RISK

A major catastrophe in Australia as defined above is inevitable. The Spanish flu pandemic (1918-19) stands out as one example of an event that overwhelmed Australia's management systems and which resulted in extraordinary impacts (approximately 12,000 deaths). Tropical Cyclone Tracy in 1974 serves as another example of an event that completely overwhelmed an Australian city, leaving only 6% of the city's housing stock habitable (Stretton, 1975). The current COVID-19 pandemic has severely altered the operation of our society, resulting in health and economic consequences.

By definition, a truly catastrophic event is infrequent. Many plausible scenarios such as extraordinary floods, bushfires, tsunami, cyclones, pandemics, infrastructure failures and heatwaves have annual average probabilities of occurrence of less than 1 in 500 years. Other more far-reaching scenarios with global consequences may arise from solar storms, earthquakes or volcanic mega-eruptions, albeit at less frequent or even more uncertain probabilities. Further technological scenarios such as risks associated with artificial intelligence are emerging. Some scenarios are likely to be unknown.

The severity of future catastrophic disasters will be dictated by the intensity of hazard events in concert with the vulnerability of at-risk societies. It is clear that to date, the rising cost of natural 'disasters' (in the loose sense of the term described above) is mainly dictated by where and how we chose to live (Crompton and McAneney, 2008, McAneney and Crompton, 2014, IPCC, 2014, McAneney et al., 2019a). This being the case, it is important to consider how future catastrophic disasters might be shaped by the choices we make as a society to various political, economic and environmental alternatives along with technological advances and changes to our climate.

The risks of cascading failures associated with disasters is increasing as networks become increasingly interconnected and interdependent. A recent Australian example was the 2016 South Australia blackout which resulted from a series of tornadoes that damaged 23 transmission towers, cutting power to the city of Adelaide for days. The blackout caused issues with access to food, public transport, finances, telecommunications, water, medications and fuel. There had been no plan for widespread extended blackouts and related consequences (Burns et al., 2017).

While many catastrophic disaster risks are either known or can be imagined, they are largely unappreciated as was illustrated in the cases of Hurricane Katrina (Comfort, 2005) and the Fukushima nuclear disaster (Funabashi and Kitazawa, 2012).

Australia has several vulnerabilities in relation to its ability to respond to catastrophic disasters, including:

- Australia is located some distance away from other English-speaking western nations which may be best suited to provide international support.
- Many of Australia's resources are located on the south east coast, meaning that major cities such as Cairns, Townsville, Darwin and Perth are relatively isolated and the provision of assistance from other jurisdictions may take several days to arrive.

- Australia has large borders to protect in regard to the incursion of diseases and bio-security threats.

Having outlined these vulnerabilities, the location of Australia away from tectonic plate boundaries and its relatively sparse population density must be considered as important in reducing the scale of a catastrophe.

COMPOUND DISASTERS

Scenario analyses usually consider potential disasters in isolation, but our nation is susceptible to series of damaging events whose compounding impacts could lead to a much larger impact. Moreover, while in general terms our nation is well diversified spatially in terms of having well-separated major concentrations of population in our capital cities, the possibility of a series of disasters across the country which collectively exhaust the response capacity of emergency responders cannot be dismissed.

With this in mind, we define compound disasters as comprising:

- Two or more extreme disaster events – component events -- occurring simultaneously or successively within a three-month period,
- Combinations of extreme events with underlying conditions that amplify their impact or
- Combinations of events that are not themselves extreme but which collectively lead to an extreme impact (Seneviratne et al., 2012; pp. 118).

In more general terms, compound disasters combine numerous drivers and/or hazards that collectively create an extreme societal or environmental risk (Zscheischler et al., 2018). Bates (2020) provides an illustration of the manifestation of a compound disaster and its possible consequences in the Australian context.

Using the above definitions, the research found that compound disasters have occurred frequently in Australia (Figures 2, 3 and 4, using different thresholds) and are associated with the highest seasonal losses in terms of both insured financial losses and fatalities. Other background societal stressors such as wars, recessions and pandemics may further exacerbate their consequences and the resources available. These are also shown in Figures 2, 3 and 4 for interest, but exploring their interaction with the management of compound disasters lies beyond the scope of the current study.

There is no temporal trend in frequency when considering financial losses (Figures 2 and 3), but there is a downward trend when considering only fatalities (Figure 4).

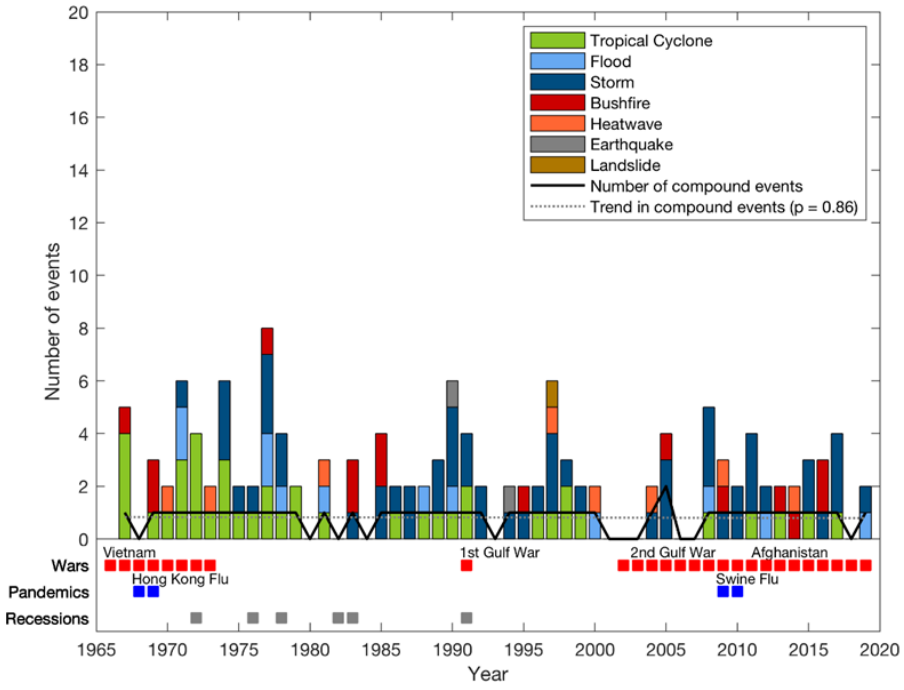

FIGURE 2: COMPOUND DISASTERS WITHIN A THREE-MONTH WINDOW AND HAVING AT LEAST 10 NORMALISED DEATHS (ND) AND/OR $100MN NORMALISED LOSSES (NL). YEARS ALONG THE X-AXIS REFER TO FINANCIAL YEARS. LONG-TERM STRESSORS INCLUDED. ANALYSIS IS CONDUCTED BASED ON PERILAUS DATABASE (FATALITIES) AND ICA DISASTER LIST (NORMALIZED LOSSES)

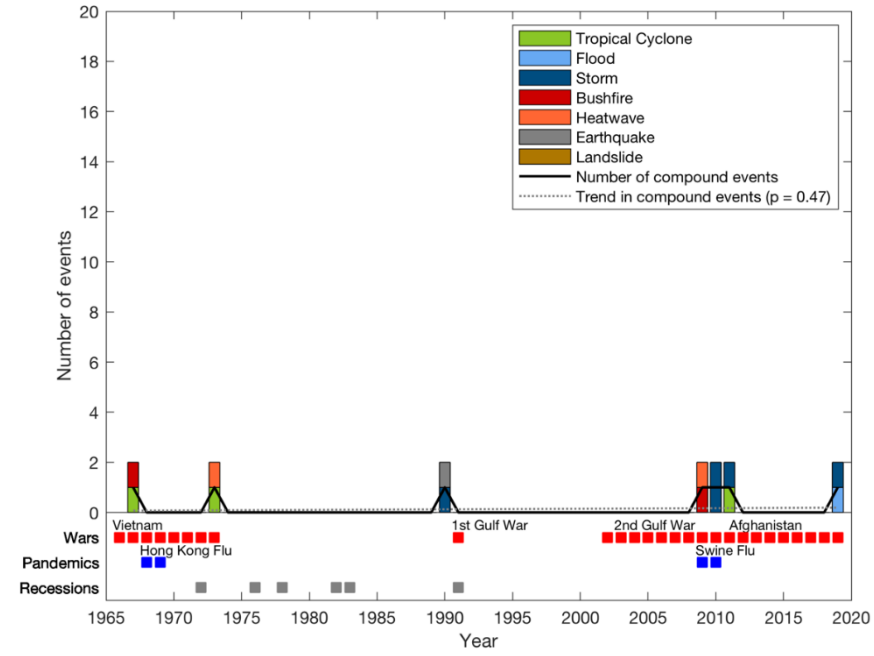

FIGURE 3: COMPOUND DISASTERS WITHIN A THREE-MONTH WINDOW WITH LOSSES IN EXCESS OF 50 ND AND/OR $1B NL BY FINANCIAL YEAR. LONG-TERM STRESSORS INCLUDED. ANALYSIS AS PER FIGURE 1.

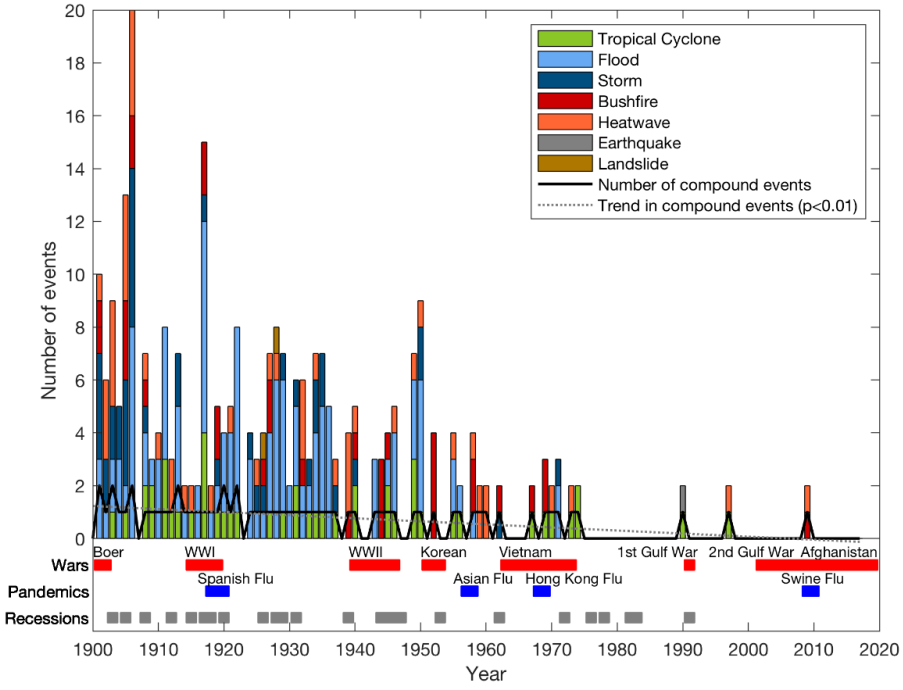

FIGURE 4: COMPOUND DISASTERS WITHIN A THREE-MONTH WINDOW AND GREATER THAN 10 ND. LONG-TERM STRESSORS INCLUDED. BASED ON ANALYSIS OF PERILAUS DATABASE. ANALYSIS AS PER FIGURE 2.

The summer of 2019/20 is illustrative of a compound disaster with multiple billion-dollar insured loss events combined with the COVID-19 pandemic. When measured in terms of normalised insured losses, however, 1967 ranks as Australia's most significant compound disaster.

1967 compound disaster

The 1967 compound disaster commenced in January 1967, when category 3 Tropical Cyclone Elsie struck Western Australia. Although no deaths were inflicted, the event incurred a normalised damage of nearly $200M as roads, railways and airfields across the state were damaged by floodwaters. Later that same month, Queensland was struck by a tropical cyclone of its own, as Dinah brought highly damaging winds and rainfalls across the state coastline with a normalised insurance loss of just over $4.5B. Not much more than a week later, the Black Tuesday bushfires ravaged the states of Victoria and Tasmania on 7 February 1967. The fires claimed 62 lives, alongside more than $2B normalised damage to houses, cars, buildings and bridges across the south-eastern states. Tens of thousands of livestock perished, while eight firefighters were injured in road accidents.

