Natural Hazards Research Australia

Australian Government

About Natural Hazards Research Australia

Natural Hazards Research Australia is Australia's national research centre for natural hazard resilience and disaster risk reduction.

The Centre was funded for 10 years in 2021 by the Australian Government as a collaborative research organisation, to address the major challenges arising from natural hazards, including bushfires, floods, cyclones, heatwaves, storms and other hazards.

The Centre's vision is that communities will be safer, more resilient and sustainable in the face of natural hazards.

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To contact Natural Hazards Research Australia,
email office@naturalhazards.com.au

Be Ahead of Ready

We live in a time of increasing risks from natural hazards.

The Royal Commission into National Natural Disaster Arrangements (2020) is among many recent reports both in Australia and internationally to conclude that natural hazard disasters, in part due to climate change, are expected to become more frequent, more complex, more intense, more unpredictable and more difficult to manage.

In the future we will likely see:

- widening impacts of natural hazards across societal, infrastructure and financial systems
- compounding hazards with impacts far greater than the sum of individual disasters
- more people living in an almost constant state of either preparation or recovery
- greater complexity of disasters as systems become more interconnected and infrastructure is transformed, leading to cascading and unforeseen impacts
- rising insurance unaffordability in high-risk areas
- increasing impacts on physical and mental health
- changing vulnerability due to trends such as decarbonisation
- greater species and habitat loss in the natural environment
- increased natural hazards disruption at a national scale, necessitating a greater need for Commonwealth government support

These changes will result in greater demand on disaster management capabilities already under pressure from the rising frequency and severity of disaster impacts and a greater interest in disaster management by non-traditional partners.

The need is urgent. Doing more of the same is no longer sufficient. Small changes won't get us there in time. As the natural hazard threat evolves, we must transform to **Be Ahead of Ready**.

To **Be Ahead of Ready** is to achieve a future end state where communities are safe, resilient and sustainable. It is to be ahead of the curve, where risk is foreseen, and proactive measures are taken to reduce or adapt to threats, and ensure sufficient future capability to minimise impacts via response and aid recovery from disasters.

To **Be Ahead of Ready** requires us all to lead by thinking bigger and bolder and embrace a diversity of ideas. We must be creative and innovative, visionary and strategic. Too often change is reactive in the aftermath of natural hazard events and incremental in its advancement. How do we switch to a transformative, more ambitious model of change, in anticipation of worsening threats, to create a long-term vision for our society?

To **Be Ahead of Ready** means we must consider emerging threats as opportunities. It requires a shift from thinking about the next high-risk weather season, to the decade ahead and beyond. It means moving from tactical, short-term considerations of the last disaster event to a focus on the implications of longer-term trends.

Not every idea will immediately transform Australia, while often several ideas will need to be implemented concurrently to ensure sustainable, coordinated change across operations, strategy and policy. Decisions must be made now to safeguard our future. What capabilities must we start to build today so we are ready for tomorrow and beyond? What policy, cultural and systemic changes are required to make real change happen? An environment and culture that best fosters and enables innovation in capability and policy sustained by long-term commitment is needed to ensure we are able to meet this challenge.

Innovation is already occurring; applicable technologies already exist and continue to be developed, posing big questions. How can the built environment be made more resilient? How will emerging technologies aid and enhance capability? How can existing technologies be scaled? How best to empower First Nations people to strengthen and protect landscapes and communities? How can we develop and maintain a suitable future workforce? What is the right role for government, business and the community? How do we fund a resilient future?

History shows that we can achieve the change needed, though often too late for some. Global natural hazard deaths, for example, have decreased over recent decades due to advances in early warning systems and global telecommunications technology.

Leveraging change from mega trends, for example deploying artificial intelligence and advanced autonomous systems, will see new disaster management technologies adapted from technological advancements and create new and exponential opportunities for intelligence, preparedness, mitigation and operational activities.

Change will not be without challenge. As innovation accelerates, agencies are challenged to keeping pace with the assessment, cost and implementation of new technologies. The rapid advancement and production of data is akin to managing a data tsunami, with government and agencies already rushed to develop policies and practices. Change is also altering the requirements of the future workforce, as well as posing ethical questions.

A proactive, whole-of-community, collaborative approach is essential, where government, agencies, not-for-profits, the private sector, researchers, First Nations people and communities are stakeholders and partners. Our future requires us to develop a diversity of skills, expertise, and ideas. Most of all we need to be curious.

Research plays a critical part in inspiring innovation, providing evidence and technologies, and testing news ideas. Research can identify the knowledge needed to build upon and the gaps where we need to know more before we proceed. Armed with this new knowledge, research will map the way forward. Through extensive collaboration with a diverse range of stakeholders and across a range of scientific disciplines, workable, efficient and sustainable solutions can be tested and implemented.

