

Flood Risk Management in Australia

Building flood resilience in a changing climate



December 2020

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Building flood resilience in a changing climate

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The Geneva Association

The Geneva Association was created in 1973 and is the only global association of insurance companies; our members are insurance and reinsurance Chief Executive Officers (CEOs). Based on rigorous research conducted in collaboration with our members, academic institutions and multilateral organisations, our mission is to identify and investigate key trends that are likely to shape or impact the insurance industry in the future, highlighting what is at stake for the industry; develop recommendations for the industry and for policymakers; provide a platform to our members, policymakers, academics, multilateral and non-governmental organisations to discuss these trends and recommendations; reach out to global opinion leaders and influential organisations to highlight the positive contributions of insurance to better understanding risks and to building resilient and prosperous economies and societies, and thus a more sustainable world.

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Contents

1. Executive summary	5
2. Introduction	22
3. Flood risk in Australia	23
3.1. Population growth and development patterns	26
3.2. Climate change	26
4. Evolution of flood risk management in Australia	28
4.1. Major floods as drivers of flood risk management in Australia	28
4.2. Institutional roles and responsibilities	28
4.3. Legislative actions	29
5. Components of flood risk management in Australia	32
5.1. Flood risk information, communication and awareness	32
5.2. Flood alerts and early warnings	35
5.3. Emergency preparedness measures	36
5.4. Risk reduction measures	36
5.5. Property-level protection measures	37
5.6. Prevention through development planning and land use	38
5.7. Disaster risk financing measures for government	39
5.8. Flood insurance and other risk transfer solutions in Australia	40
5.9. Reconstruction approaches	41
6. Towards an all-of-society approach to flood risk management	42
6.1. Cross-governmental collaboration	42
6.2. Cross-sectoral collaboration	42
7. Conclusions: Successes, continued challenges and lessons learned	44
References	46
Annexes	
Annex 1: Overarching questions used for mapping and analysing the evolution of flood risk management	50
Annex 2: Framework for assessing flood risk management systems	53

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1. Executive summary

As the world responds to the COVID-19 crisis, the potential compounding effects of weather-related extremes such as floods, tropical cyclones and wildfires could significantly challenge a country's emergency management capacities and slow down the socio-economic recovery. This report is part of a series on *Building Flood Resilience in a Changing Climate*, with a focus on mature economies. It points to the need for a paradigm shift from reacting to crises towards a risk-based, anticipatory, holistic and all-of-society approach to managing the potential impacts of catastrophes.

Flooding is one of the most important physical climate risks in many countries, affecting households, communities, businesses and governments on a regular basis. There are several kinds of floods, including fluvial floods (river floods); pluvial floods (surface water flowing towards rivers); coastal floods (storm surge and coastal tidal flooding). Each kind differs in terms of occurrence, potential damage and management measures.

The rising costs associated with floods are due to the combined impacts of increasing concentrations of people and assets in areas of high flood risk, land use, urbanisation and development practices as well as increasing frequency and severity of weather-related events linked to climate change (e.g. changing storm and precipitation patterns and rising sea levels) (Intergovernmental Panel on Climate Change (IPCC) 2018).

The Geneva Association has undertaken this study to take a deeper look at the evolution of flood risk management (FRM), offering a holistic, multi-stakeholder, forward-looking review of FRM in five high-income countries with mature insurance markets: the U.S., England, Germany, Australia and Canada (see Annexes 1, 2). Special attention is given to mapping the evolution of governance, institutional frameworks and the interplay of different components of FRM, including risk assessment, risk communication and awareness, risk reduction, risk prevention, risk financing, risk transfer (e.g. insurance and alternative risk transfer) and reconstruction measures. Trends and patterns are identified, although the study did not set out to draw comparisons among the five countries.

The methodology and overall recommendations of the study are provided in The Geneva Association (2020a). Case studies for the U.S., England, Germany and Canada are available in The Geneva Association (2020b), (2020c) (2020d) and (2020e), respectively. This report provides a review of FRM in Australia and highlights successes, lessons learned and continuing challenges.

Key findings:

- **Flood risks:** Australia is exposed to coastal, fluvial and pluvial flooding. Flooding is Australia's costliest natural hazard-related cause of disaster when both tangible and intangible losses are taken into account. Over the last decade, Australia has experienced major devastating floods
- **Governance of flood risk management:** Australia's constitution gives FRM and emergency management responsibility to the states and territories. The way flood risk assessment and management are delivered varies across jurisdictions, with local governments having differing degrees of responsibility and state or territory governments providing differing level of technical and financial support. Each state and territory government has established legislation or policies and plans in which the roles of various agencies are outlined. They may also provide guidance and funding to local councils to support local FRM. Government inquiries into the 2011 Queensland floods and the 2010/11 Victoria floods have made recommendations leading to major changes in flood insurance, early warning systems, emergency management planning, land use planning and reconstruction.
- **Risk assessment and communication:** Flood risk information (including mapping) generally rests with local councils or catchment management authorities in some states, and state governments in others. Considerable effort has been made in the past 10 years to improve the coverage, consistency and quality of flood risk mapping across Australia. In many cases, available information is limited to areas where flood-related planning controls apply, rather than risk mapping for a full spectrum of possible events, and in many cases requires payment of fees to local government to access risk information. Issues with information vary by state. Efforts at the state and federal levels to make flood hazard data available via open data portals have had mixed success. Some jurisdictions, actively encourage community involvement in studies to gather information, opinions on FRM options and to raise the awareness about flooding. However, the level of community awareness of flood risk is generally low, although this is largely dependent on prior flood experience. The Insurance Council of Australia (ICA) has led efforts to collate local government flood mapping for insurers,

distributing to all ICA members both raw data collected from local councils and a national address-level processed dataset (NFID).

- **Risk reduction and prevention:** There are three categories of risk reduction measures: 1) measures to modify flood behaviour, e.g. levees, detention/retarding basins; 2) measures to modify property, e.g. zoning and development control, voluntary purchase, voluntary house raising; and 3) measures to modify response (non-structural measures), e.g. community flood education & engagement, flood warning systems, emergency management planning. Major reviews of Australia's disaster funding arrangements have found that more funds should be allocated to disaster risk reduction and prevention measures and less to response and recovery. Following the devastating 2019/20 Australian bushfires, a national inquiry has been conducted that considers the diversion of more funding to risk reduction including for flooding.

There have been a range of voluntary house-raising and house buyback schemes in flood-prone communities across Australia, normally instigated by local councils or catchment management authorities with funding support from state governments. Individual landowners usually pay for flood proofing houses. Land swap schemes are still novel but gaining traction, particularly following major flood events.

Planning laws are developed by each of the states and territories and then implemented by local councils. In Australia, planning is traditionally based on the 1% Annual Exceedance Probability (AEP) or flood of record, in many cases leading to accumulation of risk in areas which still have large residual risk from potentially deep flooding in larger events. Australia is slowly moving to more appropriate measures of risk and to differentiate, e.g. vulnerable land uses.

- **Risk finance for government:** State and territory governments and local councils have primary responsibility for FRM project financing but receive co-funding from the Australian Government for some projects. A large proportion of Australia's disaster funding is attributed to disaster recovery rather than risk reduction and prevention including FRM. The Australian Government is looking to diversify risk financing arrangements. Through the Natural Disaster Risk Reduction Framework it will pursue collaborative

commercial financing options for disaster risk reduction initiatives.

- **Risk transfer and insurance:** Flood insurance is available in all parts of Australia for households and businesses, after being introduced by the private insurance market in 2007 and standardised through a common definition of flood in 2012. With penetration rate of around 93%, flood insurance pricing is risk-based, with insurers typically reflecting completed risk reduction projects through reductions in flood insurance premiums. The insurance industry is a strong advocate for improvements in land use planning and risk reduction programmes. Furthermore, the insurance industry, primarily via the Insurance Council of Australia, has been an integral part of this multi-stakeholder engagement leading to improvements and better understanding of flood insurance in Australia.”
- **Reconstruction:** A main ethos in Australian reconstruction is to ‘build back better’. A large proportion of post-flood reconstruction of public infrastructure is funded by the Australian Government and the flood-impacted state and territory governments. The evolution of development controls in a community over time influence the reconstruction of private infrastructure. This mechanism can lead to reconstructed development being more resilient to future floods. There is evidence of building back better following some floods (e.g. 2010–11 Queensland floods) particularly with public infrastructure (e.g. roads, rail networks, public utilities). An increasingly mature and responsive private flood insurance industry has enabled residents and businesses to build back better as provided by states and territories.
- **Multi-stakeholder engagement:** At a strategic level, national and state bodies such as the National Flood Risk Advisory Group, Flood Warning Consultative Committees and Floodplain Management Australia (Australia’s main flood industry professional body) enable and support cross-jurisdictional and multi-disciplinary engagement. National and state guidelines typically require engagement of the community in the FRM process, however most studies into flood risk are undertaken at a local area catchment level and the application and outcome of the engagement process is not universal across Australia.