Then in the middle of February, a category 1 cyclone brought extensive coastal erosion, localised flooding and a half-billion-dollar damage bill to NSW. Although Tropical Cyclone Barbara caused a lot less damage than its Queensland counterpart Dinah, it came at a time when other states were still grappling with recovery efforts for recent disasters. The last element in this compound disaster

was category 2 Tropical Cyclone Glenda, an event that killed 6 people in Queensland in early April.

NSW, QLD, and VIC experience both the most individual and the most compound disasters, as illustrated in Figure 5. NSW and QLD comprise the most frequent spatial pairing. The next most common pairings are for NSW and VIC, then QLD and VIC. Compound disasters where component events occur in different states, such as QLD and NSW, are more likely than compound disasters where component events occur within the same state.

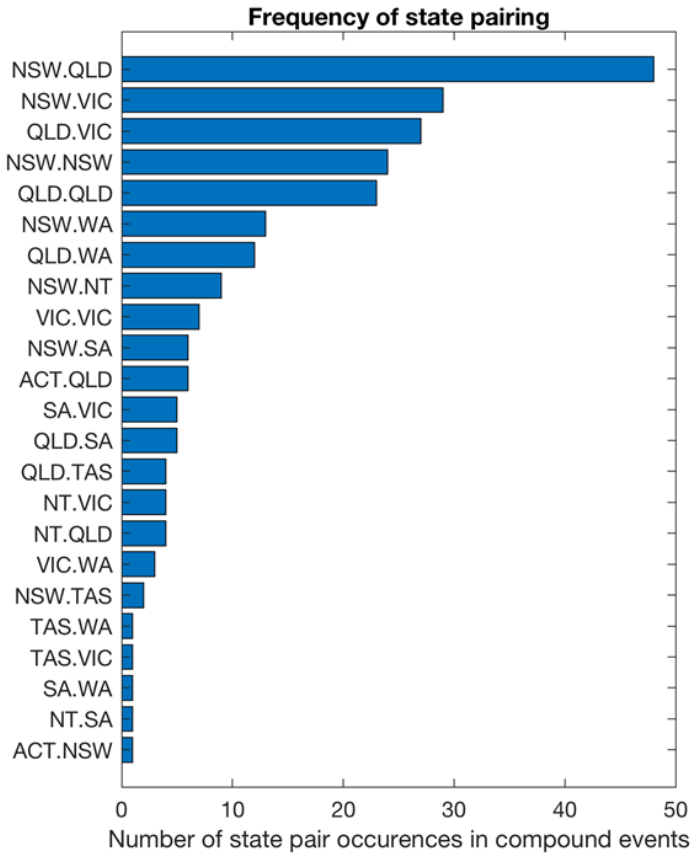

FIGURE 5: FREQUENCY OF JURISDICTIONAL PAIRING

The dynamic nature of compound disasters underlines the need for flexible and adaptable disaster plans that are scalable to the impact of multiple disasters (Gissing et al., 2018).

MANAGEMENT OF CATASTROPHE

Although Australia is a disaster-prone continent our records of natural disasters go back less than 200 years. . . . Disasters caused by enemy attack are possible, but disaster caused by natural phenomena are certain. We must therefore prepare ourselves for this certainty. As part of this preparation we must simply learn from the lessons of the Darwin disaster. We cannot afford to relearn them again during the next disaster, at the expense of more Australian lives. Major-General Allan Stretton. (Stretton, 1979)

While a truly catastrophic disaster is by definition unmanageable, emergency managers can still help reduce loss of life and property and assist in sustaining the continuity of affected communities (Harrald, 2006). However, business-as-usual response strategies that work for smaller, more frequent events will not work in truly catastrophic circumstances. By necessity, community members become first-responders (Tierney, 1993, Whittaker et al., 2015). Often, the success of the response is reliant upon the capacities already present in communities. Emergency managers must look to bolster these extant capacities.

Most emergency management activity is geared towards responding to the impacts of relatively frequent natural peril events with modest impacts. It is unrealistic to resource emergency management organisations to maintain capabilities to manage catastrophic disasters (Quarantelli, 1986, Heide, 1989, Queensland Floods Commission of Inquiry, 2012, Australian Government, 2018, Van Leeuwen and Gissing, 2019). Catastrophes such as Hurricane Katrina have been characterised by insufficient organisational capacity and preparedness, leading to the realisation of the need for increased collaboration as one way to bolster capacity (Kapucu and Garayev, 2011).

Disaster management is typically the preserve of emergency management organisations utilising an all-hazards, all-agencies approach (Johnson et al., 2011), which is predominately government-centric. For catastrophic events, however, collaborative partnerships are unavoidable, as no single organisation is capable of responding alone (Fugate, 2017, Benini, 1999, Waugh and Streib, 2006). In the case of Hurricane Katrina, for example, some 535 organisations, ranging from non-government, commercial, infrastructure, emergent, interest and faith-based organisations were all involved (Comfort and Haase, 2006). Disaster management is a joint collaborative effort (Kapucu et al., 2010, Waugh and Streib, 2006) and it is necessary to adopt a whole-of-community approach.

The whole-of-community approach has been described as:

> *As a concept, Whole Community is a means by which residents, emergency management practitioners, organisational and community leaders, and government officials can collectively understand and assess the needs of their respective communities and determine the best ways to organise and strengthen their assets, capacities, and interests. By doing so, a more effective path to societal security and resilience is built. In a sense, Whole Community is a philosophical approach on how to think about conducting emergency management (FEMA, 2011; p. 3).*

The whole-of-community approach encourages partnerships between government, community organisations and businesses (FEMA, 2011, Australian Government, 2018). It recognises that emergency management is a shared responsibility. In times of disasters, collaboration assists all organisations to better serve the needs of communities (Kapucu, 2007, Kapucu and Garayev, 2011, Waugh and Streib, 2006). These principles are espoused in the National Strategy for Disaster Resilience (Council of Australian Governments, 2011).

In practice, whereas the roles of government organisations are embedded in legislation and regulation, the roles of community organisations and businesses are less so. The 2019-20 Australian bushfire season and the COVID-19 pandemic saw heavy involvement from community organisations and businesses. Government, though, is hindered by its lack of structure to support formal cooperation and capacity to engage (Australian Red Cross, 2014).

Collaboration is not only dependent on structures but also on the culture of emergency services (Kapucu et al., 2010). Emergency managers are burdened by rules of accountability that force them to 'take charge' and implement hierarchical approaches in the face of disaster events. This creates risk aversion and a reluctance to devolve control, creating incompatibilities to fully engage and collaborate with non-government organisations (Waugh and Streib, 2006, Australian Red Cross, 2014).

Plans should allow for decentralised decision-making (Kapucu and Van Wart, 2006, Boin and McConnell, 2007), allowing for more flexible, improvised and networked responses that the centralisation of decision-making inhibits (Boin and t Hart, 2010, Tierney, 1993). Decentralised models recognise emergent group behaviours and local response capacity, and that preparedness is built on existing social structures and support networks (Dynes, 1990). Thus, planning should focus on identifying existing groups and networks that are capable of undertaking leadership roles and building their capacity to do so (Tierney, 1993, Wachtendorf and Quarantelli, 2003, Dynes, 1990).

Excessive reliance on rigid, centralised and top-down decision-making is liable to be fraught with risk, as centralised decision-makers are unlikely to have access to local knowledge, especially in the early phases when information is scarce or unreliable (Kapucu and Van Wart, 2006, Boin and t Hart, 2010); leaders may be missing or unavailable (Comfort and Kapucu, 2006) and decision-makers likely overwhelmed by competing priorities and the complexity of the event.

Success requires proactive responses to ensure that significant support is available to assist and mobilise the community when it is at its most vulnerable, often within the first 72 hours after a catastrophe when the scale of an event may still be influenced. The early movement of significant resources, however, is complex, and decisions to commit significant outside resources will take place under great uncertainty. In some instances, Australia is further challenged when mobilising support to remote areas. For this reason, it is vital that planning to support communities be integrated with logistics that will often be managed by non-government organisations.

PLANNING FOR CATASTROPHE

Key principles for developing plans for severe-to-catastrophic disasters include:

1. **Plans must be risk based** (Perry and Lindell, 2003, Quarantelli, 1998), being based on sound understanding of the community and its vulnerabilities, including possible secondary hazards, cascading impacts of infrastructure disruption, supply chain gaps and the limitations of the most vulnerable in the community.
2. **Plans need to be based upon realistic assumptions concerning social behaviour** (Sutton and Tierney, 2006, Quarantelli, 1998, Perry and Lindell, 2003, Tierney, 1993, Crosweller, 2015)**.** Plans should be based on how people are likely to act rather than assuming they can be made to fit arrangements detailed in a plan (der Heide, 2006): this includes designing plans to ensure formal responses are integrated with those of volunteers and community groups (Tierney, 1993). This should include identification of existing community capability and capacity.
3. **Plans must be proactive, adaptable and flexible.** Planning should anticipate the range of problems that might occur and the possible solutions to them (Quarantelli, 1998), including their timing. McConnell and Drennan (2006) identify a paradox in that the more elaborate and detailed a plan is, the less likely it will be used during an event. Plans should therefore be focused on general principles and not specific details, encouraging flexibility, adaptation and improvisation (Quarantelli, 1998, Perry and Lindell, 2003, Eriksson and McConnell, 2011). Catastrophe plans need to be relatively concise, principles-based and simple to interpret. They must provide an authorising environment for decision-makers, clearly detail roles and responsibilities and be written from an operational perspective.

Case study: the need for flexibility in plans

The need for flexibility in planning is underscored by an example regarding the Christchurch earthquake in 2011. Prior to the earthquake, the national civil defence organisation had planned to control operations from its base in the New Zealand capital, Wellington. After the earthquake, however, politicians insisted that the response to the earthquake be controlled from Christchurch. This meant that the national civil defence organisation had to adapt its plans on the run to enable this direction to occur. As a result, the New Zealand Ministry for Civil Defence and Emergency Management was said to now adopt a more flexible approach to planning.

4. **Plans must be holistic, considering required capabilities to manage risks across prevention, preparedness, response and recovery. They must establish priorities.** Agreement of priorities within plans is of critical importance. Knowledge of agreed priorities and of the situation enables organisations to respond with little formal direction or connection to formal structures in a way that best directs their efforts. This means that responders can exercise local leadership without awaiting direction from a chain of command as they are aware of the agreed intent of a response. Improvisation and adaptation are thus promoted in the context of the uncertain, complex and possibly unforeseen circumstances responders are faced with.

> ***"Every scenario will be different but the process will be exactly the same. Our first priority is to rescue the survivors. Our second priority is to make sure we can sustain ourselves as a response organisation. Our third priority then is to start moving from a response plan into a sort of reconciliation plan" (U.K. responder to Asian Tsunami).***

5. **Planning is a shared responsibility** inclusive of all tiers of government, the non-government and business sectors and the community (Kapucu and Van Wart, 2006).

6. **Planning must be integrated** horizontally and vertically within and across organisations (Quarantelli, 1998, Perry and Lindell, 2003, United Nations, 2008, Mamula-Seadon and McLean, 2015, Hanfling et al., 2012).

7. **Planning must be linked to required capabilities and identify capability gaps and triggers for support requests.** Planning should identify the demands that a disaster would impose and the resources needed by agencies to undertake their roles and responsibilities, including possible timing (Tierney, 1993, Perry and Lindell, 2003, Alexander, 2005). This should then be compared with resources available such that gaps can be identified. This process should include the identification of resources and service providers that might be able to assist (Ardagh et al., 2012).

8. ***Plans must establish collaborative coordination arrangements.*** Consideration should be given to management structures to coordinate resources (Tekeli-Yeşil, 2006).

9. ***Plans must address continuity arrangements*** (United Nations, 2008). This is essential to ensure critical capabilities remain available during an event. During the 2016 South Australian state-wide blackout, numerous agency business continuity plans failed (Burns et al., 2017). The Catastrophic Disasters Emergency Management Capability Working Group (2005) recommended that jurisdictions work to ensure the continuity of key supply chains: for example, those that supply food and water to communities.

10. ***Plans must be exercised and reviewed.*** Plans are 'living documents' (Alexander, 2005). They need to be maintained and regularly revised to ensure they remain relevant in the context of the risk profile they have been developed to manage (Boin and t Hart, 2010). Plans should be updated when risks change. Lessons are identified from incident debriefs,

exercises and reviews and when changes in organisations occur (Perry and Lindell, 2003, UK Cabinet Office, 2011). In short, planning is an ongoing process (Dynes et al., 1972). Regular exercises assist to build awareness and knowledge, improve decision-making skills, enhance relationships between collaborative partners (Boin and t Hart, 2010) and test plans (Perry, 2004). Short of actual events, these offer the best opportunity to test plans and to ensure they are understood (US Government Accountability Office, 2010).