Natural Hazards Research Australia, through the **Be Ahead of Ready** initiative, has undertaken research and consultation to identify big ideas that will drive a resilient, safe and sustainable future. This project has provided a unique opportunity to engage with more than 300 stakeholders from a wide variety of sectors, including the emergency management agencies and authorities, local, state and Commonwealth government, not-for-profit organisations (community and First Nations organisations), insurance and banking organisations, and research. Stakeholders were asked to think outside their sector and comfort zones to identify the big ideas that will positively change our future. This paper presents the key ideas that emerged from **Be Ahead of Ready's** iterative process of discovery with these stakeholders. A combination of select expert reviewers and AI systems[1] then refined and built upon the findings.

This paper is designed to prompt thought and discussion about what action is needed right now to ensure Australia can **Be Ahead of Ready,** as well as how research can support these actions. The ideas explored are not exhaustive and there will be more to come.

Natural Hazards Research Australia looks forward to feedback on the ideas outlined in this document, their prioritisation and areas for future exploration and research.

1 Chat GPT 4

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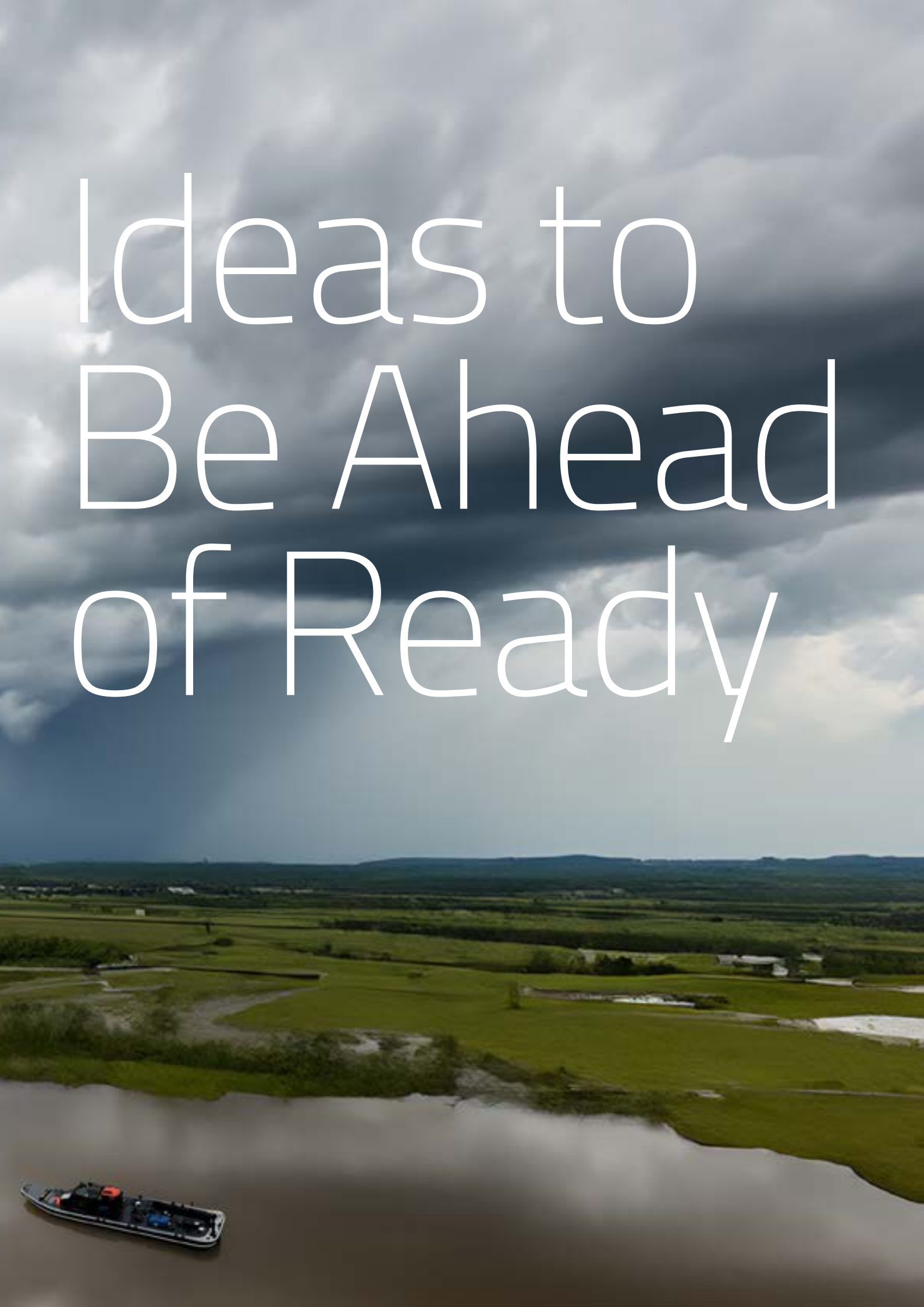

Ideas to Be Ahead of Ready

Better and faster decisions

Better and faster decisions

Imagine the threat of a severe natural hazard that emergency services could forecast in real time, identify and triage people and properties most in need, then automatically task autonomous assets with minimal human intervention to provide lifesaving assistance, warnings and other support.