In summary, Australia’s constitutional arrangements are a strength and weakness to FRM. Responsibility for flood mitigation may be devolved to local councils by state and territory governments (with shared funding arrangements) to enable a local approach, allowing FRM to be integrated with local councils’ other responsibilities including land use planning and asset management. However, the level of support provided to local councils varies across Australia based on the jurisdictional arrangements of the states and territories, with some jurisdictions providing additional funding or support to local governments with lower financial capacity. Australia’s devolved model for floodplain risk management has resulted in a range of outcomes: some communities are well progressed towards holistic floodplain risk management, while other communities are at a less mature stage, working towards flood risk assessments and appropriate FRM plans. High quality national and state guidelines and frameworks for FRM activities are in place, while overall funding issues and the variations at a local level in the maturity, resourcing and standard of implementation of floodplain risk management often lead to sub-par outcomes.

The flood risk management system in Australia

Response and reconstruction

- Government inquiries have found that expenditure for response and reconstruction far outweighs that for mitigation, and this imbalance needs to be addressed. Furthermore, funding for fire-related disaster management is far greater than for flooding in Australia.

Risk assessment and communication

- Much of the flood information (including mapping) rests with local councils across Australia, and in the past this has led to patchy flood risk understanding across Australia as it has been driven by funding support from higher levels of government.
- *Australian Rainfall and Runoff* is an industry guideline on flood estimation that sets out standard methodologies to be used for estimating rainfall events of given probabilities and the resultant flood events.

Risk governance

- Australian states and territories have primary legal responsibility for flood risk management and emergency management in their respective jurisdictions.
- The Australian Government plays a supporting role, including through the provision of funding, developing cooperative policy instruments such as intergovernmental agreements and providing information standards and guidelines.
- States and territories may devolve much of their flood risk management responsibilities to local councils and catchment management authorities (Victoria).
- Local councils and catchment management authorities are responsible for flood risk management in their local areas, playing a direct management role.
- Most of Australia's local councils do not have a sufficient rate base and resources to hire specialised flood management staff or to train their town planners in FRM.
- Funding to local councils is largely based on shared funding and some local councils do not have the necessary funds to allocate to FRM. This results in some areas of Australia (including some with potentially high flood risk) not having flood risk assessments and appropriate FRM plans in place.

Risk financing for public assets

- A large proportion of Australia's public infrastructure flood damage is covered by the Australian Government and the state and territory governments.
- Local authorities increasingly take out insurance for their physical assets.



Early warnings linked to emergency preparedness

- Australia uses the 'Total Flood Warning System' concept to design, implement and evaluate flood warning systems.
- The lead organisation for predicting floods and issuing flood warnings is the Australian Bureau of Meteorology, with state and territory emergency agencies interpreting and communicating warning information to affected local communities.
- There is particular concern about early warning systems covering flash flood scenarios in large cities such as Sydney and Melbourne.

Risk transfer

- Flood insurance coverage is voluntary, provided by the private market as supplementary cover to standard policies. Until 2008, residential flood insurance was broadly unavailable in the eastern states of Australia.
- Flood insurance coverage for households is estimated by the Insurance Council of Australia to be over 93%.

Risk reduction

- Australia uses *Australian Disaster Resilience Handbook 7: A Guide to Best Practice in Flood Risk Management in Australia* (Australian Institute for Disaster Resilience 2017) to guide FRM. The Handbook promotes FRM up to the Probable Maximum Flood (PMF).
- It is supported by a range of guides and links to other AIDR handbooks that support FRM and emergency management and land use planning for floods.

Risk prevention through planning and land use

- Planning laws are developed by each of the states and territories and then implemented by local councils.
- Planning laws tend to give local councils a degree of flexibility to identify flood risk areas and set requirements for development in those areas.

Other considerations for FRM

- Monitor, assess and provide ongoing feedback.
 - Government practice reviews and large flood events have prompted government inquiries that have led to major changes to FRM in Australia.
 - A monitoring and evaluation framework is built into some aspects of FRM (ADR Handbook 7), including flood warning systems.
- Incentivise risk-based decisions.
 - Limited evidence
- Multi-stakeholder coordination platforms.
 - National Flood Risk Advisory Group
 - Flood Warning Consultative Committees
 - Floodplain Management Australia is the main professional flood industry professional body in Australia with 140 local councils as members. It lobbies governments for improvements in FRM
- Educational, specialised and technical training programmes.
 - FRM subject was instigated in 2009 by the University of Technology Sydney as a partnership between the NSW DPIE EES and the FMA.
 - State and territory emergency agencies and other organisations (e.g. NGOs) provide community flood education and engagement programmes to at-risk communities. However, the levels of community interest in FRM and preparedness levels are generally low across Australia.
- Climate change considerations.
 - Coastal zone planning should not only take into account projected sea-level rise, but also its combination with extreme events such as windstorm and associated storm surge.
 - Climate change is predicted to increase the frequency and severity of extreme rainfall events at least in some parts of Australia.
 - Guidelines in *Australian Rainfall and Runoff* address both the coincidence of coastal and catchment flooding and the impacts of changes in flood producing rainfall events

Flood risk management in Australia: Pre-1950–2019

	Indigenous history	19th Century	1950s
 Approach to managing flood risk	Aboriginal peoples	Colony governors	NSW State Emergency Service
	LIVING WITH FLOODING	ALLOTMENTS OF HIGH LAND TO AVOID FLOODING	
 Major flood events	Historical approach to flood risk		1955 Maitland Floods: 14 deaths, 5,000 homes inundated in Hunter area, more than AUD 2 billion damages (current values)
 Major laws	<p>Oral traditions include many references to living with flooding and climate extremes. In some cases these cultural stories of flooding can be traced as far back as the rapid sea level rise following the end of the Last Glacial Period.</p>	<p>1806: First recorded flood in Maitland, NSW</p> <p>1819: Governor Lachlan Macquarie issued a general order for settlers to avoid developing in areas that were known to be flood prone and created several 'flood-free towns'.</p> <p>The historical approach to flooding was to get out of its way. The town of Gundagai was moved following the 1852 Flood. The town of Clermont in Queensland was moved following the devastating flood of 1916 when 65 people were killed. It was the first time that steam traction engines were used to relocate homes (Adams 2012). The 1875 Maitland Flood led to the first discussion about flood insurance in Australia (Box 2013).</p>	<p>NSW State Emergency Service (first dedicated emergency service in Australia): established in response to the 1955 Maitland floods. Prior to this, civil defence organisations were established during the Depression and World War II operated emergency services.</p> <p>Hunter Valley Flood Mitigation Scheme: Hunter Valley was one of the first local areas to have such a scheme.</p>
 Institutional changes and noteworthy developments			

Source: The Geneva Association



1960s

1970s



Floodplain Management Association, now Floodplain Management Australia (FMA)

Commonwealth Government, task force of the Australian Insurance Association (now Insurance Council of Australia), Queensland State Emergency Service and other Queensland Government bodies

Commonwealth Government for legislative change

PREVENTION: INVESTMENT IN FLOOD MITIGATION INFRASTRUCTURE (LEVEES, ETC.)

Other developments

1974 Brisbane Floods: 16 deaths, 300 injured, 6,700 homes inundated, approximately AUD 2.645 billion damages (current values)

Other developments

1961: Formation of the Floodplain Management Association, conceived when four coastal flood mitigation authorities met at the Maitland Town Hall to share ideas and technical solutions to flooding and to explore avenues for mutual assistance. The entity is now called Floodplain Management Australia (FMA), and its members are comprised of local councils and some corporations.