11. **Planning must be resourced and comprise part of the culture of emergency management agencies.** Embedding emergency plans within the management culture is vital to ensure effective response on the day of an emergency (UK Cabinet Office, 2011). Effective planning involves explaining provisions of the plan to personnel of organisations that will be involved in the response to and recovery from a catastrophe (Perry and Lindell, 2003, Tierney, 1993, United Nations, 2008) and embedding planning into all aspects of organisational structures, policies, practices and culture (McConnell and Drennan, 2006). Planning should be undertaken by personnel with experience and knowledge of the discipline (Alexander, 2005).

AUSTRALIAN ARRANGEMENTS

Though catastrophic disasters cannot be prevented, most emergency managers believe recovery from such events would be ameliorated if more planning was devoted to such disasters. Others sustain a confidence in existing arrangements to handle a catastrophe or think that they are unlikely to happen in Australia.

Only 20% of Australian emergency managers agreed that systems and equipment are fully interoperable across their jurisdiction. Only 9% agreed that systems and equipment are fully interoperable nationally.

There is no single approach to emergency management in Australia, with each jurisdiction maintaining its own unique frameworks, resulting in a lack of interoperability and inefficiencies relating to emergency management arrangements, systems, equipment and training. During the recent 2019/20 bushfires this was apparent by inconsistencies in the communication of bushfire warnings across jurisdictional borders. Even within jurisdictions, systems, equipment and processes are often agency specific. This can be further challenged by lack of integration between various levels of government.

The use of existing resources can be made more effective by addressing system and interoperability issues. Further risk-based consideration should also be given to the development of relevant national standards to ensure essential capabilities are interoperable across organisations and jurisdictions.

Rapid information sharing between government, business and community organisations is key to identifying response and recovery priorities. At present government organisations are limited in sharing data even between themselves, let alone exchange of data with business and community organisations. Integration of systems would also aid the speed of information dissemination and decision-making.

62% of Australian emergency managers disagreed that capabilities required to respond to a catastrophic disaster are fully understood.

There is a need to conceptualise catastrophes from a national perspective, given that they will require responses across Australian jurisdictions, Commonwealth and, most likely, international organisations. Collective capability gaps for catastrophic disasters are not well understood as capability planning tends to focus on routine emergencies and be siloed within individual organisations. There is no national view of emergency management capability maturity or any definition of societal risk appetite to determine the appropriate level of risk to prepare for. This makes national investment prioritisation difficult. The Commonwealth has developed a National Disaster Preparedness Framework to aid capability planning in the context of severe-to-catastrophic disasters. This is a positive first step to understanding capability gaps and national investment priorities.

There are national resource sharing arrangements, although these are reliant on goodwill and cooperation between jurisdictions and tend to be focused on resource sharing between emergency services. National resource sharing plans can be compromised when multiple events occur across different jurisdictions at the same time or when nationwide disasters, such as COVID-19, strike. Consideration of possible enhancements to national coordination arrangements and planning to complement leadership and planning at jurisdictional and local levels is needed. The current National Cabinet arrangement utilised for the COVID-19 pandemic has demonstrated the successful application of a cooperative framework to provide national coordination during acute disasters.

Existing arrangements to access assistance from the defence force are another strength, although there are limitations on defence services in terms of their emergency response capabilities. For example, the defence force does not provide rural fire suppression. Given that the primary role of the defence force is to defend Australia from external attack, its availability to provide significant capabilities to assist in the aftermath of a catastrophe cannot be guaranteed.

Decisions to request resources from other jurisdictions, defence, NGOs and business are required in advance of the full impact of the event being known. Interstate assignments can take around 24-72 hours from activation to resource deployment, depending upon the distances involved. This requires early warning and forecast services, but also a culture of proactive activation.

Consideration should be given to the reliability of critical supply chains for consumables that may be needed in response and recovery. For example, the COVID-19 crisis highlighted supply chain vulnerabilities for healthcare worker Personal Protective Equipment (PPE).

The need for emergency management capabilities and supporting infrastructure to be resilient in the aftermath is a given. This requires collaboration and information sharing between government and infrastructure operators, which can be limited due to commercial and security concerns.

Like generals preparing to win based on the previous war, there has been a culture of focusing planning on the last large disaster rather than what else might

be out there. Governments can also be focused on preparation for a particular hazard at the expense of others. For example, following Black Saturday, significant investment was directed into preparedness for bushfires, but it was record-breaking floods that next severely impacted Australia in 2010/11.

Emergency managers found it difficult to conceptualise catastrophe risks: more effort needs to be devoted to evidence-based scenario modelling. Barriers to achieving this include:

- A too narrow focus on traditional risks such as flood and bushfire,
- A lack of knowledge of scientific studies regarding impacts and probabilities of catastrophic disasters in the Australian context. Some 52% of Australian emergency managers did not believe that catastrophe scenarios were available to inform planning,

"The weaknesses are that they are focused on what we know, what we've experienced, what we're comfortable with" (Australian emergency manager)

- A lack of imagination to explore and define catastrophe scenarios,
- A lack of information sharing between agencies. Only 29% of Australian emergency managers agreed that information about possible catastrophic disaster scenarios was shared regularly among emergency management agencies,
- Cultural factors like emergency service workers finding it difficult to contemplate scenarios where they might become overwhelmed, as they are trained to cope and
- A sense that it is all too hard due to the magnitude and complexity of catastrophic disasters.

Only 32% of Australian emergency managers believed that senior management actively promotes the importance and benefits of disaster planning for catastrophic disasters.

Attempts to understand and address catastrophe risk are stifled by a response-orientated culture, lack of trust between organisations, poor information sharing, lack of planning capability, inconsistent governance structures and an emergency management sector that is largely inwardly focused. For example, an emergency manager said:

> *The people who are running emergency management are like a conductor ... not understanding that they have got second strings and they have got the bass at the back and they've got the drums. It's like you've got the first and second violin, violas and the cellos and that's it when all the other parts of the orchestra are available to you — if you've helped get them up to speed a little bit in advance... It doesn't have to be massive because they still know how to read music — they're still a community structure — and some level of organisation but we're not understanding how to use the full orchestra. That's the power of it if we get it right: it's really fantastic and where it's done well it's amazing and it's completely transformative for everybody in the community because*

it's really empowering for everyone... Part of it is about recognising the value of that skill base and giving it some prominence (Emergency Manager).

Emergency management planning groups tend to be heavily government-focused, often ignoring wider community stakeholders such as businesses and community organisations (Figure 6).

Emergency managers also believed that there has been a lack of exercising for catastrophic disasters in the past, although this is beginning to change.

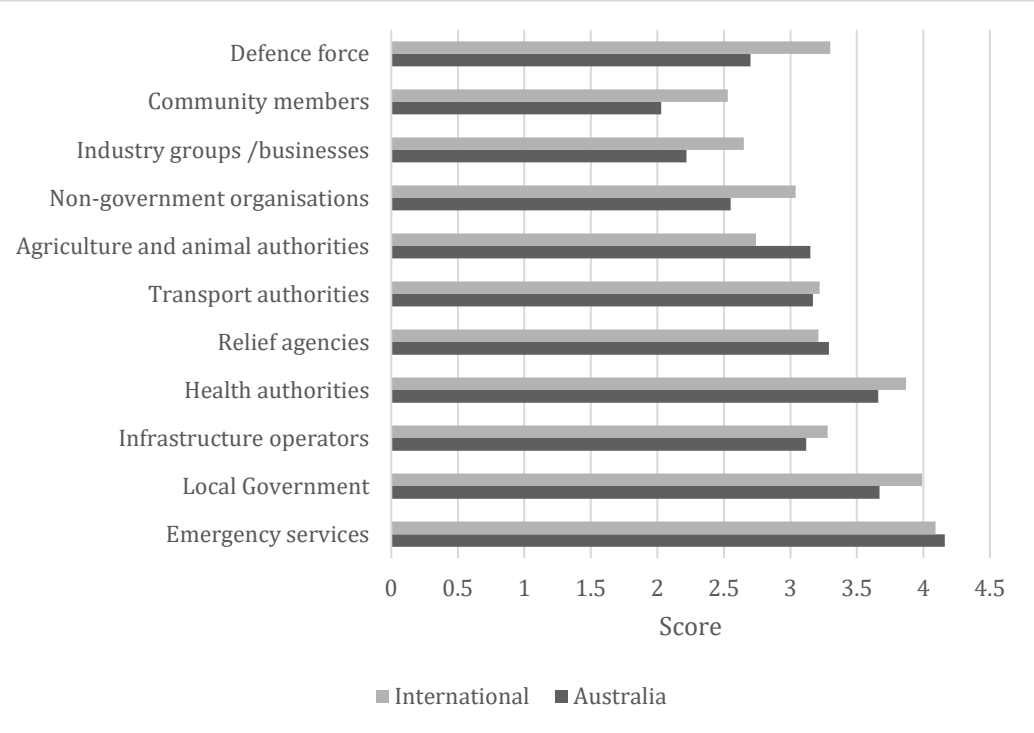

FIGURE 6: LEVEL OF PERCEIVED STAKEHOLDER INVOLVEMENT ACROSS DIFFERENT GROUPS ON SCALE OF 1 TO 5, WHERE 1 IS NOT INVOLVED AND 5 IS ALL RELEVANT STAKEHOLDERS ARE EXTENSIVELY INVOLVED.

Only 21% of Australian emergency managers believe that disaster plans integrate arrangements for international assistance.

Australia has traditionally relied upon its own resources in responding to disasters. While there has been use of international assistance in the context of firefighting and international arrangements are in place for urban search-and-rescue, plans to utilise international assistance have not considered wider possibilities. There can be issues with the timeliness of such help and difficulties of integrating cultures, communication and interoperability, just as there are between jurisdictions. A review of international assistance during the 2019/20 bushfires would undoubtedly provide lessons to further mature arrangements. Further international capability standards – for example for firefighting – would also help integration of international capabilities.

Emergency services need to conceptualise how their service delivery models will have to adjust to the overwhelming demand for services and the complexity of

catastrophes, including how they will anticipate and work with community first responders. Emergency management organisations must define capabilities they are best able to deliver in support of wider community efforts. Gissing (2016) proposed that priority capabilities should comprise leading communities; facilitating coordination and supporting the efforts of communities and infrastructure providers; facilitating infrastructure restoration to allow the arrival of supporting resources; collecting and providing situational awareness; providing public information to activate and inform community responses and providing critical specialist capabilities, such as medical, logistics and hazardous materials response. For other capabilities, planners should look to community-based sources to supplement those available within government and consider altering service delivery standards. Arrangements should be documented in plans to activate these additional supports.

There are tremendous challenges in building incident management leadership skills and experience in the context of severe-to-catastrophic disasters. Few leaders are likely to have had previous experience of such events; every large bushfire event, for example, is described as "unprecedented". How previous leaders have coped when faced with complex and catastrophic circumstances is helpful (Ellis and MacCarter, 2016, Stack, 2017) and leadership training programs at all levels should consider catastrophic disasters. This is particularly important at local levels, where initial leadership actions could make large differences.

To the extent that local leadership is key, it is also the most likely level of leadership to be disrupted by a catastrophe, as individuals may have been personally impacted. Given this perspective, leadership succession planning is critical. Not only should it be assumed when planning that local leadership may be disrupted, but emergency services first responders may also be impacted and unavailable, either from the outset or progressively over time.

> ***"Leadership during a catastrophic event must adopt a holistic focus. A leader cannot afford to focus just on a certain activity or consequence but must consider the broader picture and establish priorities". (Australian emergency manager)***

Recognising the limitations of Australia's catastrophic disaster experience, there is a need to consider building experience, perhaps through international exchanges, and leveraging skills that may rest in Australia's humanitarian and defence sectors.

Overall, there is a need to consider a nationwide planning framework for catastrophic disasters. A possible framework could comprise a largely generic national plan focused on defining key priorities, rapid appreciation of impacts, resource acquisition and integration, logistics, national coordination, linkages with state-based coordination, public messaging, business continuity and Commonwealth recovery arrangements. A similar Commonwealth plan (NATCATDISPLAN) was endorsed in 2010, but its status is unknown.