The rapid and effective decision-making required during natural hazards is a critical component of emergency response and management. The escalating deployment of advanced sensors, including drones, wearables, ground-based sensors and satellites, alongside the expanding capabilities of artificial intelligence (AI), presents a transformative opportunity to enhance situational awareness, predictive modelling and ultimately, the decision-making process. These technological advancements have the potential to revolutionise how we prepare for, respond to, and recover from natural hazards, helping ensure communities are safer and able to be more resilient.

Integrating data from diverse sensors provides a comprehensive real-time picture of human, natural and built environments. AI's ability to analyse vast datasets from these sensors means decision-makers can access nuanced insights into rapidly evolving emergency situations. Satellite imagery can track the spread of bushfires in real time, while drones can assess the damage to infrastructure immediately after a natural hazard to provide intelligent insights on damage and useability. This enhanced situational awareness will enable better informed decisions, ensuring the efficient and effective allocation of resources.

Sensors augmented with enhanced insights into individual and asset level vulnerabilities and capabilities will enable emergency services to prioritise the most vulnerable people and properties and identify others who have the skills and equipment that may assist.

The development of common, integrated national systems for data integration and sharing is essential to fostering interoperability among emergency services, achieving multi-dimensional situational awareness, and scaling future innovation. Sharing systems ensures all stakeholders can access the same information, facilitating a coordinated response to disasters. This national framework would streamline communications and decision-making processes, significantly improving the speed and effectiveness of emergency responses.

Significant progress in areas such as weather forecasting, impact assessment and bushfire detection illustrates the potential of these technologies. For example, research shows that AI can significantly outperform traditional approaches to flood forecasting and warnings and is already being used to assist emergency call centres to utilise resources more effectively. Further advancements in natural hazard impact-based forecasting could dramatically enhance our ability to protect communities.

Autonomous robots and vehicles, equipped with advanced sensors, AI, and communication technologies, represent a leap forward in emergency response capabilities. Autonomous assets deployed with minimal human intervention based on predictive analytics to areas of greatest need could coordinate with each other to perform a variety of tasks, from firefighting and search and rescue operations to rapid impact assessment and the delivery of emergency relief. By working in environments too dangerous for humans, these robots and vehicles augment human response capabilities, as well as ensure the safety of first responders. From a community perspective, driverless vehicles could be programmed along evacuation routes and directed away from hazards such as floodwater or to shelter during hailstorms.

Examples of areas for further research include:

- Identification of end-user system requirements against data and analytical capabilities
- Ethics of the deployment of AI in disaster management environments
- Implications for current workforce arrangements, including skills and training
- Ensuring decision making tools are accessible and inclusive for everyone who needs them

Better warnings

Better warnings

Personalised warnings and engagement

Imagine as a natural hazard threatens, you receive an emergency warning tailored to your personal circumstances that prompts you to take action.

Emergency warnings are vital in providing alerts to communities about impending natural hazard threats. Despite research demonstrating that warnings result in lower fatalities, deficiencies are routinely highlighted by post event inquiries and research.

Warnings could be more personalised[2]. Current warnings largely assume that everyone is similar, when in reality, individuals and households have significant differences in their vulnerabilities, habits and interpretation of information.

By leveraging the wealth of data generated by individuals' digital footprints, personal digital twins can be created. Personal digital twins are a digital representation mirroring an individual's physical, psychological and behavioural characteristics. Emergency warning systems can utilise personal digital twins to generate alerts that are not only geographically specific but also tailored to individual circumstances, behaviours, vulnerabilities and preferences. This approach has the potential to dramatically improve the effectiveness of warnings, enhancing public safety and reducing the impact of natural hazards.

Imagine a system where emergency warnings are tailored to an individual's specific living situation, including their type of home, its construction materials, state of repair, floor height, surrounding vegetation and location relative to the natural hazard risks. The system could also consider the characteristics of the individual or household: for example, age, disability and medical conditions that might mean additional assistance is required. Based on a history of previous emergencies, the system could also identify decision making preferences, as well as information about relationships between different household members and social networks. By integrating data about the daily habits and routines of individual community members, warnings could be tailored to maximise the persuasive influence to take action.

Individuals' digital footprints, including metadata from social media, online shopping, smart home devices, previous information provided to access emergency or government assistance and mobile phone usage, can provide valuable insights into personal routines, preferences and needs. By analysing this data, AI algorithms can generate personalised warnings that account for an individual's location, communication preferences, and even the most effective language or imagery to prompt action. For example, a young family might receive tips on how to explain the situation to the children and be provided with the best evacuation route.