Calls for compulsory flood insurance led to the '**Feasibility Study into the Introduction of a Natural Disaster Insurance Scheme for Australia**'. In principle it was supported by the 1976 Fraser Government but rejected in 1979 ('National disaster insurance: a policy information paper'). It initially received strong support from the insurance industry but diverging views developed.

Wivenhoe Dam established to protect South East Queensland from future flooding. Later criticised in 2011 for failing to provide adequate protection.

Queensland State Emergency Service established

First major public backlash against insurers

1974: The Trade Practices Act 1974 (C'th) was updated to promote more competition between insurers (particularly, removal of 'tariffs' that set market pricing). Until 1974 the insurance industry largely acted in concert. The predominantly U.K.-based insurers were members of the Fire Accident and Marine Underwriters Association (FAMUA) which published 'tariffs' for certain types of risk.

Further development of flood mitigation measures (e.g. building six flood levees in Grafton NSW)

Approach to flood insurance at the time: 'Unless building and contents policies carry a specific extension to include damage by flood, no flood cover exists'.

Jointly-funded house-purchasing scheme with the Australian Government

1980s



Approach to managing flood risk

Commonwealth Government, Northern Territory Government, Insurance Council of Australia, NSW Government, Department of Primary Industry and Energy

RESPONSE AND RECOVERY: INCREASED FOCUS ON THE IMPORTANCE OF EMERGENCY MANAGEMENT



Major flood events

1984: Adoption of standard flood insurance cover:

Insurance Contracts Act 1984 (C'th) and **Insurance Contracts Regulations 1985** (C'th) – 'flood' originally undefined

'Flood' included in standard cover, but could be easily varied by informing customers of variation through Product Disclosure Statement (Part V Division 1A of the Act; Part V Division 8 of the Regulations).

Early 1980s: Northern Territory state-owned insurer, the Territory Insurance Office, introduced cover for flood and storm surge from the sea as standard in household insurance policies to ensure that insurance for these events was available to residents of the Northern Territory.



Major laws

1984: NSW Government almost released flood maps but decided not to due to fear of election backlash caused by reduced property values. Lack of flood maps remains an issue until the development of the National Flood Information Database by the Insurance Council of Australia.

1986: NSW Government releases its first Floodplain Development Manual, promoting a merit-based approach to floodplain development.

1989: The insurance industry established the Claims Review Panel to review decisions on individual insurer members. The Panel made determinations on the 1993 Benalla Floods and 1998 Townsville Floods and brought more losses within scope of the definitions of storm but did not lead to broad provision of flood cover.

1989: First publication in the *Australian Emergency Manuals Series*. Originally skills-based reference manuals without specific volumes on floods, these were developed from 1996 onwards.

1989/1990: Proposed inclusion of flood in every household insurance policy, a standard premium levy, community rated, irrespective of flood exposure or not, and a reinsurance pool.

1990: Nyngan in western NSW. Nyngan's levees were overtopped by a 1-in-200 year event that flooded the whole town. All 2,500 residents were evacuated by helicopter and could not return for several weeks. Subsequently the levees were raised and strengthened to exclude such an extreme event.

1992: Recognition of the advantages of a 'national approach' to floodplain management (Department of Primary Industry and Energy, 1992), following the work of Australian Water Resources Council's Floodplain Management Working Group. (See SCARM Report No. 73)

Warragamba Dam safety investigations led to understanding the consequences of beyond 1% AEP, evacuation capability, flood emergency plans and community flood education. The investigations led to the EMA handbook series.



Institutional changes and noteworthy developments



1990s

Australian Securities and Investments Commission
 Australian Building Codes Board, Emergency Management Australia and related bodies

RESPONSE AND RECOVERY: INCREASED FOCUS ON IMPORTANCE OF EMERGENCY MANAGEMENT

1998 Wollongong Floods: 1 death, 34 injuries, AUD 125 million damages, 34% insured losses

Criticism of insurers (e.g. disruption of NRMA general meeting by Wollongong Storm Water Action Group) led to some insurers making ex gratia payments, extending policies to include flash flooding or partial cover with sub-limits.

Community and media pressure, including rallies outside NRMA and QBE headquarters, one insurance company CEO's house, and statements by Prime Minister and Governor-General, put pressure on the industry to pay claims.

Contributed to ASIC review of consumer flood insurance issues ('Consumer Understanding of Flood Insurance' (2000)) and highlighted areas for improvement, including disclosure.

1990: Nyngan NSW flood leads to forced evacuation and brings the importance of emergency management to light.

1994: establishment of Australian Building Codes Board - initially did not address floods.

1995: Handbook Series by Emergency Management Australia (on advice from National Emergency Management Principles and Practice Advisory Group) expanded to include a more comprehensive range of emergency management principles and practice reference publications.

- Manual 20 Flood Preparedness
- Manual 21 Flood Warning
- Manual 22 Flood Response
- Manual 23 Emergency Management Planning for Floods Affected by Dams

Led to a proposal for the government to take responsibility for 'uninsurable risks', but the proposal did not receive any traction.

1999: Emergency Management Australia develops Steering Committee consisting of representatives of State and Territory Emergency Services, water management agencies and Australian Bureau of Meteorology. Updated best practice flood manuals identified above:

- Managing the Floodplain (now archived, replaced by Handbook 7)
- Flood Preparedness (updated in 2009)
- Flood Warning (updated in 2009)
- Flood Response (updated in 2009)



2000 – 2006



Approach to managing flood risk

Standing Committee on Agriculture and Resource Management/Emergency Management Australia, Council of Australian Governments, NSW Government, Queensland Government



Major flood events



Major laws

2000: Release of Standing Committee on Agriculture and

Resource Management (SCARM). Report No 73, 'Floodplain management in Australia: best practice principles and guidelines' (2000). Since replaced by *Australian Emergency Manual Handbook 7*.

2003: COAG gives in-principle approval to recommendations of report 'Natural Disasters in Australia: Reforming Mitigation, Relief and Recovery'. Major catalyst for insurance industry activity per ANZIIIF.

Two key recommendations:

Recommendation 65: Insurers have a responsibility to offer effective cover for natural disasters for all hazards for households and businesses at fair and competitive premiums.

Recommendation 66: 'The insurance industry should take active steps to ... avail themselves of the proposed new access to state, territory and local government information on flood risk and accept that insurers' special needs for data on risk are a matter for insurers to address collectively'.

2004: Review of Natural Disaster Mitigation, Relief and Recovery Arrangements (2004) by COAG led to:
- formation of National Flood Risk Advisory Group (working group of the Australian Emergency Management Committee).

- Development of Australian Flood Studies Database (2006).

2005: NSW flood guidelines: 'Floodplain Development Manual' (2005) is brought about by changes in the composition of authorities in NSW responsible for FRM.

2006: Flood insurance cover is estimated at 10% by Insurance Council of Australia (Adam 2012). Flood insurance is not developed mainly because of industry concerns about the magnitude of exposures based on research and technical work done by committees of the Insurance Council of Australia (Adams 2012).

2006: Queensland undertakes Voluntary Home Purchase Scheme for houses with > 50% chance of flooding in a year. As of June 2012, 73 properties were purchased.