State-based plans could be scenario-based and focused on arrangements to combat jurisdictional-specific threats and associated longer term recovery. Such a planning model could be supported by a national planning team who would

provide expertise in developing scenarios and arrangements with national level stakeholders. Plans should be developed with consideration of end-user needs.

Plans must be based on a knowledge of disaster risk and an understanding of communities. However, in practice, emergency planners struggle to achieve this: for example, only 22% of Australian emergency managers agreed that disaster plans are based on a thorough understanding of the community.

Recovery planning should not only consider short-term arrangements but the long term, with consideration given to achieving risk reduction through recovery strategies. In practice, however, only 24% of Australian emergency managers agreed that plans consider long-term recovery arrangements.

There is a need to consider the role of politicians throughout various levels of government who are '*wanting to be seen to be doing something*'. Previous instances of governments appointing a specific high-profile coordinator to lead efforts or for ministries to be established to specifically oversee efforts are ways for governments to react to reassure public confidence.

"The demand for information from the political level has just jumped in terms of expectations. It's all about information these days. They want to know the finest detail and there's no sense in arguing that the detail needn't concern them" (NZ Emergency Manager).

Processes for developing plans are not well-understood. Only 19% of Australian emergency managers agreed that processes for developing catastrophic disaster plans were well-understood. Planning is under-resourced, with only 17% of Australian emergency managers agreeing that planning for catastrophic disasters is effectively resourced.

"Planning is increasingly being hived off into the policy realm and hence lacks an operational reality" (Australian Emergency Manager).

Overall, existing Australian disaster plans appear not to be consistently utilised in informing decision-making, with only 39% of Australian emergency managers agreeing that plans effectively inform decision making. The COVID-19 Pandemic in Australia has shown that emergency management plans can simply be ignored by senior officials. An after-action-review following Hurricane Sandy in the U.S. found that 64% of FEMA's planners either never used, nor had access to, regional hurricane plans (FEMA, 2013). In other cases plans have been out of date (NSW SES, 2017).

Although exercising is recognised as being essential to being prepared, most Australian (59%) emergency managers disagreed that exercises routinely test catastrophic scenarios.

LEGISLATIVE FRAMEWORK

Currently, the Commonwealth has no overarching or specific counter-disaster legislation. In the absence of legislation there is Commonwealth power to respond to emergencies within the areas of Commonwealth responsibility. Further, there is inherent power to deal with catastrophic disasters vested in the Crown as part of the prerogative power of the Crown and now incorporated into the Executive Power of the Commonwealth.

Exactly what constitutes a 'catastrophic disaster' is open to debate and, in the absence of legislation, may be the subject of judicial challenge. A disaster where a state government is overwhelmed to the point where it is at risk of collapse and there is no effective state government would be a national catastrophic disaster that would justify Commonwealth intervention in the affairs of the state in order to restore effective state government. What disaster, short of the collapse of state government, would be sufficient for direct Commonwealth intervention cannot be conclusively defined.

In the absence of legislation and a truly catastrophic event, the Commonwealth's authority to exercise national leadership and coordinate Commonwealth, state and private assets will depend on good will and cooperation. The extent of the Commonwealth's executive power cannot be identified until the circumstances of the particular disaster have been identified.

Failing to define, in legislation, the role and power of the Commonwealth will leave the Commonwealth to 'cope ugly' with any particular catastrophe. That may be acceptable as it will leave the Commonwealth with adaptive flexibility. It has, however, been a consistent recommendation of commentators (Eburn et al., 2019) that the Commonwealth should legislate to ensure that the Commonwealth is able to cope with an inevitable catastrophe.

A WHOLE-OF-COMMUNITY APPROACH

The whole-of-community approach is already being partially implemented in Australia, with community organisations and businesses contributing resources and expertise. Collaboration, though, is limited and ad-hoc, diminishing the value that partnerships could achieve.

Only 33% of Australian emergency managers agreed that disaster plans anticipate that the community will be the first responders to a catastrophic event compared to 60% of international respondents.

Emergency managers typically do not understand capabilities that community organisations and businesses possess. Some 78% of Australian emergency managers did not have a full understanding of the capabilities and resources of businesses, industry groups or communities. Emergency managers were uncertain as to how best to engage.

Government does not need to formally activate businesses and community organisations as they are already reactive in ensuring their own resilience and meeting the needs of staff and customers. Strong involvement and collaboration reduces the need for government services and resources and community organisations and businesses should be integrated into collective disaster plans (Waugh and Streib, 2006). Challenging this idea is the Australian Government's desire for further military involvement in disaster management (Jennings, 2020), reflecting a desire to strengthen government capability rather than collaborate more broadly.

The role of emergency service first responders in responding to a catastrophe must adjust from one which typically undertakes direct taskings to one which would facilitate, lead, support and enable community-led actions.

An initial step would be to focus efforts on enhancing collaborations across government, community organisations and businesses. The implementation of the approach would best be supported through the development of a framework defining collaboration mechanisms at different levels.

"In Christchurch, the CBC Building, most of that first life-saving activity was done by people who saw it collapse, being coordinated by a couple of emergency services personnel that had a little bit of thought and experience in leading. They took people to hospital on doors in the back of utes and they lived" (NZ Emergency Manager).

During the COVID-19 crisis, the Australian government formed a National Coordination Commission (the Commission) that comprises representation from government, community organisations and businesses with the purpose of 'mobilising a whole-of-society and whole-of-economy effort' (Prime Minister of Australia, 2020). The Commission also established a specific not-for-profit working group to provide recommendations to lessen social and economic impacts. Such structures should be key components of a wider collaboration framework integrated with national disaster arrangements.

Efforts should be made to increase the awareness of different organisations, build relationships and progress joint planning initiatives. This could be achieved through the establishment of forums such as local resilience groups that involve government, business and community organisations and have linkages with formal emergency management planning mechanisms. Some local resilience groups already exist and their expansion to other areas has been recommended by post-disaster inquires (Comrie, 2011).

There is a need to proactively plan engagement with community leaders in the response and recovery to a catastrophe. As a starting point, planners should attempt to identify key community leaders and build relationships during the preparedness phase.

Community organisations

Community organisations provide essential functions to support community resilience. They are part of the community fabric and their core business is building community resilience. There are significant opportunities to invest in the capabilities of community organisations to further build community resilience, to bolster critical capabilities required in the event of severe-to-catastrophic disasters and to integrate them further in disaster management through the whole-of-community approach.

Community organisations represent significant value for investment. Community organisations have played valuable roles before, during and after disasters with little funding support, often relying on the goodwill of volunteers and staff. Community organisations are critical to community-led disaster recovery

initiatives: it would be impossible to achieve community involvement in recovery without community organisations.

"I think the community sector has a big role to play because they are the ones who have the ears and trust of the most vulnerable in our sector and they know where they are" (Community organisation representative).

Arrangements between government and community organisations vary in individual jurisdictions, making it difficult for larger community organisations to define consistent roles. Community organisations have a degree of trust in their relationships with government organisations.

Key strengths of community organisations include the understanding of community needs; access to local knowledge, skills and experience; the ability to focus on people who may be vulnerable or disadvantaged and having pre-existing links to at-risk communities and their diversity of membership. People are generally more comfortable dealing with community organisations than government and hold more trust in community organisations.

Opportunities to enhance involvement

Some 50% of community organisations surveyed had a high or very high appetite to become more involved in disaster management although, ultimately, were resource-constrained. Community organisations are motivated by benefit to their community and to provide a critical service or good to enable community functioning.

Barriers posed by lack of funding need to be addressed (Figure 7). This may include specific grants to bolster capability but there is also a need to increase flexibility of existing funding models so that budgets can be utilised for disaster management. Any funding arrangements should inspire collaboration and avoid creating competition between agencies.

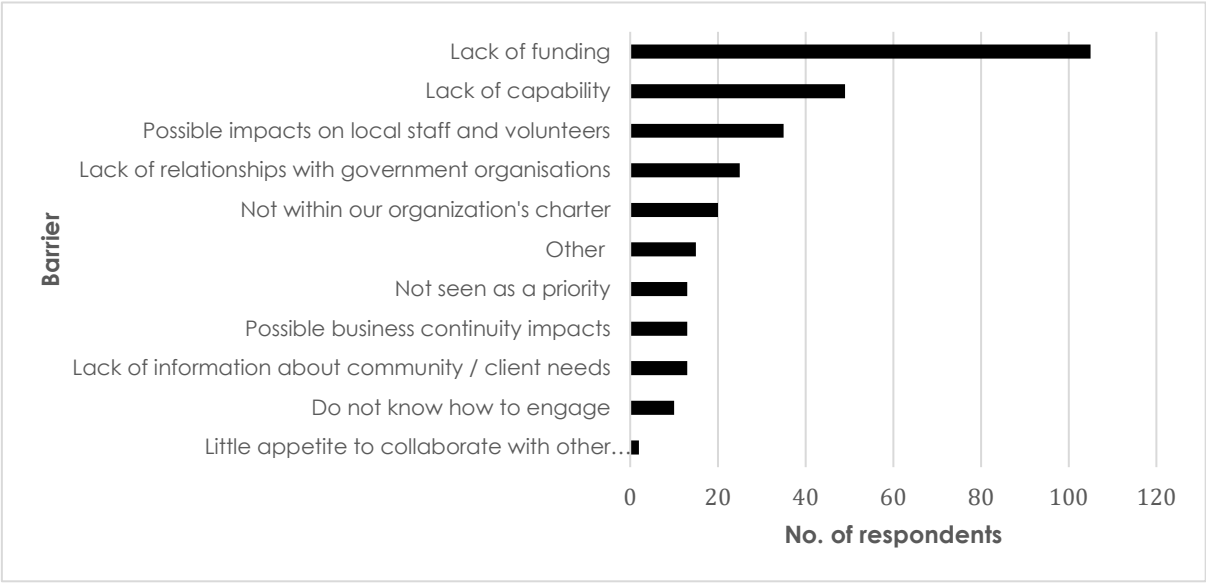

FIGURE 7: BARRIERS THAT EXIST TO ASSISTING CLIENTS AND/ OR COMMUNITIES TO RESPOND AND RECOVER FROM A DISASTER

Overall, the pivotal role played by community organisations requires further recognition and definition. Government planning should work with community organisations to actively identify the range of organisations, their networks and needs. The activity should enhance awareness of the capabilities of different community organisations. Government and business should also pursue collaboration with community organisations to build community resilience, particularly when targeting the vulnerable and to leverage their local networks and knowledge.

The staff and volunteers of community organisations require training. Emergency services should integrate community organisations into training programs. Government emergency managers could also gain from learning lessons from large community organisations operating in significant international catastrophes.

Specific efforts should be made to improve the business resilience of community organisations. The Australian Council of Social Services has developed a business resilience program, although it requires further effort to embed it throughout organisations.

Businesses

Large businesses interviewed acknowledged a role in ensuring their resilience and the safety of their staff, whilst smaller businesses saw less of a role. Large businesses expected other businesses to be investing in their business resilience. Businesses were motivated to invest in disaster resilience to keep employees, customers and neighbours safe and to reduce the risk of business disruption.

> ***"It's an expectation from a social/ corporate responsibility piece that an organisation such as ours support the community they're involved in" (Large business representative).***

Most businesses did not perceive a role for them in community disaster preparedness and believed they lacked the capabilities to play a role. Some were unsure as to what role they would play if they were to become involved. Despite this, a small number of businesses would like to do more to enhance wider community resilience. For example, insurers are making efforts to incentivise property level prevention and preparedness.

Most big businesses but few small businesses believed that they had a role in disaster response. These roles were to protect the safety of staff and customers, ensure the resilience of their operations and support any staff who volunteered with emergency services. Businesses were motivated to take this role by the need to ensure employee and customer safety and the resilience of their operations.

Only a few businesses saw a role for them in supporting emergency services during disasters. Those that did had access to plant and equipment, and some were trained in emergency management. Similarly, businesses thought that community organisations would have little role in disaster response and that, rather, government emergency services needed to take the lead as they were appropriately trained and equipped.

Large businesses believed they had a strong role in disaster recovery from both an internal and wider community perspective:

- They saw they must lead the restoration of their business operations and infrastructure whilst maintaining the safety of their staff and customers. Restoration of business operations was seen to be critical to ensure that vital supply chains recommenced, that people could return to their employment and local economies could commence recovery.
- Businesses saw their role in provision of support to communities as: fulfilling obligations to customers; making cash donations, fund raising and managing public appeals; allowing staff to volunteer to support recovery efforts through corporate volunteering projects with community organisations; assisting to coordinate spontaneous volunteering; making product and service donations; providing specialist equipment and expertise; collaborating to ensure provision of necessities; providing flexibility to customers to be responsive to their needs; providing facilities for evacuation, recovery centres and accommodation; taking leadership and coordination roles in recovery; assisting to provide recovery information to community members; providing priority in their service provision to emergency management organisations and assisting in reconstruction activities.