2 See further here: Dr Sally Potter's TEDX presentation on personalised warnings https://www.youtube.com/watch?v=ndk62I_Z_wU

Incorporating AI-powered chatbots and virtual assistants into emergency warning systems could also transform the way individuals interact with and respond to warnings. Instead of one-way communication, at-risk residents could ask questions specific to their circumstances, receive real-time updates and access advice on how to prepare or respond. This interactive capability would ensure dynamic warnings and advice as the situation evolves, and residents' needs change throughout the duration of the hazard.

The use of augmented reality would enable community members to see and understand the potential outcomes of emergency warnings, including a forecast flood height in their home, or their property during bushfire ember attack. AI could guide and inform property preparedness by highlighting at-risk areas and preparation activities needed to provide the best chance of avoiding danger and reduce damages.

Beyond immediate emergency warnings, the same personalised and interactive approach can enhance longer term community engagement and preparedness activities. Tailored advice on reducing risk, based on specific property characteristics and local hazard profiles could be offered through interactive platforms. Residents could also receive customised recommendations for mitigating risks such as retrofitting their home for flood, bushfire or cyclone resilience.

The implementation of highly personalised warnings raises important considerations, including privacy concerns, data security and the need for opt-in and opt-out mechanisms to ensure individuals are comfortable with how their data is stored and used. Moreover, ensuring equitable access to these advanced warning systems is crucial so that, regardless of digital literacy, financial resources or access to technology, all community members are able to access and benefit from AI-supported preparedness and personalised warnings. It must also be noted that current back-up systems will still be required, such as the battery powered radios and other traditional formats.

Examples of areas for further research include:

- → Development of personalised warnings including how such warnings could be delivered to cater for a range of digital literacies and to consider ethical, privacy and liability concerns
- → Construction of messaging including the delivery of personalised warnings to ensure they are simple, clear and that they ultimately compel action

Global warnings

Imagine travelling anywhere in the world and you receive timely and personalised warnings through a single global application.

Travellers throughout the world are uniquely vulnerable to the impacts of natural hazards. 26 Australians died in the 2004 Asian tsunami while holidaying abroad. The development of a global emergency warning system application would ensure that tourists, regardless of their home and destination, receive timely and relevant warnings about potential natural hazards and other emergencies, in a language and format that is easy for them to understand. This addresses a critical gap in current emergency management systems, where tourists may be unaware of local warning systems or unable to understand alerts due to language and social barriers.

A global emergency warning application would be accessible via everyday platforms, including smartphones, smartwatches and other personal devices, and leverage existing technologies and infrastructure, such as GPS and mobile internet, to ensure alerts are received directly and immediately, wherever you are in the world. To enable this, the global system must be integrated with local and national emergency management systems, allowing for seamless flow of information from local authorities to international travellers through the common application. This would require cooperation and data sharing agreements between countries, as well as standardised formats for issuing warnings to ensure consistency and reliability.

Beyond providing emergency warnings, a global application could offer educational resources and preparedness information tailored to the specific destinations of travellers. Before and during their trip, tourists could access tips on local hazards, emergency contacts and evacuation routes, further enhancing their ability to effectively respond to any hazard they might face.

Examples of areas for further research include:

- Establishment of global data governance to enable international collaboration and data sharing
- Development of global warning via accessible of global warnings via accessible deliverable platforms across diverse communities

Resilient infrastructure, homes and communities

Resilient infrastructure

Imagine blackouts never happen during a natural hazard or you can always contact loved ones to reassure them that you are safe.

Infrastructure resilience is paramount to community wellbeing. It not only minimises disruption of essential services, but also ensures the fastest possible recovery of communities following a natural hazard. Technology plays a critical role in building and enhancing this resilience, with advances and innovative solutions to transform the way critical services and infrastructure are able to withstand, respond to, and support recovery from natural hazards.

Decentralised power generation and the development of microgrids are a significant shift away from traditional, centralised power systems. This approach ensures that even if one part of the grid fails, other sections remain operational, significantly improving operational performance and community resilience. Microgrids can operate independently from the main power grid using local energy sources, including solar panels, wind turbines and battery storage. This is crucial during natural hazards as it ensures the ongoing operation of critical infrastructure, such as hospitals, emergency services, and evacuation centres. Additionally, the increasing number of electrical vehicles provide an alternative power source for homes and businesses when the mains supply is cut.

Advanced monitoring systems in infrastructure management can significantly improve the response and the ability to pre-empt potential failures. Embedding sensors within infrastructure provides continuous and real-time data about the stress, vibrations, cracks, and possible early signs of equipment and service failure, enabling emergency services and maintenance teams to prioritise interventions, focusing resources where they are needed most and potentially preventing catastrophic failures. Furthermore, AI and machine learning can analyse sensor data to predict and mitigate future vulnerabilities, enhancing long-term resilience.