Institutional changes and noteworthy developments



2007 – 2009

<p>Insurance Council of Australia, Australian Competition and Consumer Commission</p>	<p>National Flood Risk Advisory Group, Insurance Council of Australia, Brisbane City Council, Minister Council for Policy and Emergency Management (now Law Crime and Community Safety Council) of Council of Australian Governments, Geoscience Australia, Commonwealth and State and Territory Governments re Natural Disaster Resilience Program</p>
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2007 Newcastle and Hunter Valley Floods (flash floods):
10 deaths and AUD 1.17 billion in damages

<p>Insurance Council of Australia proposes a common definition of 'flood' following a large amount of consumer confusion about coverage. It was rejected by the ACCC because the proposed definition was deemed unlikely to reduce consumer confusion.</p> <p>Many insurance claims were rejected on the basis that the cause of inundation was riverine flooding or sea surge.</p>	<p>2008: National Flood Risk Advisory Group sets a vision for Australian flood risk management: "Floodplains are strategically managed for the sustainable long-term benefit of the community and the environment, and to improve community resilience to floods."</p> <p>2008: Development of the National Flood Information Database by Insurance Council of Australia, combining government flood mapping for underwriting flood risks at the address level, allowing flood insurance to be provided nationally.</p> <p>2008: Brisbane City Council begins putting Floodwise Property Reports on its website. These reports provide information on flood risk for specific properties. Over 1 million individual reports have been generated.</p>
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	<p>2009: Adoption of the 'National Disaster Resilience Framework' by the Ministerial Council for Police and Emergency Management. It provides a high-level disaster resilience agenda and calls for a co-operative, nationwide and community-based effort to increase resilience.</p> <p>2009: Geoscience Australia releases an ad hoc database, the Review of the Australian Flood Studies Database.</p> <p>2009: Commencement of the Natural Disaster Resilience Program, established under the National Partnership Agreement for Natural Disaster Resilience to strengthen community resilience to natural disasters consistent with state risk profiles and the priority outcomes of the NSDR in the following areas:</p> <ul style="list-style-type: none"> - Leading change and coordinating effort - Understanding risk - Communicating with and educating people about risks - Partnering with those who effect change - Empowering individuals and communities to exercise choice and take responsibility - Reducing risks in the build environment - Supporting capabilities for disaster resilience <p>Joint funding under the Natural Disaster Resilience Program between Commonwealth and State and Territory Governments, which can pass the funding on to local governments.</p>
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2010



Approach to managing flood risk

Insurance Council of Australia, Review Panel of the Natural Disaster Insurance Review, Commonwealth Government, Queensland Government, Department of Natural Resources and Mines, Brisbane City Council



Major flood events

2010/11 Queensland and Victoria Floods: 35 deaths, tangible and intangible costs of AUD 14.1 billion (Australian Business Roundtable); lesser impact in Victoria with AUD 2 billion in damages



Major laws

2011: Insurance Council of Australia establishes Hydrology Panel to assess and report on floods; a number of reports are made.

2011: Natural Disaster Insurance Review by Review Panel (initial consultation paper titled 'Reforming flood insurance: Clearing the waters'). Called for flood reinsurance facility, premium discounts, and Affordability Council. Calls rejected.

2011–2012: Consultation documents from Insurance Council of Australia:

- 'Response by Insurance Industry to National Disaster Insurance Review'
- 'Response to Reforming flood insurance – Clearing the waters'
- 'Consultation Feedback on Reforming Flood Insurance'

2012: National Disaster Insurance Review leads to adoption of Insurance Contracts Amendment Act 2012 (C'th). Key outcomes:

- Adoption of standard definition of flood
- Requirement for Key Facts Sheet – to simplify disclosure

2012: Queensland Government investigates floods, releases 'Queensland Floods Commission of Inquiry – Final Report'. Community awareness campaigns in Queensland begin to develop (e.g. 'Get Ready Queensland' program to promote resilience).

2011: Joint Flood Taskforce prepares report for Brisbane City Council with key recommendations for managing flood risk.

2011: Brisbane City Council establishes a flood action plan in response to the floods.

2011: Development of Queensland Flood Mapping Program, now part of Department of Natural Resources and Mines. Floodcheck maps available online.

2011: Victorian Government Review of 2010/11 floods led by Neil Comrie AO.



Institutional changes and noteworthy developments



2011 – 2012

Council of Australian Governments, Green Cross Australia, Victorian Department of Justice, Victoria Environment and Natural Resources Committee, State Government Victoria, National Flood Risk Advisory Group, Queensland Reconstruction Authority

Commonwealth Government (Geoscience Australia), Insurance Council of Australia (Australian Resilience Taskforce), Australian Building Codes Board

2011: COAG adopts the National Strategy for Disaster Resilience and Companion Booklet, high-level guidance on disaster resilience for a broad range of stakeholders (governments, businesses, the NFP sector, etc.), which rebalances the 'response and recovery' approach to 'preparation and mitigation'

2011: Commencement of the 'Harden Up - Protecting Queensland' and 'Build it Back Green' projects by Green Cross Australia

2011–2012: Three inquiries conducted in Victoria:

- 'Inquiry into flood mitigation infrastructure in Victoria'
- 'Review of the 2010-11 Flood Warnings and Response'
- 'North East Victoria Flood Review'

2011: Announcement of Victorian Flying Squad Program to assist with planning in regional and rural councils. Planning laws have been identified by some in the insurance industry as a major challenge to achieving flood risk management. Lauded by Productivity Commission. However, not funded past 2015; replacement identified as inadequate by councils.

2011: Strengthening Grantham Project undertaken with the movement of 100 residents of Grantham, the single most devastated community in Queensland, to higher ground. Very strong community support, multi-funded by local, state and federal.

2011 onward: Floods-induced review of *Australian Emergency Manuals Series* as relates to flooding (together with the adoption of the National Strategy for Disaster Resilience), instigated and managed by the National Flood Risk Advisory Group. Collection now published by the Australian Institute for Disaster Resilience:

- Handbook 7: 'Managing the Floodplain: a guide to best practice in flood risk management in Australia' (2017)
- Manual 20: 'Flood Preparedness' (2009)
- Manual 21: 'Flood warning' (2009)
- Manual 22: 'Flood response' (2009)
- Manual 23: 'Emergency management planning for floods affected by dams' (2009)

2011: Establishment of the Queensland Reconstruction Authority. It has two roles: to oversee the re-building of damaged infrastructure and, more widely, to improve the state's preparedness for extreme weather events and release of 'Planning for stronger, more resilient floodplains'. It has also has produced two floodplain management guidelines to help councils better align floodplain management and land use planning.

2011: Raising of the Hinze Dam (located in the Gold Coast hinterland) by 15 metres. More flood mitigation storage behind the dam reduced the risk of flooding to Nerang River floodplain. Flood planning levels were maintained.

2012 onward: Studies into the impact of the 2010/11 floods released. For example, see O'Brien, J. (2012). Analysis of damage to buildings following the 2010-11 Eastern Australia floods. National Climate Change Adaptation Research Facility: Gold Coast. NCCARF Publication 02/13.

2012: Commencement of 'National Flood Risk Information Project' by Commonwealth Government. Three components:

- Australian Flood Risk Information Portal - flood studies, maps, satellite data etc. made available
- *Australian Rainfall and Runoff* guidelines
- Archive of satellite imagery for water observations. General focus on improving quality, availability and accessibility of flood information (consistent with National Strategy for Disaster Resilience)

2012: Establishment of Australian Resilience Taskforce by the Insurance Council of Australia, which has released the Building Resilience Rating Tool and Building Resilience Knowledge Database.

2012: Australian Building Codes Board issued non-mandatory guidance called 'Construction of Buildings in Flood Hazard Areas'.



2010 – 2014



Approach to managing flood risk

Insurance Council of Australia, individual insurers

Bureau of Meteorology, Commonwealth Government and Queensland Government, Australian Government Productivity Commission, Queensland Department of Natural Resources and Mines



Major flood events

2013 Cyclone Oswald – Queensland and NSW: insured losses approximately AUD 1.1 billion; approximately 103,000 in claims



Major laws

- Declared a catastrophe by the Insurance Council of Australia
- Claims processed in record time according to Insurance Council of Australia (Edwards 2013)
- Reports of significant repricing by Suncorp after flooding for communities protecting themselves from natural disasters.

2013: Bureau of Meteorology releases 'National Arrangements for Flood Forecasting and Warning' report. Prepared to provide a summary of Australia's flood forecasting and warning services following 2011 flooding.

2014: Commonwealth and Queensland enter into 'Project Agreement for the Implementation of the National Insurance Affordability Initiative – Ipswich and Roma' (2014) to improve flood defences in uninsurable parts of Queensland.

2014: 'Natural Disaster Funding Arrangements – Productivity Commission Inquiry Report No. 74' by Australian Government Productivity Commission is prompted by concern with funding allocation leaning to disaster recovery.

2014: Release of the Queensland Flood Mapping Implementation Kit



Institutional changes and noteworthy developments



2015 – 2016

Queensland Inspector-General Emergency Management, PwC Australia, Department of Natural Resources and Mines

Australia-New Zealand Emergency Management Committee, Australian Institute for Disaster Resilience, Geoscience Australia, Queensland Audit Office, Queensland Department of Natural Resources and Mines, Insurance Council of Australia, Brisbane City Council, Commonwealth & State and Territory Governments

2015 Cyclone Marcia: estimated insured loss value AUD 544 million (77% domestic, 23% commercial); 37,160 in claims

2015: Report by Queensland Inspector General Emergency Management, '2015 Callide Creek Flood Review Volume 1: Report', on the impacts of Cyclone Marcia.