Large and small businesses were motivated to participate in disaster recovery to: ensure the safety of their staff and customers, maintain market share, serve the community as a core part of their brand and values, ensure prosperity of economies that businesses rely on, build their brand; utilise a socially responsible brand to their advantage; and build staff motivation and satisfaction.

"Our employees demand it. We know it's the right thing that needs to be done… Our employees, the way we approach certain disasters, has an impact on how our employees perceive us and work with us. That action is, sometimes, in their eyes, a strength" (Business representative).

The provision of support to communities was viewed as discretionary and dependent on the capability and type of business. Whilst businesses need to deliver profits to shareholders, it is not the sole objective driving business: rather, the purpose of a business was regarded as more complex in serving multiple objectives. Social responsibility was seen to be a demand of customers, employees and external stakeholders. The ability to provide support to communities and act in a socially responsible manner is dependent upon a company's ability to afford to do so by making profits: that is, a balance must be achieved between profit-making and investing in communities.

Analysis of previous business involvement in major Australian disasters shows that, most frequently, corporations act as support providers. On occasions, however, businesses may act to coordinate support from their employees and/or customers. Businesses provide support directly to communities or via community organisations and government.

There are many strengths of involving large businesses in disaster management that include: prior experience in disaster response and recovery; vast logistical capabilities and knowledge of supply chains; relevant resources such as plant and equipment and trained personnel; extensive and trusted national networks;

collaborative approaches; diversity of capability and specialist expertise; flexibility, scalability and adaptation; local presence and connections.

Barriers to further involvement in disaster management for larger businesses included: lack of understanding of community needs and of how best to be involved; lack of existing relationships or disruption to relationships; lack of alignment between businesses and government, typified by a government centric approach; commercial resources being finite, with commercial realities to consider; different emergency management and operating arrangements in different jurisdictions; concurrent major disasters straining resources and lack of information-sharing between businesses. Barriers to small businesses included: lack of capability, not being within the charter of their organisation, lack of relationships with government organisations and lack of knowledge as to how to engage.

> ***"Nevertheless, we see it, as part of our brand and our commitment to the community, an event of national significance could trigger us to move into a crisis response and activate all the bells and whistles of our crisis management framework. Secondly, we need to be prepared for those events where, either community, government, some part of society, may put its hand up and say "Can you help?"". (Business Representative)***

Some large businesses had an appetite to be more involved in disaster management, particularly to support communities. Appetite for involvement was context-dependent, driven by the expectations of customers and employees, dependent on businesses having a suitable role and alignment with company values. Few small businesses had any appetite for further involvement in disaster management.

Some large businesses saw a risk to their businesses brand and reputation if they were not involved in disaster management. Some risks when businesses get involved included: not meeting community expectations; not adequately understanding the needs of impacted communities; partnering with organisations that were not credible; ensuring donations were effective; work, health and safety (WHS) of staff operating in disaster areas; undermining of local businesses and reducing the speed of local economic recovery and lack of insurance cover.

Opportunities to enhance involvement

Suggestions by businesses to improve their involvement in disaster management included: invite businesses to collaborate; proactively enhance relationships and networks between businesses, government and community organisations; create a national model for engagement between government and businesses, including industry coordination points in each jurisdiction; raise awareness of what capabilities are available; provide businesses awareness of what problems need to be solved; provide greater awareness of government disaster plans and expectations upon businesses; and establish panel arrangements to procure specialist expertise.

> ***"It's really hard to say what we'd be able to offer, unless you give us a problem and we could tell you how we might be able to solve it. Pose the weird and difficult problems that you have as a government organisation to the industry, and ask for help and you will be surprised at the answers that come back. We can help find unique or different capabilities to help you solve it" (Business representative).***

Lessons in collaboration and engagement can be gained from elsewhere. The United States has adopted an approach to incentivise business collaborations through information exchange and asking businesses what government can do for them to help them recover and ensure their continuity. This approach recognises that maintaining business continuity is key to reducing demands on government services. FEMA developed a virtual National Business Operations Center that acts to exchange information between government and the business sector. During disasters, the Center provides real-time situational awareness and ground-truthing on the needs of impacted communities. Further, FEMA created a business sector role within its National Coordination Center to facilitate information-sharing with businesses. Regular forums are also held between government and business to promote this collaboration.

To assist with the direct contracting of businesses, New Zealand emergency services now integrate specialist procurement agencies within their incident management teams. These organisations are best placed to understand appropriate governance arrangements that would apply to emergency procurement and have existing relationships with major suppliers. Where capability gaps are identified that could be filled by business, panel contract arrangements should be proactively established to enable their rapid activation during times of disaster.

Regulatory relief can be utilised to promote collaboration. During the worldwide COVID-19 outbreak, competition regulators in Australia, New Zealand and the U.K. have provided exemptions to competition regulations to promote collaboration between businesses for public benefit. In Australia this included supermarket, mining, health insurance, oil, medicine, telecommunications and banking companies (Australian Competition and Consumer Commission, 2020). In the case of supermarkets, a special taskforce was established, led by government and involving major supermarkets, to ensure the supply of grocery essentials. Supermarket executives had never met each other before but came together for this crisis. One executive stated, "it was never about our sales, it was about Australia" (Powell, 2020).

In Australia, Trusted Information Sharing Networks exist to enable sharing of information between the Commonwealth Government and critical infrastructure providers. The Networks, however, do not include all types of businesses and are siloed by industry groups. The Australian Business Roundtable for Disaster Resilience, a collaboration between large businesses and a large community organisation to promote disaster mitigation, is a model that could be expanded to promote further dialogue and collaboration. The Minderoo Fire Fund is another example.

There are opportunities for businesses to plan their involvement in disasters either through business continuity plans or as part of corporate social responsibility

programs. Efforts may include decisions regarding preferred delivery partners, types of support and relationship-building. The opportunity for government could be in informing businesses as to the likely priorities for assistance, how information may be obtained about such priorities at the time of a disaster and encouraging investment in resilience-building initiatives.

Discussion must take place in relation to what level of engagement the authorities responsible for the Australian national emergency management framework desire with the business sector in order to facilitate formal partnerships. From the perspective of a large multinational or national corporation, the prospect of engaging with a single nationwide coordinating entity would be advantageous, rather than establishing individually negotiated agreements with individual jurisdictions. Jurisdictional emergency management organisations could then focus on relationships with small- to medium-sized businesses that operate mainly within their jurisdiction. Such a model would lead to the need for the Commonwealth to take a greater role in emergency management or for jurisdictions to collaborate to expand national resource-sharing arrangements.

RESILIENCE

Ultimately, the ability to withstand a possible catastrophic disaster is determined by the resilience of a community. Improving community resilience is an incredibly powerful method to reduce natural disaster impacts, as illustrated by the reduction in fatalities associated with natural hazards in Australia over time (Figure 8).

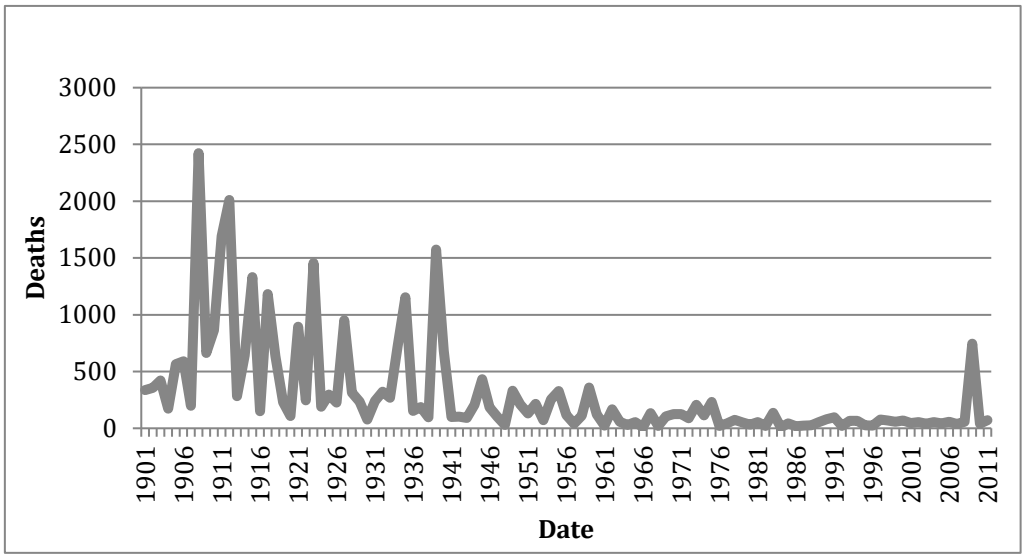

FIGURE 8: NORMALISED FATALITIES – AUSTRALIA – 1900 TO 2011 (SOURCE: PERILAUS)

The vast majority of disaster-related spending goes on recovery rather than risk reduction. Calls from the Productivity Commission and the Australian Prudential Regulation Authority (APRA) for more disaster mitigation funding have been largely ignored.

The Federal government's recent National Disaster Risk Reduction Framework highlights the need to identify highest-priority disaster risks and mitigation opportunities. Catastrophe loss modelling based on current and future scenarios should be utilised to help set priorities.

This would see priority investments in, for example, flood mitigation and strengthening of buildings against tropical cyclones in northern Australia, a practice that would also help address insurance affordability (Gissing and Langbein, 2020).

Accountabilities for disaster prevention and preparedness are not always clear. For example, in NSW there is no clear lead agency for the prevention of and preparedness for the impacts of severe storms or heatwaves. Small local governments also lack capacity to assess risks and manage mitigation projects.

There are opportunities to further identify household mitigation options to retrofit existing buildings and link these with incentive measures such as discounted insurance premiums. Some insurers are already implementing such practices for cyclone in northern Australia.

There is a need to inform residents of the full extent of natural hazard risks and making risk data more available. Opportunities should also be given for

communities to participate in building resilience. The Community Fire Units program is an example of how communities can successfully participate.

Land-use planning needs to be improved to reduce the chance that future developments are exposed to unreasonable risks. A case in point is the proximity of construction close to bushfire-prone bushlands. Land-use planning must be risk-informed; however, this is not the case. For example, flood regulations are largely probability based, reliant on set thresholds and do not fully account for the wider consideration of possible flood consequences above defined levels.

Infrastructure must be constructed to be resilient. Following a disaster, destroyed buildings should be rebuilt away from dangerous areas. Land swaps such as those implemented in Grantham after the 2011 floods should be planned and implemented where possible. This requires pre-emptive recovery planning.

FUTURE CAPABILITY

Existing capability development plans tend to be short-term. There is a need for more strategic long-term capability planning stretching well beyond 2030. There are opportunities to utilise new technologies to improve the management of disasters. By way of example, this is discussed in respect to future bushfire fighting.

Today's management of bushfire risk is largely reliant on long standing approaches that are resource-intensive and which inevitably struggle to control fires when conditions are catastrophic. An inherent problem is that bushfire detection is complex and, in the time it takes before resources can be tasked and deployed, bushfires have already spread to the point where suppression is difficult. This problem is exacerbated when bushfire ignition occurs in remote areas far from emergency management resources.

It is widely agreed that, in the short term, there are many technologies and systems already existing that could enhance firefighting and broader disaster management capabilities. Specific opportunities identified by industry experts include:

- Satellites, such as data sourced from the Himawari satellite, should be evaluated for their ability to enhance fire detection. The Bushfire and Natural Hazards CRC, in collaboration with RMIT University, have used Himawari-8 data feeds to identify potential fire starts that, in evaluation by the NSW Rural Fire Service, have been able to deliver outputs within 90 seconds of satellite image acquisition. High Altitude Platform Systems may be another option.
- In the United States, Unmanned Aerial Vehicles (UAV) have been employed to provide enhanced imagery over firegrounds and, if equipped with infrared sensors, these can support monitoring of fire conditions at night. The Victorian Government has established a panel contract with UAV providers to assist with real-time fire detection and monitoring. Further policy regarding airspace management is required to support wider demand-based deployments of UAVs.
- Use of airborne sensors to improve data availability regarding bushfire fuel loads.
- Existing agricultural monitoring technologies could be repurposed to monitor bushfire fuels and soil conditions.
- Balloons equipped with radio communications could provide coverage when traditional communications technologies have been disrupted. Alternatively, small UAVs could create a mesh network to provide a wireless communications network or equipment fitted to aircraft.
- Advances in the use of robotics in the mining sector may provide applications to firefighting; for example autonomous trucks.
- Resource tracking technologies could be implemented to improve coordination and firefighter safety.
- Implementation of nighttime aerial firefighting capabilities.