3D printing technology can provide rapid repair to damaged infrastructure. Onsite construction of replacement components using 3D printing significantly reduces repair time and cost, particularly in remote or hard-to-access areas where transporting materials is logistically challenging, or in the immediate aftermath of a disaster when quick restoration is critical.

The development of smart materials and self-healing technologies presents a futuristic yet increasingly viable solution to infrastructure resilience. Materials that can respond to environmental changes, then initiating repairs without human intervention could drastically reduce maintenance needs and extend the lifespan of infrastructure components.

Future design and positioning of infrastructure is critical to safeguarding their resilience to current and changing nature of natural hazards. This includes rethinking the design, materials, construction and positioning of powerlines, bridges, roads and buildings so that they can withstand natural hazards. Incorporating flexibility, redundancy and the latest materials science innovations will be key in developing infrastructure that not only survives but thrives in the face of natural hazards.

Examples of areas for further research include:

- Creation of data analytics-informed risk reduction activities, including the development of advanced algorithms and models that can more accurately predict infrastructure failures
- Acceleration of smart materials development, focusing on durability, cost effectiveness, and application in, and integration with various infrastructure components.

Resilient homes and communities

Imagine no new homes were exposed to high hazard, frequent natural hazard impacts, and existing homes in high-risk areas were retrofitted to ensure resilience to impacts or their residents were supported to relocate to a safer area.

Australia is a land of natural hazards with many homes located in areas at high risk of natural hazards. As the frequency, intensity and complexity of hazards increase, existing and new home exposure to natural hazards and associated impacts will also increase, especially as population growth and housing development grows to meet our population needs.

Without change, community resilience in Australia will decline, making some homes unliveable or in a state of continuous recovery. It will also follow that insurance becomes unavailable or unaffordable for many households. Mortgages for houses in high-risk areas will become difficult to obtain and community wellbeing will be negatively affected. Vulnerable members of our communities will again bear the brunt of insecure and unaffordable housing, rental stress and difficulty in relocating to safer areas. In such areas assisted relocations will warrant further consideration[3].

Even though natural hazards exposure and resilience is considered by existing planning regimes, land use planning decisions do not always account for them, exposing homes and communities to risks that could be avoided or reduced. Construction standards and materials that do not properly consider current and changing natural hazard risk means homes may not be built to withstand or reduce the impact of natural hazards.

A better approach to land use planning, urban design and home construction would make our homes and communities less exposed and more resilient to natural hazards. Standard of living and community wellbeing would increase with less in-home extreme temperature management and disruptions from natural hazard events and impacts, and the economic and social costs of natural hazard would reduce.

3 See further here: Assisted Relocations – a community centred approach.pdf (naturalhazards.com.au)

While reforms and investment in land use planning, urban design and home construction are required, trade-offs must be managed to ensure a successful implementation of consistently resilient homes. Not all homes in all parts of Australia will be exposed to the same level of natural hazard risk, while not all individuals or organisations will be able to afford the highest possible standard of construction. Housing affordability must be considered and an approach that understands and mitigates these trade-offs in an integrated, wholistic and socially equitable way is vital.

This could be achieved by developing:

- A national settlement plan that sets clear and consistent criteria for land use planning, urban design and home construction by accounting for current and future natural hazard risk. The plan should be informed by careful analysis of existing practice, codes and regulations, and by best practice planning and design standards. It would need to be supported by:
  - nationally consistent hazard mapping, inclusive of all natural hazards and guidance for use of climate projections
  - improved understanding of community risk appetite and avoided losses through decision making
  - consistent land suitability analysis to identify opportunities to develop areas with low or no natural hazard risk and consideration of policies to encourage development in these areas
  - nationally consistent legislation, construction codes and standards that respond to different land uses with different risk profiles
  - the development of building risk ratings for hazard risk and resilience
  - uniform guidance on the data and knowledge needed to inform local planning and design consistent with the plan
  - maintenance and investment in social infrastructure
  - consideration of assisted relocation strategies for homes in areas of high risk
  - development of local government capability activities
- A nationwide 'resilient build' program that showcases examples of how to make homes more resilient to the natural hazards that are or may be prevalent in a local area. A program delivered in partnership between government, insurers and builders would focus on providing an onsite and virtual education and communication component for building professionals and homeowners to enable and mainstream a better understanding of available technologies and how to design and implement improved resilience outcomes for Australian homes. Ongoing property management information would be incorporated, as would landscape and vegetation management for risk reduction
- The development of new building materials that make our homes more resilient. Resilient building materials may include materials that offer higher levels of protection to natural hazards and can be more easily and quickly repaired after a natural hazard.

Existing building stock cannot be ignored. There is a need for a risk-based national retro-fitting strategy to ensure existing homes in high-risk areas are made resilient to natural hazards impacts.