2015: Australian Government launches North Queensland Home insurance comparison website, designed to improve consumer understanding of options in the face of rising costs.

Reports of significant increases in flood insurance cost. For example see Stevens (2015)

2015: PWC releases review into flood risk management arrangements in Queensland.

2015: Australia-New Zealand Emergency Management Committee releases the 'National Strategy for Disaster Resilience: Implementation Review'.

2015: Australian Institute for Disaster Resilience appointed custodian of the Australian Disaster Resilience Handbook Collection

2016: Release of report by Geoscience Australia on 'Household experiences of flooding in Brisbane and Ipswich, Queensland' relating to flooding in 2011 and 2013.

2016: Release of report by Queensland Audit Office, 'Flood Resilience of River Catchments', on the effectiveness of Queensland resilience since the 2011 floods.

Report recognised limitations:

- Department responsible for resilience not fulfilling role effectively
- Need to assess local council floodplain management capabilities
 - Division of responsibilities can be complex and unclear
 - State and local governments can act in their own silos

2015: The report, 'Performance Review of Flood Warning Gauge Network in Queensland', prepared for the Department of Natural Resources and Mines, improves flood warning mechanisms.

2016: Queensland Department of Natural Resources and Mines releases 'Guide for Flood Studies and Mapping in Queensland' to assist local governments and local disaster management groups in implementing outcomes of flood studies.

2016: 'National Partnership Agreement on Natural Disaster Resilience' entered into by Commonwealth and State and Territory Governments to implement the co-funding of resilience measures.

2016: Release of Brisbane Floodsmart Future Strategy - capital city most affected by floods in 1974 and 2011 - building on previous initiatives such as the Lord Mayors Taskforce on Suburban Flooding (2005) and the Flood Flag Map (2009).

2016: Northern Territory Government announces it is considering a buyback scheme for households made uninsurable by flood risk.

2015: ICA estimates standard coverage at 93%.

2015: Release of 'Grantham Commission of Inquiry' report.

2016: Release of the Victorian Floodplain Management Strategy



2017



Approach to managing flood risk

Insurance Council of Australia

NSW Office of Environment & Heritage, NSW Department of Primary Industries (Water), Queensland Government, Council of Australian Governments, Australia Competition and Consumer Commission, Queensland Reconstruction Authority



Major flood events

2017 Cyclone Debbie: estimated insured loss value AUD 1.7 billion



Major laws

Renewed calls for subsidised flood insurance from specialists, which are rejected by some experts.

Forums held by Insurance Council of Australia to clear up flooding definition for those affected by Cyclone Debbie.

Reports of significantly rising premiums in Queensland and northern NSW following Cyclone Debbie.

2017: NSW Office of Environment & Heritage's 'Floodplain Management Program', provides state level funding to local governments for resilience - 59 projects totalling \$8,845,684 in funding was awarded to local councils and other authorities

2017: Commencement of NSW Department of Primary Industries (Water), 'NSW Healthy Floodplains Project', reforming water management in northern basin floodplains by implementing the NSW Floodplain Harvesting Policy (2013).

2017: New State Planning Policy in Queensland and state interest guideline on 'Natural hazards, risk and resilience'.

2017: Release of new 'Guide for Flood Studies and Mapping in Queensland' in October 2017 by the Queensland Government.



Institutional changes and noteworthy developments

2017: Release of COAG 'Intergovernmental Agreement on the Provision of Bureau of Meteorology Hazard Services to the States and Territories' (2017). Agreement formalises and standardises services provided to states and territories for flood management (and other extreme hazards such as fire).

2017: Release of new Handbook 7, 'Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia' and related guidelines.

2017: Release of Queensland Strategy for Disaster Resilience (no explicit mention of insurance).

2017: ACCC releases North Australia Insurance Inquiry Issues Paper to look at pricing, market competitiveness, etc.

2017: NSW announced Flood Data Access Program, consisting of the NSW flood data portal and the NSW Flood Database.

2017: Queensland Reconstruction Authority works with local governments and state agencies on 'Burnett Catchment Flood Resilience Strategy', testing a consistent and coordinated approach to managing flood risk across the four local councils located within the catchment.

2017: NSW Government releases the Resilient Valley, Resilient Communities – Hawkesbury-Nepean Valley Flood Risk Management Strategy (the Flood Strategy). The cornerstone of the strategy is the proposed raising of Warragambah Dam.

2017: Government issues response to Northern Australia Insurance Premiums Taskforce and General Insurance Senate Inquiry.



2018 – 2019

	<p>Federal Government, National Resilience Taskforce, Australian Business Roundtable, ALGA, Queensland Reconstruction Authority, Brisbane City Council</p>
<p>Heavy flooding in North Queensland. The costs are still being determined, but the Insurance Council of Australia had estimated AUD 16.8 million as of 2 May 2018</p>	
<p>Labelled an official catastrophe by the Insurance Council of Australia</p>	<p>2018: Announced development of the National Resilience Taskforce, to include industry voices. The Taskforce has been welcomed by the Australian Business Roundtable and its key roles are to develop a national five-year disaster mitigation framework, and develop national disaster risk information capabilities. It has been suggested that the Taskforce takes the lead on developing a National Strategy for Disaster Resilience.</p> <p>2018: ALGA budget submission calls for AUD 200 million in mitigation funding per year over four years.</p> <p>2018: Release of 'Resilient Queensland: 2018–2021' strategy to implement the Queensland Strategy for Disaster Resilience released in 2017.</p>
	<p>2018: Brisbane City Council announces the Flood Resilient Homes Program, trialled from June 2018 to June 2019 on homes in flood prone areas. It includes an online flood resilient design virtual home and three key steps: 1) FloodWise Home Service, 2) FloodWise Home Service Resident's Report, 3) FloodWise Resilience Incentive Scheme.</p> <p>2018: Land swap arrangement funded by NSW Government to help South Murwillumbah businesses affected by 2017 flooding, with the aim of helping businesses move operations to flood-free land. Businesses will have up to 10 years to relocate.</p> <p>2019: Significant flooding in Townsville, North Queensland, resulting in the deaths of up to 500,000 cattle and the release of the Ross River Dam, is described by the Townsville City Council as a '1-in-1,000-year' event in certain areas.</p>



2. Introduction

Australia is exposed to coastal, fluvial and pluvial flooding, particularly in urban areas. Riverine flooding is a major concern across the whole country, with all of its big river catchments experiencing severe losses due to major floods. Tropical cyclones, experienced in northern Australia, and East Coast Lows (on the southern half of the east coast of Australia) can cause widespread flooding and generate coastal inundation due to storm surge. As an island continent, Australia is prone to coastal flooding from storm surge, tsunamis and sea level rise. In addition, although there are some warning systems in place, localised urban flash floods are an area of growing concern.

This report provides an overview of flood risk management (FRM) in Australia, applying a holistic, multi-stakeholder, forward-looking framework (The Geneva Association 2020a; Annex 1). Such measures include availability of risk information and risk awareness for informed decision-making, reduction of existing risks and prevention of new risks, early warning and emergency preparedness measures, risk financing for the public sector and risk transfer (insurance and alternative risk transfer measures) and building back better after an event (Annex 2).

Section 2 provides an overview of flood risk in Australia and the evolution of FRM is examined in section 3. Section 4 describes the components of FRM in Australia. The latest trends towards an all-of-society approach to flood resilience are discussed in section 5 and section 6 provides concluding remarks.