Operational decisions could be improved by enhanced collation and fusion of data already available. There are many data sources that are managed by different organisations, not just government agencies. Collating these datasets to provide a common operating picture across all organisations would improve situational awareness and data analytics.

The widespread adoption of artificial intelligence and greater digital connectedness across the economy and emergency management sector will instigate new ways to make sense of data and improve decisions. In the built environment, improved information to households about the resilience of their buildings, along with programs to implement simple retrofitting measures, should be considered. Enhanced data availability and analytics could be utilised to further tailor emergency warnings to households.

A key area for research and innovation investment over the coming decade should be how to rapidly suppress bushfires once detected. This could see swarms of large capacity UAVs supported by ground-based drones to target suppression and limit fire spread. Resources would be rapidly dispatched and coordinated autonomously once a bushfire was detected. Pre-staging of resources would be informed by advanced predictive analytics and enabled by unmanned traffic management systems. UAVs and drones would have applications beyond fire suppression, including for rapid impact assessment, search and rescue, logistics and clearance of supply routes.

A research and innovation blueprint is needed that outlines how technologies will be translated to enhance firefighting and resilience in the short term and, beyond this, how the next generation of capability will be designed and built. Its development should involve government, research and industry stakeholders in a collaborative manner. The final blueprint should be integrated with future workforce and asset planning to support broader change management.

DISCUSSION AND CONCLUSION

The problem of catastrophic disasters cannot be eliminated, but it is clear that actions can be undertaken to improve Australia's understanding and ability to withstand and cope with a possible future catastrophe. Many existing constraints and barriers such as inwardly focused arrangements and poor information sharing appear to be largely cultural or related to existing governance structures. Similar over-confidence in existing capabilities and beliefs regarding the low probability of catastrophe have been evident in previous international catastrophes. Though not all catastrophes are imaginable, many are, as evidenced by the current COVID-19 pandemic. More is needed than just simply scaling up existing emergency management arrangements. Different thinking is required.

Our results support existing well-defined principles for disaster planning and risk reduction (Alexander, 2005); however, we find they are not effectively implemented to develop plans that consistently inform decision making. Planning is being inhibited by cultural, knowledge and resource constraints dominated by reactive response-oriented approaches. There is a need to enhance senior leadership buy-in to ensure that proactive, risk-based and end-user-driven planning is championed and supported. This will require the application of appropriately trained and resourced planning teams to the task. Further information on catastrophic disaster scenarios and information exchange with infrastructure operators, businesses and community organisations is needed. Further efforts are required to understand collective capability maturity and provide an ongoing measurement of preparedness for severe-to-catastrophic disasters. This should be informed by a definition of societal risk appetite.

There are significant opportunities to enhance traditional all-hazards, all-agencies jurisdiction-led approaches. To ensure effective preparedness, response and recovery, Australia must move further to an all-hazards, nationwide, whole-of-community approach.

Severe-to-catastrophic disasters will require resources beyond the impacted jurisdiction. Although resources are already shared between jurisdictions, a nationwide approach recognises the need to bolster approaches for jurisdictions to work seamlessly together including investments to enhance interoperability and to strengthen mechanisms of national coordination. The Commonwealth's role must also be defined by Commonwealth emergency management legislation, as has previously been recommended (Eburn et al., 2019).

The need for strengthening national coordination arrangements is reinforced by analysis of historical compound disasters, showing that it is possible for numerous concurrent or sequential disasters to occur across multiple jurisdictions, resulting in potential resource conflicts across those jurisdictions.

Our research ultimately supports the principle of shared responsibility. The whole-of-community approach recognises that any severe-to-catastrophic disaster will involve whole-of-society responses. Business and community organisations offer opportunities to enhance capability and capacity to respond and recover. Our results support previous findings regarding the need to adopt collaborative and inclusive approaches as opposed to only government-centric command and

control frameworks (Fugate, 2017, Waugh and Streib, 2006). Despite the recognition of the value of businesses and community organisations in the National Strategy for Disaster Resilience, emergency management approaches are based on an inadequate view of community organisation and business capabilities and the culture remains largely government-centric. Our results offer insights into the barriers and motivations of community organisations and businesses regarding their further involvement in disaster management which can be utilised to enhance engagement.

Given the clear significance of compound disasters and the challenges that they present, further attention must be applied to their incorporation in risk assessments. This should include the adoption of a multi-hazard approach that considers the occurrence of multiple disasters (including societal stressors) occurring concurrently or sequentially as recommended under the Sendai Framework (United Nations, 2015). At present, the National Emergency Risk Assessment Guidelines do not consider compound disasters. Analysis should be forward-looking to consider impacts of projected climate change on extreme weather and changes in exposure. Such an approach should inform capability analyses and disaster planning.

Governments, whilst considering the lessons of previous disasters, must be proactive, forward-looking and risk-based. Capability and capacity requirements for severe-to-catastrophic disasters will likely evolve into the future due to societal, environmental and technological changes. Technology offers significant opportunities to enhance capabilities. Unlike the defence forces, emergency services collectively lack a long-term view of capability requirements. There is need for a collective national view of future capability requirements to inform investment.

Ultimately, our research supports the need for further efforts to mitigate disaster risk and build resilience, similar to recommendations of the Productivity Commission and APRA.

AREAS FOR IMPROVEMENT

To further support efforts to enhance prevention, preparation, response and recovery in the context of severe-to-catastrophic disasters, the following opportunities for improvement are described:

1. **Investment in disaster risk mitigation must be prioritised and evidence-based** utilising catastrophe modelling outputs to prioritise investment, including consideration of future risk scenarios encompassing climate change projections. This will include consideration of community and individual property scale options. Catastrophe modelling outputs can be used to construct catastrophic disaster scenarios to inform disaster planning.
2. **Enhance guidance and resourcing to undertake planning for catastrophic disasters.** A national planning team could be formed to assist jurisdictions to undertake detailed scenario planning and understand joint state and Commonwealth capability requirements.

3. **Infrastructure operators must invest in the resilience of their assets** to minimise associated cascading consequences.
4. **Risk assessments and plans must consider multiple large-scale concurrent or sequential events.** This should include updating national guidelines such as the National Emergency Risk Assessment Guidelines and exercising arrangements involving multiple large concurrent or sequential disasters.
5. **Promote societal resilience to withstand the impacts of disasters** including establishment of local community resilience groups and efforts to build capabilities in supporting their communities. An outcome of these groups should be the development of local community resilience action plans as recommended by Comrie (2011).

   Efforts should be made to enhance community understanding of natural hazard risks and incentivise preparedness actions. This could involve the establishment of a national community resilience charter to outline the roles of community members such as know your risk, know first-aid to help others, prepare your property, ensure adequate supplies of essentials for at-least 72 hours, keep in touch with warnings, follow instructions of emergency services and look out for those most vulnerable.
6. **Risk informed landuse planning is critical** to manage future risk.
7. **Assess the maturity of emergency management capability nationally** to identify gaps that require investment. This project has developed a capability maturity assessment tool and process that could be utilised on a national basis. Capability maturity assessments should be ongoing to provide a national view of preparedness for severe-to-catastrophic disasters.
8. **Enhance national interoperability between organisations and jurisdictions** through the development of standards for priority capabilities and promoting systems integration and data sharing. Plans should also ensure integration and information sharing between local, state and national levels, as well as between government, community organisations and businesses.
9. **Further engage businesses and community organisations and encourage them to strengthen their resilience.**

    a. For businesses this should include:

        i. Development of a national framework for the involvement of businesses in emergency management to articulate roles at Commonwealth, state and local levels and provide businesses with an understanding of how best to engage with different levels of government.

        ii. Clear definition of the role of businesses, including peak bodies, in relevant emergency plans where necessary.

        iii. Involvement of business groups by government emergency planning organisations in state and regional disaster planning through the establishment of collaborative forums

that consist of business representatives and peak and membership bodies. Consideration for establishment of groups should include that:

1. They have wider representation than the existing trusted information-sharing networks and take a multi-sectoral approach.
2. Business representatives have nominated government contact points in each jurisdiction.
3. The groups take on a coordination and information-sharing function during disaster to better direct the efforts of business and enhance collaboration.

iv. Resourcing of engagement with businesses and community organisations by government agencies.

v. Holding specific conferences and forums between government agencies, businesses and community organisations to explore collaborative opportunities and to build relationships.

vi. Identification of key capabilities and gaps by government emergency planning and, where necessary, establishment of panel contracts to enable the fast procurement of specific services in times of disaster.

vii. Incorporation of specific training on working with businesses in disaster management into relevant emergency management training units.

viii. Continuation of business continuity programs for small business to further build the resilience of local economies.

b. For community organisations this should include:

i. Clear definition of the role of community organisations, including peak bodies, in relevant emergency plans.

ii. Involvement of community organisations in government-led disaster planning and exercises, including involvement in relevant emergency management committees.

iii. Development of an understanding of community networks and community organisation capabilities on the part of government emergency management organisations by collectively working with community organisations.

iv. Enablement of funding flexibility by government funding bodies to allow community organisations to integrate disaster management initiatives into their core business activities.

v. Targeting of specific disaster management grants to community organisations to assist with maturing of disaster

management capabilities and engagement with communities.

vi. Funding arrangements should enable collaboration between different community organisations, businesses and government.

vii. Community organisation peak bodies taking an active role in building the disaster management capabilities of their members.

viii. Development of a training strategy by emergency management organisations to upskill the staff and volunteers of community organisation peak bodies in relevant disaster management roles. This could include a toolkit for community organisations to provide guidance on roles and better practice.

ix. Collaboration of peak bodies and emergency management organisations with universities and training providers to incorporate emergency management content in relevant degree and training programs.

x. Development of business resilience plans by community organisations. These can be supported by relevant toolkits tailored to community organisations.

xi. Inclusion of community organisations by jurisdictions within capability maturity assessments.

xii. Continual evaluation of the roles performed by community organisations in disaster management to ensure robust measurement of the value provided by community organisations.

xiii. Implementation of initiatives by jurisdictions to raise the awareness of the role of community organisations in disaster management. These could include:

    1. Integration of the role of community organisations within emergency management training.
    2. Inclusion of community organisations in policy development and emergency management forums.
    3. Specific communications outlining the role and value of including community organisations in disaster management.
    4. Senior leadership involvement as champions.

10. **Develop Commonwealth Emergency Management legislation** to define the role of the Commonwealth in catastrophic disasters and to detail the role and accountabilities of a Commonwealth coordinating officer. Legislation should identify what powers may be exercised, in what

circumstances they may be called upon and establish systems to review and ensure they have been used appropriately.

11. **Strengthen national coordination mechanisms for catastrophic disasters** and revise NATCATDISPLAN to provide an overarching national framework and for the integration of international assistance.

    Jurisdictions should develop scenario-based catastrophic disaster plans and ensure that responses to such scenarios are exercised. A national planning team could work to assist jurisdictions and ensure wider national integration. Plans should also consider recovery arrangements to reduce future disaster risks such as land swaps.

12. **Review supply chains for essential items** that may be required in the event of catastrophic disaster to ensure their resilience to meet supply demands.

13. **Research and innovation to empower the next generation of emergency management capability.** Capability planning should focus on the long-term. There is a need to develop a future national emergency management capability blueprint to guide investment in the next generation of capability, incorporating industry collaboration. Such a blueprint should also consider future emergency management workforce needs to support technological enhancements.

14. **Invest in leadership capabilities at all levels.** Leadership programs for emergency services could utilise case studies of leadership during severe-to-catastrophic events – for example, Cyclone Tracy – and include international exchanges with humanitarian organisations. At local levels, resilience leadership and mentoring programs for community leaders could be offered.

15. **Provide inclusive training and education regarding the management of severe-to-catastrophic disasters.** This should not only include government stakeholders but also businesses, community organisations and community members.