The role of nature in building resilient communities, through nature positive disaster risk reduction, is an approach to mitigating the impact of natural hazards by working with and enhancing natural eco-systems. We already know that measures such as planting trees reduces urban heat, while restoring mangroves can reduce the severity and impact of coastal hazards. These measures have significant co-benefits including better air and water quality, enhanced biodiversity and enhanced human health. Implementation can be linked to national decarbonisation and biodiversity markets and targets.

Examples of areas for further research include:

- → Understanding suitable incentives for the uptake of resilient homes across Australia, including individual homeowner motivation and incentives (for example, the role of insurance) and incentives for developers
- → Development of resilient building materials that withstand the impact of natural hazards
- → Consolidation and communication of post-construction risk mitigation information, including property maintenance, pre-event preparation and landscape and vegetation management
- → Identification of the most beneficial pathways and triggers for a consistent approach to managed retreat and assisted relocation, including the role of buy-back schemes

Workforce capability

Workforce capability

Imagine when a severe natural hazard threatens, there was confidence in the capability and capacity to meet the threat.

Preparing for, responding to and recovering from natural hazards has traditionally required a large, skilled and coordinated workforce. Australia's long history of a career and volunteer workforce working in partnership with local communities, not-for-profit organisations, businesses, and other service providers to manage natural hazards means that strong inter-state, national and international coordination of resources, particularly in response, is a feature of the Australian system, but less so in preparation and recovery.

Our current workforce and ways of working are being stretched thin by the increasing pressures of climate change, settlement and land use change, and changes to how we live and work. At the same time, new technology offers the opportunity for a more innovative and efficient workforce. As the need to build capability to manage future natural hazards grows, so too does the complexity of ensuring alignment of resources and planning across Australia. The emergency management workforce must undergo a transformation to develop the new capabilities required to navigate the evolving landscape of natural hazards into the future. This transformation must integrate seamlessly across various sectors, ensuring a unified front against the ever-changing natural hazard threat. This is not only a necessity, it is a mandate for the future resilience of our communities in the face of looming challenges.

A systematic understanding of workforce capability, now and in the future, will aid in the planning and development of the future workforce. It will allow the emergency management sector to identify the skills and resources required across career and volunteer workforces, and proactively identify recruitment needs, surge capacity models and opportunities to adopt technological solutions.

Technology opportunities include the adoption of bionic augmentation such as exoskeletons, augmented reality and brain computer interfaces. Exoskeletons offer unprecedented prospects for enhancing physical abilities, enabling individuals to perform tasks with increased strength and endurance. Augmented reality transforms the way we interact with the world, overlaying digital information onto the physical environment to provide immersive experiences and real-time data. Brain-computer interfaces represent a groundbreaking leap, facilitating direct communication between the human brain and external devices, potentially revolutionizing how we control technology and access information.

Assessing capability will increase efficiency by ensuring the right people are used at the right time, in the right places, with the right tools and skills to get the job done. We need to better utilise existing capabilities across businesses, not-for-profit and First Nations groups as these sectors offer additional critical capacity to contribute to disaster preparedness and recovery[4]. This will also involve embracing community leadership and emergent volunteering.

4 See relevant NHRA research projects here Connecting Indigenous people and the emergency management sector – effective partnerships | Natural Hazards Research Australia, and here community_organisation_involvement_final_report.pdf (bnhcrc.com.au).

Given likely deficiencies, consideration of multi-national capability models may assist, supported by international cooperation, governance, standards, systems, training and logistical capability. In the future, hypersonic transport will aid the deployment of international teams increasing the feasibility of global disaster response collaborations, though such models will likely have limitations given that global partners may too be overwhelmed by natural hazard impacts.

The creation of a national capability is an opportunity to identify a road map to transform Australia's emergency management capability. Such a plan would ensure that there is sufficient capability to meet future demands.

A national capability plan should focus on:

- an approach to managing natural hazards that extends beyond traditional emergency management workforce roles to articulate the roles of non-emergency management sectors for example the business sector, not-for-profits and First Nations ranger groups through the adoption of a whole-of-community approach
- technologies to reduce demands on traditional workforce models and augment career and volunteer workforces, whilst considering how technologies will alter workforce capability needs
- actively diversifying the emergency management workforce to include critical knowledge and a range of perspectives, particularly those of First Nations people, new arrivals, a range of ages, gender and workforce experiences
- opportunities for further international collaborations

Examples of areas for further research include:

- Understanding the potential for new and innovative roles for volunteers, including digital volunteers
- Understanding the current level of natural hazards 'literacy' in the non-emergency management workforce, to identify areas where additional information or training could enhance capacities
- Understanding how to harness shifts in career and volunteer engagement, which include increasing diversity, modernising career development pathways, utilising both regular and spontaneous volunteers, and working with increasingly mobile populations
- Understanding how best to incorporate new technologies into the future workforce

Investment informed by the triple bottom line

Investment informed by the triple bottom line

Imagine if we understood the true costs of natural hazards to effectively allocate resources to maximise disaster risk reduction outcomes for communities.