Brisbane River Floods, 2011



3. Flood risk in Australia

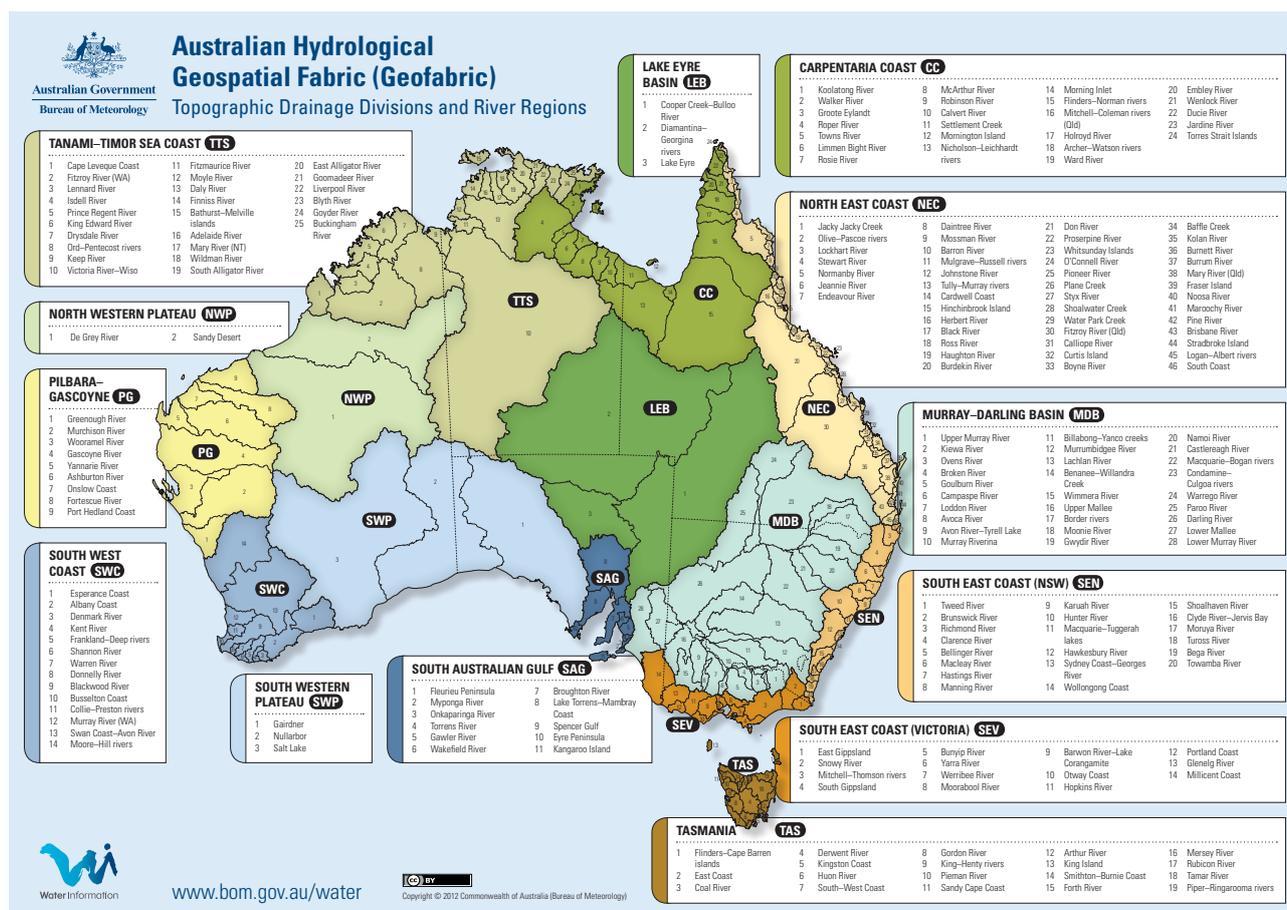
Australia is divided into six states and two territories:

- Australian Capital Territory (ACT)
- New South Wales (NSW)
- Northern Territory (NT)
- Queensland (Qld)
- South Australia (SA)
- Tasmania (Tas)
- Victoria (Vic)
- Western Australia (WA)

As shown in Figure 1, Australia has several large drainage basins divided into smaller catchments. Of particular note is the Murray-Darling Basin, which includes two of the world's longest rivers – the Murray River and the Barwon-Darling River. It should also be noted that one of Australia's largest drainage basins (Lake Eyre Basin) does not flow to the coast; rather floodwaters end up in Lake Eyre, a large intermittent lake, part of which is below sea level.

The majority of Australia's population live in coastal catchments.

Figure 1: Australia – Topographic drainage divisions and river regions



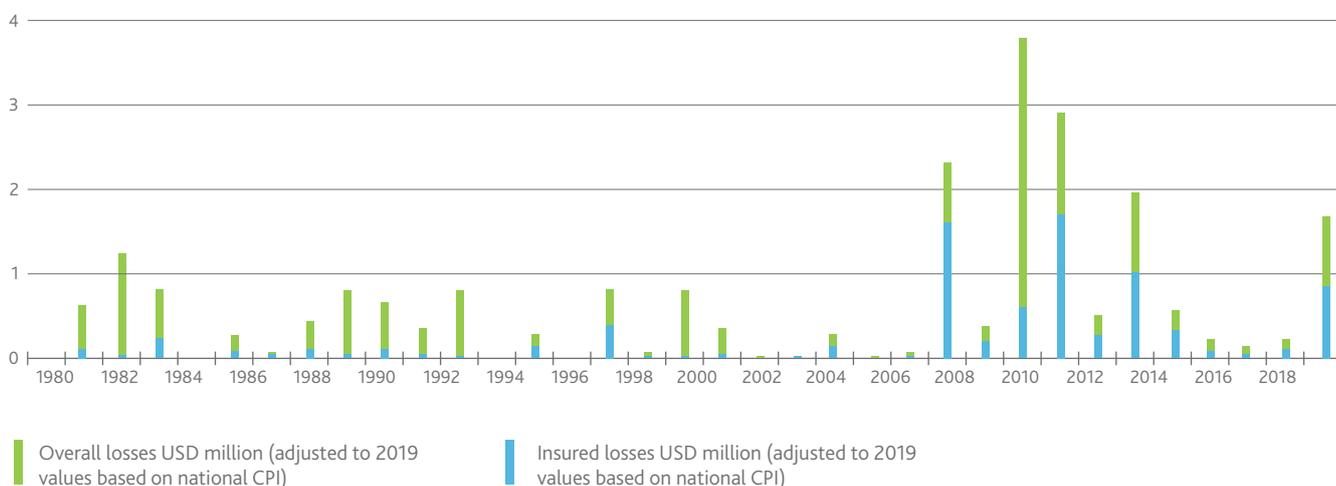
Source: Australian Bureau of Meteorology

Large parts of the interior of Australia are uninhabited or sparsely inhabited and the potential damage from flooding in these drainage basins is far less than those fringing the coast where there is more intense agriculture and denser population.

Figure 2 provides the total economic and insured losses associated with floods in Australia from 1980–2019. It should be noted that residential flood insurance only became widely available from 2007 onwards.

Table 1 provides a list of the most prominent recent flood events, impacted regions and total and insured losses.

Figure 2: Overall (shown in green) and insured (shown in blue) losses in USD billion for floods in Australia between 1980 and 2019



Source: NatCatSERVICE Munich Re

Note: Losses are inflation-adjusted via the country-specific consumer price index and by considering the exchange rate fluctuations between local currency and USD.

Flooding is Australia’s costliest natural hazard-related cause of disaster when both tangible and intangible losses are taken into account (Deloitte Access Economics 2017). Approximately 7% of households have flood risk, with 2.8% being located in high-risk areas; that is, up to 170,000 buildings in 5% Annual Exceedance Probability (AEP) flood zones (AXCO 2018).