KEY MILESTONES

Project Milestone	Status 30/6/2020
Literature review completed on catastrophic disaster planning and capability planning	Complete
Commence interviews and survey of emergency management stakeholders	Complete
Poster for BNHCRC Conference	Complete
Quarterly Report	Complete
Commence development of evaluation criteria and evaluation of planning and capability systems	Complete
Survey of emergency management stakeholders and interviews completed.	Complete
Quarterly Report	Complete
Report on the current and future nature of catastrophic disasters in Australia	Complete
Completion of evaluation criteria for benchmarking framework	Complete
Commence interviews and surveys of businesses, NGOs and emergency management executives regarding non- traditional capabilities	Complete
Commence development of benchmarking framework tool and commence drafting of academic paper summarising year 1 outcomes	Complete
Quarterly Report	Complete
Commence literature review regarding integration of non-traditional capabilities.	Complete
Completion of the benchmarking framework and tool for feedback from end-users	Complete
Draft Academic Paper summarising results	Complete
Quarterly Report, Annual Report, Self-Assessment Matrix, Adjust Utilisation Road Map accordingly	Complete
Interviews and survey of businesses, NGOs and emergency management executives regarding non-traditional capabilities, including change management considerations	Complete
Literature review regarding integration of non-traditional capabilities	Complete
Commence research report regarding a model for integration of non-traditional partners including practice recommendations	Complete
Poster for BNHCRC Conference	Complete
Quarterly Report	Complete

Initiate discussions with end-users regarding benchmarking framework to seek trial	Complete
Continue interviews and survey of business, NGOs regarding non-traditional capabilities including change management considerations	Complete
Quarterly Report	Complete
Commence investigation of legal framework to support national coordination during a catastrophic disaster	Complete
Analysis of ASX 100 and NZX 100 involvement in previous severe catastrophic events	Complete
Interviews and survey of businesses, NGOs and emergency management executives regarding non-traditional capabilities; change management considerations	Complete
Commence trial of benchmarking framework with an end-user organisation	Complete
Complete research report summarising investigation of legal framework to support national coordination during a catastrophic disaster	Complete
Quarterly Report	Complete
Complete research report summarising results of interviews and company analysis including practice recommendations for a model of integration of non-traditional partners and change management	Complete
Commence interviews and literature review to inform and assess emergency risk assessment practice for catastrophic disasters (with a focus on compounding events)	Complete
Quarterly Report, Annual Report, Self-Assessment Matrix	Complete
Trial of benchmarking framework completed, and tool updated to reflect feedback	Complete
Visits to each major jurisdiction to promote research outcomes and identify utilisation opportunities	Complete
Poster for BNHCRC Conference	Complete
Quarterly Report	Complete
Develop and publish case study of emergency management leadership during a catastrophic disaster	Complete
Complete draft Academic Paper summarising results of non-traditional partnerships model	Complete
Quarterly Report	Complete
Conduct and complete analysis of PerilAUS to investigate the occurrence of compounding events	Complete

Complete research report summarising results of compounding events analysis, including practice recommendations	Complete
Visits to each major jurisdiction to promote research and consult regarding final end-user utilisation	Complete
Quarterly Report	Complete
Complete draft academic paper on compounding events research	Complete
Synthesis Report summarising all project activities and identifying opportunities for further end-user research utilisation	Complete
Quarterly Report, Final Report, Self Assessment Matrix	Complete

UTILISATION AND IMPACT

SUMMARY

There are a variety of utilisation opportunities emerging from the research. These are summarised in the following sections.

CAPABILITY MATURITY ASSESSMENT TOOL

The connection between disaster planning, capability and capacity are essential, but often overlooked. The emergency management sector lacks an understanding of its capability and capacity to address severe-to-catastrophic disasters. To enhance understanding, a capability maturity assessment tool has been developed.

The tool was developed by the research team in collaboration with end-users (Emergency Management Victoria, Resilience NSW and Emergency Management Australia – Home Affairs). The tool has been developed for use by jurisdictions and organisations to assess the current maturity of their capabilities utilising a series of criteria.

The tool has been built to align with the National Disaster Preparedness Framework. Criteria are structured around the Framework's capability elements of people, resources, governance, systems and processes and have been written based upon outputs of the research.

A capability maturity assessment process has been developed to support the implementation of the tool. The process consists of workshop discussions with capability subject matter experts to benchmark specific capabilities utilsing the criteria against severe-to-catastrophic disaster scenarios.

The tool is Excel-based and easy to tailor to specific contexts. Functions to support summary reporting have been incorporated. The tool can be utilised on a longitudinal basis to assist jurisdictions and organisations to measure and report on their preparedness.

Extent of use

- The tool was co-developed with Emergency Management Victoria.
- The tool is in use to conduct a capability maturity assessment of the NSW Emergency Management Sector. The maturity assessment is due to be completed in 2020/21. This project has involved all emergency services and functional areas in NSW with an interim report presented to the NSW Capability Development Sub-Committee in May 2020.
- A BNHCRC utilisation grant has been provided for a road show across jurisdictions to provide training and awareness of the tool in conjunction with Emergency Management Australia – Home Affair's implementation of the National Disaster Preparedness Framework. Jurisdictional workshops will occur in 2020/21. These were delayed due to COVID-19.

- The tool can be utilised on a longitudinal basis to inform preparedness reporting.

Utilisation potential

- Utilising the research on community organisation and business involvement in disaster management, the tool could be adopted to better understand capability within these sectors.

Utilisation impact

- The tool has allowed the NSW emergency management sector to determine the maturity of capabilities identified in its state capability framework.

Element	Maturity Level – Collective Capability			
	1 = Informal	**2 = Developing**	**3 = Established**	**4 = Self-sustaining**
People	Insufficient trained, exercised and skilled personnel Capability targets are not understood	Insufficient trained, exercised and skilled personnel available, however capability targets are established and understood with pathways in place to achieve sufficient capacity	Sufficient trained, exercised and skilled personnel readily available when compared with capability targets	Number of trained, exercised and skilled personnel readily available exceeds capability targets.
People	Arrangements for surge capacity have not been considered	Arrangements for surge capacity are informal, reactive and untested for major emergencies	Arrangements for surge capacity are documented in plans but untested for major emergencies	Arrangements for surge capacity are documented in plans, regularly exercised and operate effectively during major emergencies when tested
People	Capacity building pathways are informal	Capacity building pathways are organisation specific	Collective capacity building pathways exist but are reactive. Culture of working as one is maturing.	Collective capacity building pathways are strategic proactive and operating effectively. Culture of working as one is embedded.
Resources	Insufficient resources	Insufficient resources available, however, capability targets are established and understood with pathways in place to achieve sufficient capacity	Sufficient resources readily available when compared with capability targets	Available resources readily exceed capability targets
Resources	Arrangements for surge capacity have not been considered	Arrangements for surge capacity are informal, reactive and untested for major emergencies	Arrangements for surge capacity are documented in plans but untested for major emergencies	Arrangements for surge capacity are documented in plans, regularly exercised and operate effectively during major emergencies when tested
Resources	Resource capacity building pathways are informal	Resource capacity building pathways are organisation specific	Collective resource capacity building pathways exist but are reactive	Collective resource capacity building pathways are strategic, risk based, proactive and/or operating effectively
Governance	Roles and responsibilities are not defined	Roles and responsibilities are inconsistently defined	Roles and responsibilities are mostly well defined	Roles and responsibilities are consistently well defined
Governance	No systematic governance, strategy, monitoring, risk management, and reporting	Specific project / single agency-based governance, capability planning, monitoring, risk management and reporting Collective governance largely inconsistent and disconnected	Collective governance, risk management, capability planning, monitoring and reporting processes are established	Collective governance, monitoring, risk management, capability planning and reporting is actively connected and exercised Governance enables flexibility, adaptability and transformational change
Governance	Assurance activities are limited and inconsistent Poor lessons learnt culture	Assurance activities are organisation specific and lack independence Lessons learnt culture is emerging	Assurance activities are sector wide and collaborative though lack independence Lessons learnt culture and systems exist.	Independent sector wide risk-based assurance is provided Strong lessons learnt culture and management system
Systems	Systems are insufficient, operate in isolation and have suffered from previous failures	Systems are one-off, project specific or not well embedded Systems might be connected and interoperable at an organisation level, but not across organisations	Systems are user friendly, fit for collective purpose and are interoperable across organisations Limited ongoing resourcing for systems enhancement to meet changing purpose	Systems are user friendly, fit for collective purpose and are interoperable across organisations Active connection with system users to enhance systems with sustainable ongoing resourcing
Systems	Business continuity and IT recovery plans are not developed or well outdated	Business continuity and IT recovery plans are being developed or reviewed	Business continuity and IT recovery plans are established	Business continuity and IT recovery plans are established, tested and proven to be robust
Processes	Processes are informal, organisation and hazard specific.	Collective processes exist but with limited collective adoption across agencies/organisations Reactive refinement when problem emerges	Collective processes documented and clearly visible Limited appetite or capacity to refine in proactive manner	Collective processes fully embedded, tested and regularly updated with feedback loops across /organisations Proactive anticipation and resolution of problems not yet established
Processes	Processes are not well understood by personnel	Processes are partially understood by personnel, though efforts are underway to improve understanding	Processes are understood by personnel	Processes are well understood by personnel and have been exercised/tested and proven to be robust

FIGURE 9: CAPABILITY MATURITY ASSESSMENT MATRIX

POLICY REFORM AND CHANGE

Through collaboration with end-users, conference and workshop presentations, dialogue with official inquiries and project publications there have been opportunities to inform disaster management policy and stakeholders' understanding of the challenges faced when managing severe-to-catastrophic disasters.

Extent of use

- Research outcomes have been used to inform the development of policies and approaches; for example, the implementation of the National Preparedness Framework by Emergency Management Australia – Home Affairs.
- Outcomes of the research were presented in evidence to the Royal Commission into National Natural Disaster Arrangements.

Utilisation potential

- The recent report on Community Organisation Involvement in Disaster Management has received positive feedback. Agencies have stated they are keen to widely distribute the results and utilise them in policy development. Further follow-up meetings will continue.

Utilisation impact

- Outputs from the project were used to inform the development of the National Flood Planning for Disaster Resilience Handbook.
- Outcomes of the research have been presented widely across industry forums including:

2017/18

- NT BNHCRC research workshop, Darwin.
- International Day for Disaster Risk Reduction, Sydney.

2018/19

- Australasian Fire and Emergency Services Council Conference, Perth.
- Australian and New Zealand Disaster and Emergency Management Conference, Gold Coast.
- APRU Multi-Hazards Symposium, Canberra.
- South Australia Government Zone Emergency Management Conference, Adelaide.
- Victoria State Emergency Service Crisis Leadership Workshops, Mt Macedon.
- South Australian Government Business Resilience Forum, Adelaide.

- National Floodplain Management Conference, Canberra.
- 2nd Annual Emergency Management Leaders Forum, Melbourne.
- BNHCRC Research Advisory Forum, Melbourne.
- BHNCRC Research Advisory Forum, Canberra.
- BNHCRC Research Advisory Forum, Perth.
- Department of Home Affairs Catastrophic Disasters Planning Workshop, Canberra. A key discussion point recorded in the workshop outcomes was " better understanding of the capabilities of the public, private and non-government sectors is required to support a whole-of-community, nationwide approach" to catastrophic disasters.
- RFS Volunteers Association Conference, Sydney.

2019/20

- Australasian Fire and Emergency Services Council Conference, Melbourne.
- NSW Smart Sensing Network Bushfire Forum, Virtual.
- Australasian Business Continuity Summit, Sydney.
- Venture Café, Macquarie University, November.
- Venture Café, Macquarie University, February.

- Other meetings to brief organisations on the research outcomes were held with Department of Prime Minister and Cabinet, Bushfire Recovery Authority, Home Affairs, VCOSS, Mountains Community Resource Network, QFES, SA Department for Environment and Water, VIC IGEM, QLD IGEM, NSW Bushfire Inquiry, VICSES, APRA and Australian Business Roundtable.
- The following publications have been published or submitted:
  - Gissing, A (2018) Late bushfire season and extreme heat put pressure on resources. [Available Online] lighthouse.mq.edu.au/article/late-bushfire-season-will-cost-australia-dearly.
  - Gissing, A (2018) Could Sydney be the next Houston? Fire Australia [Available Online] bnhcrc.com.au/news/2018/could-sydney-be-next-houston
  - Gissing, A (2018) Could Sydney be the next Houston? Asia Pacific Fire Magazine
  - van Leeuwen, J., Gissing, A and Avci, A. (2018) Response to the Lombok Earthquake, 2018 – rapid assessment study. Non-peer reviewed research proceedings from the Bushfire and Natural Hazards CRC & AFAC conference. Perth, 5-8 September 2018.
  - Gissing, A., Eburn, M. and McAneney, J. (2018) Planning and capability requirements for catastrophic and cascading events.