Delivering resilience outcomes in Australia will require significant investment. Investment decision-making is complex and involves using criteria to assess a range of options to ensure the final investment decision offers the highest value. However, accounting for the value of environmental, social and wellbeing benefits can be particularly challenging. As a consequence, investments that deliver these benefits are easily overlooked.

Examples of particular types of investments targeting improved resilience that are more likely to be overlooked currently include nature-based solutions and investments targeting social or cultural outcomes. These types of investments often have a higher proportion of environmental, social and wellbeing benefits that are more difficult to economically value and quantify. These benefits are also often delivered over longer timeframes than more immediate benefits.

Existing methods to overcome this challenge (for example, cost-benefit analysis) are useful, but are currently not used or used inconsistently, and rarely within an organised framework specific to natural hazards and disasters. Consequently, some beneficial investments are missed.

Transforming our understanding of the true costs of natural hazards and the benefits of mitigation via a data driven approach will ensure disaster risk reduction resources are most effectively directed. New methods will empower decision-makers to pinpoint, evaluate, benchmark and advocate for investments with conviction and evidence-based clarity. This transformative approach will also unearth investments previously shrouded in uncertainty, ensuring they receive the recognition and fair assessment they deserve based on their comprehensive benefits. This leap forward not only redefines the landscape of investment evaluation but also guarantees that every potential opportunity is leveraged to its fullest, paving the way for a future where every investment's true potential value is highlighted.

Improved and nationally consistent investment decision-making could be achieved through the development of a national 'return on investment' framework for resilience initiatives, supported by guidance of suitable assessment methods. This national framework would ensure a transparent, consistent approach to undertaking investment decisions that accounts for all economic, environmental and social costs and benefits.

The framework would need to be supported by:

- consistent methods to measure, quantify and compare the value of economic, environmental and social outcomes from investment in resilience initiatives
- the incorporation of the frameworks approach in Commonwealth and state/territory government funding guidelines
- the availability of contextually relevant and accurate data to support the use of the framework
- guidance for framework users, including those seeking grants or other investment from government

Examples of areas for further research include:

- Mapping of the current status of data and the definition of 'sufficient' quality to ensure the desired uplift in analysis can be undertaken
- Adaptation and/or development of assessment methods specifically suited to varying resilience, natural hazards and disaster contexts, where such applications may have been absent in the past[5]
- Development of technological pathways and tools that can best enable the framework and lower the costs of implementation
- Identification of the most appropriate application of the framework and suite of methods to different types of decisions, such as monetary and user thresholds to ensure decision-making is efficient and resources are not unnecessarily used on decision-making processes
- Investigation of the most viable pathways to communicate the purpose and use of the framework and encourage its use

5 See more on NHRA research here: Modelling impacts of natural hazards on interconnected infrastructure networks | Natural Hazards Research Australia

Dynamic measurement of risk and resilience

Imagine a continuous snapshot of natural hazard risk and resilience across Australia.

We live in a time of rapid change. Our climate is warming, community exposure and vulnerability is changing, and new risks are evolving through decarbonisation, the interactions of complex systems resulting in cascading consequences and the compounding nature of threats. These dynamics are further compounded by the rapid pace of socio-economic and environmental changes, which continue to alter resilience capacity. Despite the need to respond to the dynamic nature of natural hazard risk and resilience, the regular measurement of natural hazard risk and resilience remains insufficient, making it impossible to effectively track trends, understand the impact of stressors and shocks and gauge the effectiveness of resilience interventions across various scales – from local communities to national levels.

The dynamic measurement of risk and resilience is crucial for maintaining a timely understanding of the challenges and opportunities presented by disaster risk reduction and climate adaptation. Such dynamic measurement would serve critical functions in ensuring real-time understanding of risk and resilience, reflecting the latest environmental changes, socio-economic developments, and technological advancements. This awareness is also vital in anticipating future trends and preparing for emerging threats.

Secondly, dynamic measurement allows or the evaluation of resilience investments, enabling stakeholders to assess the effectiveness of different interventions and allocate funding to where it will have the greatest impact. This is essential for optimising the use of limited resources and ensuring resilience-building efforts are both cost-effective and impactful.

For emergency managers, a dynamic approach to measuring resilience would also facilitate informed resource allocation decisions. By understanding the current state of community resilience and the specific needs arising from ongoing and/or anticipated natural hazards, emergency preparedness and response will be more targeted and effective. Similarly, recovery managers would benefit from insights into recovery needs, the ability to identify emerging issues, and the capability to monitor recovery progress. Such information is invaluable for informing future recovery planning, ensuring that lessons learned from past events are integrated into more resilient recovery strategies.