Table 1: Ten most expensive (highest overall economic losses) flood events in Australia between 1980 and 2019

Period	Event	Affected area	Overall losses (USD million, original values)	Insured losses (USD million, original values)	Fatalities
3 Dec 2010– 20 Jan 2011	Flood	Queensland (Rockhampton, Cairns, Innisfail, Theodore, Chinchilla, Dalby, Moura, Mundubbera, Jericho, Alpha, Emerald, Bundaberg, Burnett, Woorabinda, Warra, Wowan, Pittsworth, Condamine, Burketown, Bajool, Logan, Mackay, Baralaba, Dysart, Warwick, Gympie, Withcott, Helidon, Gatton, Murphys Creek, Stanthorpe, Ingham, Lowood, Withcott, Goondiwindi); New South Wales (Boggabilla, Toomelah, Grafton, Tenterfield); Victoria	3,700	530	13
10–14 Jan 2011	Flood, flash flood	Queensland (Brisbane, Ipswich, Toowoomba, Grantham, Gladstone)	3,200	1,900	22
21–31 Jan 2013	Flood, flash flood (Ex-Tropical Storm Oswald)	Queensland (Bundaberg, Brisbane, Gympie, Kowanyama, Pormpuraaw); Northern New South Wales (Grafton)	2,300	1,200	6
26 Jan–10 Feb 2019	Flood	Queensland (Townsville, Whyanbeel, Port Douglas, Daintree, Bluewater, Julia Creek)	1,700	920	3
11–18 Feb 2008	Flood	Queensland (Mackay, Rockhampton, Mareeba, Townsville, Bowen, Burdekin, Burnett, Charters Towers, Dalrymple, Mirani, Miriam Vale, Nebo, Peak Downs, Thuringowa, Whitsunday Shire)	1,300	950	2
14–31 Jan 2008	Flood	Queensland (Proserpine, Airlie Beach, Townsville, Giru, Charters Towers, Bowen, Georgetown, Richmond, Whitsundays, Emerald, Charleville, Rockhampton, Muttaborra, Willow, Belyando, Barcoo Shire, Sapphire, Mackay, Quilpie, Thargomindah, Clermont, Blackall, Finch Hatton, Cunnamulla, Yaamba)	600	450	
30 April–4 May 2015	Flash flood, severe storm	Queensland (Brisbane, Sunshine Coast); New South Wales (Sydney, Ballina, Coffs Harbour, Hunter, Lismore, Tweed Heads)	450	280	6
21–29 May 1983	Flood	New South Wales, Queensland	390		1
14 –16 March 1989	Flood	Canberra	300	20	
18–20 Dec 1992	Flash flood	Victoria, South Australia, New South Wales	270		2

Source: NatCatSERVICE Munich Re

3.1. Population growth and development

Australia's population of 26 million (Australian Bureau of Statistics 2020a) is largely confined to the coastline, with more than 90% of its population living within 100 km of the coast. This makes it one of the world's most urbanised coastal dwelling populations (Australian Bureau of Statistics 2020b).

Over one third of Australia's population is located in the cities of Melbourne and Sydney, both with populations of approximately 4.5 million.

Large parts of Melbourne, Sydney and Brisbane (population of 2 million) are flood prone. Flooding in these cities is fluvial, coastal and also due to surface water (pluvial). Brisbane has suffered several major floods via the Brisbane River which flows through it. Although smaller in magnitude than the 1893 Brisbane floods, the impact of the 1974 flood remains one of the most severe examples of urban flooding in Australia. Related damage was greater than in 1893 because Brisbane's population had grown from around 175,000 in 1893 to around 1 million and due to the greater exposure afforded by new buildings and infrastructure. Insured losses from the 1974 event ran to almost AUD 2.29 billion (normalised to 2006 exposure, societal conditions, inflation and wealth) (Crompton & McAneney 2008). With further development and a larger population, the normalised insured losses from the 2011 Brisbane floods were approximately AUD 3.3 billion (van den Honert & McAneney 2011).

Of concern in Australia is the future development of urban floodplains and related population growth. For example, in the Hawkesbury- Nepean River floodplain in Western Sydney, up to 134,000 people live and work on the floodplain and could require evacuation. This number is forecast to double over the next 30 years. Over 25,000 residential properties and 2 million square metres of commercial space are currently subject to flood risk, and this will increase significantly in the coming years (Infrastructure NSW 2017). Insurers describe the existing flood risk on the Hawkesbury Nepean floodplain as the most significant and unmitigated community flood exposure in the country (Insurance Council of Australia 2019).

Also concerning are considerable areas of new development in Western Sydney and Melbourne that are susceptible to surface water and local riverine flooding which can cause flash flooding from intense, short-duration bursts of rainfall. A significant proportion of the inhabitants of these areas are new immigrants from overseas and people of low-socio economic status, many of whom cannot afford flood insurance (Molino Stewart 2012).

Development and associated population growth also occurs in rural and regional floodplains of Australia, increasing exposure to future flooding. "The future will see

Australia's population continue to grow, placing increased pressures on our waterways, many of which already experience high levels of flood risk. A growing population will result in increased development on the floodplain and the temptation to build in flood corridors" (Office of the Queensland Chief Scientist 2020).

3.2. Climate change

There are two main impacts of climate change on future flood risk in Australia:

- Sea level rise
- Changes in extreme weather patterns that can cause flooding

Sea levels are rising globally and around the Australian coastline and will continue to rise through this century and beyond. Consistent with global increases, sea levels have risen in Australia at an average rate of 2.1 mm/year over the past half century. The likely estimate of sea-level rise in Australia by 2090 is about 45-82 cm higher than 1986–2005 levels. Coastal capital cities such as Brisbane, Darwin, Perth, Adelaide and Sydney show an average increase of 60–66 cm by 2090 (CSIRO & Bureau of Meteorology 2015).

Large-scale systems such as El Niño can also affect sea levels over timescales of a few years; for example, sea levels rise around Australia during El Niño and fall during La Niña events. The occurrence of El Niño and La Niña events (their frequency and severity) will be affected by climate change, with knock-on implications for sea-level rise.

Coastal zone planning should not only take into account projected sea level rise, but also its combination with extreme events such as windstorm and associated storm surge. The consequences of sea level rise will include increased flooding of low-lying coastal, including tidal, areas and are likely to result in coastal erosion, loss of beaches and higher storm surges that will affect coastal communities, infrastructure, industries and the environment.

A significant proportion of Australia's infrastructure – such as transportation and communication networks – is located around coastal population centres. At the same time, as described in section 2.1, the coastline is becoming more developed with people and industries increasingly concentrated along the coastline.

Climate change is predicted to increase the frequency and severity of extreme rainfall events at least in some parts of Australia (CSIRO and Bureau of Meteorology 2015). Although it is difficult to attribute the impacts of climate change to specific disasters, increased sea surface temperatures have been estimated to have contributed up

to 20% of the heavy rainfall experienced during the 2010-11 Queensland floods (Hendon et al. 2014). By the end of the century, maximum one-day rainfall is expected to increase by up to 17% and 18% for NSW and Queensland respectively (CSIRO and Bureau of Meteorology 2015).

As a result of the projected increase in the frequency and severity of extreme rainfall events, sensitivity analysis conducted by Dyer et al. (2019) found possible 20% and 40% increases in national Annual Average Loss (AAL) for two-degree and three-degree Celsius warming scenarios, respectively. There was also a compounding risk factor in areas where tropical cyclone risk is likely to increase; mainly, South East Queensland and Northern NSW.

Whilst extreme rainfall events are predicted to become more frequent and severe, climate models consistently agree that rainfall will decrease over much of southern Australia, with the greatest confidence that this will happen for the south-west (CSIRO and Bureau of Meteorology, 2015). This pattern of prolonged drought followed by intense rainfall events will pose challenges to promoting flood risk awareness among at-risk Australian population and to lobbying for flood funding during low rainfall periods.



Queensland Floods, 2011



4. Evolution of flood risk management in Australia

Given the constitutional arrangements for FRM in Australia, its evolution across different areas of Australia has been varied.

This evolution has been influenced by both major floods and government reviews. Taking NSW as an example, floods in the late 1940s and early 1950s led to the first flood mitigation act, the *Hunter valley Flood Mitigation Act*, the precursor to today's Floodplain Management Program and the starting point for what would become the NSW State Emergency Service. The 1990 Nyngan flood led to the need to consider larger floods in FRM, and learnings from the 1998 Wollongong floods fed in to updates of the NSW Floodplain Development Manual in 2001 and 2005 incorporating the need to address pluvial flooding in urban areas through the same risk-based approach. However, government reviews (independent of major flood events) led to both stringent land use planning controls in the 1970s, and the merit-based decision making process supported by the 1986 Floodplain Development Manual in the 1980s.

National best practice principles and guidance were first established in 1999 (CSIRO 1999). This has since been updated in 2013 (AEMI 2013) and 2017 (AIDR 2017), with the latter updates led by the National Flood Risk Advisory Group. The 2017 handbook was supported by a range of flood risk management guidelines.

4.1. Major floods as drivers of flood risk management in Australia

Australians have a long history of living with flood risk. Australian Aboriginal peoples' oral traditions include many references to living with flooding and climate extremes. In some cases these cultural stories of flooding can be traced as far back as the rapid sea level rise following the end of the Last Glacial Period, between 7,000 to 13,000 years before present era (Nunn & Reid 2015). Aboriginal Australian knowledge of the land continued to inform early town planning decisions in the years following European colonisation, with sites of Aboriginal camps often forming the

foundation of colonial settlements (Kerkhove 2018). When the town of Gundagai was colonised in 1841, local Wiradjuri people warned settlers of the history of extreme flooding at the proposed town site (O'Gorman 2012). Gundagai was flooded soon after in 1844 and again in 1852 in Australia's deadliest flood event: 89 people, comprising almost a third of the town's population, lost their lives to floodwaters.