Non-peer reviewed research proceedings from the Bushfire and Natural Hazards CRC & AFAC conference. Perth, 5-8 September 2018.

- Gissing, A., Eburn, M. and McAneney, J. (2019) Planning and capbility requirements for catastrophic and cascading events. Palgrave Series ARPU proceedings.
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- van Leeuwen, J. & Gissing, A. (2019). Business involvement in natural disasters in Australia and New Zealand. Australian Journal of Emergency Management Monograph 4.
- Gissing, A. & Eburn, A. (2019). Australia needs a national crisis plan, and not just for bushfires. https://theconversation.com/australia-needs-a-national-crisis-plan-and-not-just-for-bushfires-128781
- Gissing, A., Timms, M., Browning, S., Coates, L., Crompton, R., McAneney, J., (2020) Compound natural disasters in Australia: a historical analysis. (Submission)
- Gissing, A. & George S, (2020) Enhancing planning and capability for dealing with Australian catastrophic disasters through the involvement of community organisations and businesses: a whole-of-community approach. (Submission)
- Gissing, A. (2020) Leading through catastrophe: leadership experience of Major-General Alan Stretton during Cyclone Tracy aftermath. (submission)

- Significant opportunities have been taken in 2019/20 to promote the research through the media including:
    - ABC Background Briefing (Queensland Fires).
    - Interviews ABC 24 (x2).
    - Interview National Geographic Documentary.

- Channel 7 The Latest - twitter.com/7NewsSydney/status/1193880028632637446
- Sky News Breakfast - www.news.com.au/video/id-5348771529001-6102713873001/fireauthorities-warn-100000-sydney-homes-are-at-risk.
- Studio 10 Channel 10 10play.com.au/studio-10/episodes/2019/studio-10-12-nov2019/tpv191112dpshb.
- Channel 10 News.
- The Drum iview.abc.net.au/show/drum.
- Interview with Bloomberg Media.
- Interview Triple M radio.
- Interviews with the Guardian www.google.com.au/amp/s/amp.theguardian.com/australia news/2019/nov/14/lightning-strikes-likely-to-spark-fires-as-thunderstorms-forecast-for-tinderdry-queensland and www.theguardian.com/australia-news/2019/nov/22/australiabushfires-factcheck-are-this-years-fires-unprecedented.
- New Scientist - www.newscientist.com/article/2223061-worsening-bushfires-causeaustralia-to-declare-state-of-emergency/.
- Xinhuanet - www.xinhuanet.com/english/2019-11/13/c_138551601.htm.
- Scoop.co.nz - pacific.scoop.co.nz/2019/11/bushfires-rage-along-australias-east-coast/.
- Newshub.co.nz - www.newshub.co.nz/home/world/2019/11/australia-fires-nswbushfires-threaten-100-000-sydney-homes.html.
- SunSentinel South Florida - www.sun-sentinel.com/sns-tns-bc-australia-fires-1st-lede20191112-story.html.
- AAP Interview.
- Interview ABC Brisbane Drive.
- Interview Queensland Country Radio.
- Interview with the Guardian on bushfire smoke.
- Interview BBC world news.
- Interview BBC Asian Business NEWS.
- Interview Sky News.
- Interview CNA (Singapore).
- Interview 7.30 Report.
- Interview Channel 4 UK.
- Interview Australian Financial Review - www.afr.com/companies/financial-services/asfires-rage-does-australia-need-to-a-strategy-to-deal-with-national-disasters-20191210-p53iin.
- Interview The Age - www.watoday.com.au/national/victoria/already-blackened-by-firevictoria-s-bushfire-peak-could-still-be-ahead-20200107-p53pkp.html.

- Interview Sydney Morning Herald - www.smh.com.au/politics/federal/political-stuntfederal-government-launches-bushfire-inquiry-to-probe-state-policy-20191223-p53mh3.html.
- Interview Bloomberg - www.bloombergquint.com/global-economics/deadly-australiafires-spur-calls-to-mitigate-disaster-risk.
- Interview New York Times – www.nytimes.com/2020/01/14/world/australia/firesmallacoota.html.
- Interview Scientias - www.scientias.nl/het-australische-landschap-staat-in-vuur-en-vlammaar-waarom/.
- Interview Financial Times.
- Interview Xinhua - www.xinhuanet.com/english/2020-01/09/c_138691225.htm.
- Interview Yahoo Finance - au.finance.yahoo.com/news/homes-at-risk-of-bushfiresinsurance-hikes-231643369.html.
- Interview Le Monde.
- Japanese TV Documentary.
- Interview Sydney Morning Herald - www.smh.com.au/national/incredibly-blessed-royal-commission-to-eye-fire-success-and-failure-20200522-p54vej.html.

LEGISLATIVE REFORM

Following the completion of the legal analysis, a Model Act was drafted. The report and Model Act were presented to Home Affairs.

Extent of use

Presentations:

- Expert Panel - International Disaster Law. Hosted by University of Victoria, Canada to provide expert commentary on proposed amendments to disaster law in British Columbia, Canada. 13 March 2020.
- Meeting ASPI, 25 November 2019.

Blog posts

- What is a national emergency? A question the Royal Commission into National Natural Disaster Arrangements is asking (May 11, 2020).
- What is a national emergency? Answer: Covid-19. (March 25, 2020).
- A commonwealth emergency response agency (January 5, 2020).
- What is a 'national emergency'? (December 25, 2019).

Submissions

- Submissions were made by Risk Frontiers and ANU to the Royal Commission into National Natural Disaster Arrangements referencing key findings of the project.

Utilisation potential

- There is potential to consider the Model Act in drafting any future legislative reform to provide additional powers to the Commonwealth in the context of a catastrophic event.
- The Model Act can now be considered by end-users.

COMPOUND DISASTERS

In 2019/20 research was completed to conduct an analysis of disaster loss databases to identify the historical frequency of compound disasters in Australia. The results will help to better inform risk assessment of compound disasters.

The recently released reports of the Climate Measurement Standards Initiative recommends the use of historical compound disaster case studies to inform climate related disclosures (Earth Systems and Climate Change Hub, 2020). Our research provides evidence of the five most significant compound disasters since 1966/67 that can be utilised for this purpose.

Extent of use

- The research was presented at the following conferences:
    - AMOS, Perth, February 2020.
    - Floodplain Management Australia, (Virtual), May 2020.
- The research was presented to QFES in 2020, who indicated a strong appetite to utilise the research to better inform risk assessments.
- Outcomes of the research were presented in evidence to the Royal Commission into National Natural Disaster Arrangements.

Utilisation potential

- The research could be utilised to draft specific guidance on how to consider compound disasters as part to the National Emergency Risk Assessment Guideline.
- The methodology could be repeated utilising different disaster loss databases; for example, on a global scale.
- Research was completed in May 2020 so the utilisation impact would be expected over the coming months to years.

NEXT STEPS

The following utilisation activities will occur:

- The research team is now working with Emergency Management Australia – Home Affairs to promote the capability maturity assessment framework across Australia.
- A communications plan will be developed with key stakeholders to communicate the outcomes of the business and community involvement in disaster management research. Findings will be distributed amongst the national Social Recovery Reference Group.
- Further utilisation opportunities will be explored regarding the research on the historical frequency of compound events. Jurisdictions have indicated an interest in utilising this work.
- Consideration by end-users of the Model Commonwealth Emergency Management Act.

PUBLICATIONS LIST

PEER-REVIEWED JOURNAL ARTICLES

1 Gissing, A., Timms, M., Browning, S., Coates, L., Crompton, R., McAneney, J., (2020) Compound Natural Disasters in Australia: A Historical Analysis. (Submission)

2 Gissing, A. & George S, (2020) Enhancing planning and capability for dealing with Australian catastrophic disasters through the involvement of community organisations and businesses: A whole-of-community approach. (Submission)

3 Gissing, A. (2020) Leading through catastrophe: leadership experience of Major-General Alan Stretton during Cyclone Tracy aftermath. (submission)

4 Gissing, A (2020) Planning for Catastrophic Disasters in Australia (under revision)

CONFERENCE PAPERS

5 van Leeuwen, J & Gissing, A (2019) Business involvement in natural disasters in Australia and New Zealand. Proceedings of Bushfire and Natural Hazards CRC & AFAC conference. Melbourne.

6 Gissing, A., Eburn, M. and McAneney, J. (2019) Planning and Capbility Requirements for Catastrophic and Cascading Events. Palgrave Series ARPU proceedings.

7 van Leeuwen, J., Gissing, A and Avci, A. (2018) Response to the Lombok Earthquake, 2018 – Rapid Assessment Study. Non-peer reviewed research proceedings from the Bushfire and Natural Hazards CRC & AFAC conference. Perth, 5-8 September 2018.

8 Gissing, A., Eburn, M. and McAneney, J. (2018) Planning and Capability Requirements for Catastrophic and Cascading Events. Non-peer reviewed research proceedings from the Bushfire and Natural Hazards CRC & AFAC conference. Perth, 5-8 September 2018.

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9 Gissing, A. and George, S. (2020) Community Organisation Involvement in Disaster Management. Bushfire and Natural Hazards Cooperative Research Centre, East Melbourne.

10 Gissing, A. and George, S. (2020) Business Involvement in Disaster Management. Bushfire and Natural Hazards Cooperative Research Centre, East Melbourne.

11 Gissing, A., Timms, M., Browning, S., Coates, L., Crompton, R. and McAneney, J., (2020) Compound Natural Disasters in Australia: A Historical Analysis. Bushfire and Natural Hazards Cooperative Research Centre, East Melbourne.

12 Eburn, M., Moore, C. and Gissing, A. (2019) The Potential Role of the Commonwealth in Responding to Catastrophic Disasters. Bushfire and Natural Hazards Cooperative Research Centre, East Melbourne.

13 Gissing, A., Eburn, M. and McAneney, J. (2018) Shaping Futrue Catastrophic Disasters. Bushfire and Natural Hazards Cooperative Research Centre, East Melbourne.

14 Gissing, A. (2018) Increasing Emergency Management Capacity Through Business Sector Involvement. Bushfire and Natural Hazards Cooperative Research Centre, East Melbourne.

15 Gissing, A., Eburn, M. and McAneney, J. (2018) Planning and capability requirements for catastrophic disasters- perspectives of Australian and International Emergency Managers. Bushfire and Natural Hazards Cooperative Research Centre, East Melbourne.

16 Gissing, A., Eburn, M. and McAneney, J. (2018) Planning and Capability Requirements For Catastrophic and Cascading Events. Bushfire and Natural Hazards Cooperative Research Centre, East Melbourne.

OTHER

17 Eburn, M. What is a national emergency? A question the Royal Commission into National Natural Disaster Arrangements is asking (May 11, 2020)

18 Eburn, M. What is a national emergency? Answer: Covid-19. (March 25, 2020)

19 Eburn, M. A commonwealth emergency response agency (January 5, 2020)

20 Eburn M. What is a 'national emergency'? (December 25, 2019)

21 Gissing, A. & Eburn, A. (2019). Australia needs a national crisis plan, and not just for bushfires. https://theconversation.com/australia-needs-a-national-crisis-plan-and-not-just-for-bushfires-128781

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RESEARCH TEAM

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Lucinda Coates

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END-USERS

End-user representative	End-user organisation	Extent of engagement (Describe type of engagement)
Roger Mentha	FRNSW	Lead End-User
David Baker	VICSES	Presentations provided on research progress and completion of VICSES Masterclass
John Rolfe	QFES	Presentations provided on research progress
Matthew Thompson	QFES	Presentations provided on research progress
Melanie Mills	EMV	Presentations provided on research progress
Joe Buffone	Home Affairs	End-user champion for use of maturity assessment tool in NSW
Ed Pikusa	DEWNR	Presentations provided on research progress
Liz Connell	SA SES	Presentations provided on research progress. Provided presentation to SA Emergency Management Forum
Danielle Meggos	Resilience NSW	End-user champion for use of maturity assessment tool in NSW
Sue Gould	SAFECOM	Presentations provided on research progress
Brenton Keen	SAFECOM	Presentations provided on research progress

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