A dynamic approach to measuring resilience would require a concerted effort to develop and implement standardised, yet adaptable, methodologies that can account for the dynamic nature of risk and resilience. It would involve near real-time data collection, continuous monitoring, and adaptive learning to understand how resilience capacities evolve over time and under different stressors.

The approach will require coordinated efforts across different stakeholders and is reliant on data sharing across sectors, including government, research and private sectors; data being available on a national scale; and local community participation.

Examples of areas for further research include:

- Identifying the best data sources to deliver dynamic insights of risk and resilience
- Measurement of the effect of compound disasters on resilience

Innovative public-private partnerships

Public-private partnerships to deliver innovation

Imagine disaster management could directly leverage the innovation, research and development progress of commercial enterprises by being a partner from concept to delivery.

Innovation is essential to deliver the exponential growth in capability required to support Australia in effectively and efficiently meeting the disaster management challenges of the future. Innovation includes both the creation of new products and services and the application of existing products and services to new areas. Research and development are only a limited part of Australia's emergency management sector's remit. Commercial enterprises, typically the private sector or research and development organisations, but also including non-profit and philanthropic bodies, drive much of the innovation in Australia. However, innovation can be costly and time consuming.

Australian disaster management could significantly benefit from the full innovative capacity of commercial enterprises. However, existing approaches used to foster innovation limit viable ideas becoming commercialised. Without a clear pathway to commercialisation, those most capable of innovating are discouraged from developing ideas for disaster management, preferring to focus on commercially viable areas. In addition, the pursuit of potentially viable ideas for the emergency management sector can be lost before being fully developed or implemented. There are opportunities to leverage experience internationally and from different sectors to provide for an improved model.

A transformed model would catapult Australia's emergency management sector into a new era of innovation, unlocking the full spectrum of possibility and guaranteeing access to advanced cutting-edge technology and solutions. This transformed model would not only amplify Australia's capability in navigating disaster risk management but also equip it to agilely evolve in the face of our rapidly changing risk and technology landscape.

The outcomes of this revamped model would safeguard and promote the development and delivery of other ideas identified in this paper, further feeding innovation in a closed loop. For instance, a surge in local innovation will build a future workforce that is not only safer but also dramatically boost the decision-making capability of individuals and organisations, further encouraging innovation.

Beyond the immediate enhancements to Australian disaster management, an overhauled model would serve as a powerhouse for our innovation ecosystem. It would ignite a surge of new industry players and opportunities for the sector and enhance Australia's global leadership in emergency management.

A new public-private partnership model is needed to unleash a wave of innovation within the emergency management sector. This leading approach would introduce a robust national governance and investment framework, designed to galvanize commercial organisations into action by cultivating a fertile investment landscape. Achieving this vision hinges on the model's ability to provide commercial entities with a supportive investment environment that provides streamlined avenues for commercialisation and opportunities to scale innovations through a national approach.

The universal availability of government and private data provides a transformative opportunity to foster innovation by offering the private sector unprecedented access to valuable datasets. This initiative would allow businesses to tap into a rich trove of information, driving the development of solutions that cater to the varied natural hazards risk landscape. From enhancing urban planning and public health strategies to optimizing transportation systems, the availability of data opens a realm of possibilities for innovation. It encourages a collaborative ecosystem where innovators can leverage data to devise advanced, data-driven solutions, thereby catalysing technological advancements and contributing to societal progress. This symbiotic exchange not only accelerates the pace of innovation but also propels economic growth and enhances the quality of life for communities.

Examples of areas for further research include:

- → Identification and application of existing models of national governance and investment for matters of national importance, to the emergency management sector
- → Iterative testing and validation of innovation in procurement arrangements and processes that are supportive of and uphold the principles of government for equitable access to and provision of funding by government and the private sector

The challenge to Be Ahead of Ready

Our generation of disaster managers are presented with significant worsening challenges. It is critical that we **Be Ahead of Ready**.

This paper has provided ideas to inspire thinking about transformative change in the areas of future capability and policy. We do not claim it to be a comprehensive summary of all the good ideas from the **Be Ahead of Ready** process, as there are some obvious gaps. There will be many more ideas but it is hoped that in considering those outlined in this paper that conversations and debate can be inspired as to what will be necessary to create transformative change to safeguard the future safety, resilience and sustainability of Australian communities.

Research, science and innovation will be required to take a leading role in this change.

Find supporting research documents and the portfolio of projects on our website
www.naturalhazards.com.au

Natural Hazards Research Australia's staff work from Wurundjeri, Yuggera, Wangal, Tharawal, Wadawurrung and Dja Dja Wurrung Country. We thank and acknowledge the Traditional Custodians of these lands and all the lands where we work, live and walk, and pay our respects to Elders past, present and emerging. We recognise that these lands and waters have always been places of teaching, research and learning, and that sovereignty has not been ceded. We have developed a Reconciliation Action Plan to strengthen our reconciliation with First Nations peoples and communities.