Australian society has become increasingly isolated from the natural environment in the years since, yet flood events continue to impact the lives of Australians. Recurrent high-impact floods have led to growing political, public and industry concern about the need for action.

It should be noted that disasters related to other hazards have also driven change in FRM in Australia. For example, the Royal Commission Inquiry into the 2009 Black Saturday bushfires in Victoria (Victorian Government 2009) made recommendations that have improved aspects of emergency management (e.g. interoperability), crisis communication and early warning systems that have driven changes in FRM across Australia.

The Royal Commission into National Natural Disaster Arrangements was established by the Australian Government on 20 February 2020 in response to the extreme bushfire season of 2019–20 which resulted in loss of life, property and wildlife and environmental destruction. The Commission will draw information from a variety of sources, including public submissions and hearings. This will inform the Commission's report and recommendations for mitigating and responding to future disasters including floods (Australian Government 2020).

4.2. Institutional roles and responsibilities

Under Australia's constitutional arrangements, the states and territories have primary legal responsibility for FRM and emergency management in their respective jurisdictions (Wenger 2013). This includes, but is not limited to, setting disaster risk policy and developing disaster risk management action plans, taking direct action to support flood risk

management such as flood mapping and providing funding to local councils to increase resilience and set planning and development rules (Wenger 2013).

The way flood risk assessment and management are delivered varies between the jurisdictions corresponding to the level of state or territory involvement. The extent of local government responsibility differs depending on the level of technical and financial support from the jurisdiction.

For example, in the state of Victoria, FRM is the responsibility of catchment management authorities. In NSW local councils are responsible but get specialist technical support and financial assistance from the state government under the Floodplain Management Program which supports the NSW Flood Prone Land Policy. The responsible entity may undertake flood studies and FRM plans in their local areas – often with state or territory government support, as seen with the NSW Floodplain Management Program which has operated since the 1980s, and the more recent Queensland Flood Mapping Program – and make development and planning decisions that consider state or territory guidance (Wenger 2013).

The Australian Government plays a supporting role to the states and territories, including through the provision of some funding, developing cooperative policy instruments such as intergovernmental agreements, and supporting the cooperative development of guidelines (Wenger 2013). The states and territories consider this guidance in their disaster risk management framework.

A problem with devolving flood planning to local government is that local councils vastly differ in size and resourcing. As a result, most of Australia's 537 local councils do not have a sufficient rate base and resources to hire specialised flood management staff or to train their town planners in FRM.

In consideration of the limitations of local government in FRM in NSW and consistent with the NSW Flood Prone Land Policy, the state government established the State Flood Program in the 1980s. This program continues to provide specialist technical support and financial assistance to local councils for developing and implementing floodplain risk management plans to understand and manage their flood risk in accordance with the NSW Floodplain Development Manual 2005. This has resulted in the preparation of thousands of studies, hundreds of floodplain risk management plans and significant state and local investment, at times supported by the Australian government, in flood mitigation for local communities in NSW since the 1980s. This program also provides flood information to support both emergency management and land use planning. The level of funding support provided by the state under the program considers the financial capacity of the councils. Councils receive a limited indemnity for

managing flood risk consistent with the Manual, which is gazetted under the NSW Local Government Act (1993).

The Victorian Government's 'Rural Council Planning Flying Squad' model addressed this skill inequality by providing short-term specialist support staff to assist rural councils on complex planning matters, including updates to flood planning controls, between 2011 and 2015. This model was cited by the Australian Productivity Commission as leading practice for moderating the effects of local government skills shortages and facilitating the transfer of knowledge, skills and processed across councils.

4.3. Legislative actions

The Australian Government does not have any direct legislation related to FRM due to its constitutional arrangements with the states and territories. National legislation does however provide direction and guidance to several agencies acting in a flood emergency. For example, the Bureau of Meteorology, Australia's national weather, climate and water agency, operates under the authority of the Meteorology Act 1955 and the Water Act 2007 which provide the legal basis for its activities, including issuing warnings and watch notices to the community. Similarly, the Telecommunications Act 1997 provides for the disclosure of information from the Integrated Public Number Database (IPND) for emergency warning purposes (Attorney-General's Department 2013).

In 2009, the National Partnership Agreement (NPA) for Natural Disaster Resilience established a whole-of-nation approach recognising that a coordinated and cooperative effort is needed to withstand and recover from natural disasters. Subsequently, the National Strategy for Disaster Resilience (NSDR) was adopted by the Council of Australian Governments (COAG) in 2011 (ABR DRSC 2017). The NSDR provides high-level guidance on disaster management to Australian, state, territory and local governments, business and community leaders and the not-for-profit sector. The Strategy provides the foundation for governments to shift the traditional emphasis of emergency management efforts from response and recovery from natural disasters to preparedness and prevention. It also recognises that disaster resilience is a shared responsibility between all levels of government (Australian, state and territory, and local), business and industry, non-governmental organisations (NGOs), community groups, emergency management volunteer organisations and the community (Australian Institute for Disaster Resilience 2014). The Strategy recommends building resilient communities through:

- Leading change and coordinating effort
- Understanding risks
- Communicating with and educating people about risks

- Partnering with those who effect change
- Empowering individuals and communities to exercise choice and take responsibility
- Reducing risks in the built environment
- Supporting capabilities for disaster resilience

The National Disaster Risk Reduction Framework (Department of Home Affairs 2018) is designed to guide Australia's efforts to reduce disaster risk associated with natural hazards including flooding. The Framework establishes a 2030 vision, goals and priorities broadly aligned to the Sendai Framework for Disaster Risk Reduction 2015–2030 and the 2030 Sustainable Development Goals and outlines foundational strategies for action to meet these across the five years from 2019–2023.

Each state and territory government has established emergency response agencies (e.g. urban and rural fire brigades and various state emergency services) as well as overarching emergency or disaster management legislation and plans in which the roles of various agencies are set out. The focus of the legislation and the various plans tends to be on preparing for, responding to and recovering from an emergency. While the plans recognise the need to mitigate risk and develop resilience, taking steps to prevent losses or taking a long-term approach to developing a resilient community are not part of an emergency plan but are expected to be considered in 'business as usual' (for example, when state departments and local governments are making land-use planning decisions) (Australian Institute for Disaster Resilience 2014). Local councils also have disaster or emergency management plans related to state emergency management plans.

States and territories provide guidance to local councils to assist in their FRM roles. For example, in NSW the aim of the Flood Prone Land Policy is to reduce the impact of flooding and flood liability on owners and occupiers of flood-prone property and reduce public and private losses. The policy recognises the benefits of use, occupation and development of flood-prone land.

The NSW Floodplain Development Manual (NSW Government 2005) supports the policy and guides councils through the floodplain risk management process. The Manual, along with the specialist technical support and financial assistance provided through the State Floodplain Management Program, helps councils develop and implement local floodplain risk management plans. It also supports emergency management and land use planning. Since 1986, the NSW Floodplain Development Manual and Flood Prone Land Policy has promoted a merits-based approach to floodplain development. It should be noted that the NSW flood

planning arrangements (and the Manual) are currently being reviewed in consideration of updated national best practice and lessons learnt.

In Victoria, the Victorian Floodplain Management Strategy was developed in 2016 to help communities be better prepared for future floods. The strategy clarifies the roles and responsibilities of government agencies and authorities involved in flood management. It aims to improve the evaluation and communication of flood risks so communities and relevant agencies can take better-informed action to manage floods.

The Australian Government also provides guidance to assist FRM across Australia. In 2005, the National Flood Risk Advisory Group (NFRAG) was established to facilitate national coordination and cooperation in best-practice FRM. It brings together technical representatives actively involved in FRM in their jurisdictions with other key stakeholder groups. Membership includes technical representatives from each state and territory, the Australian Government, Australian Local Government Association, Australian Council of State Emergency Services, Australian Building Code Board, Insurance Council of Australia and the broader research community. It also links with key industry groups.

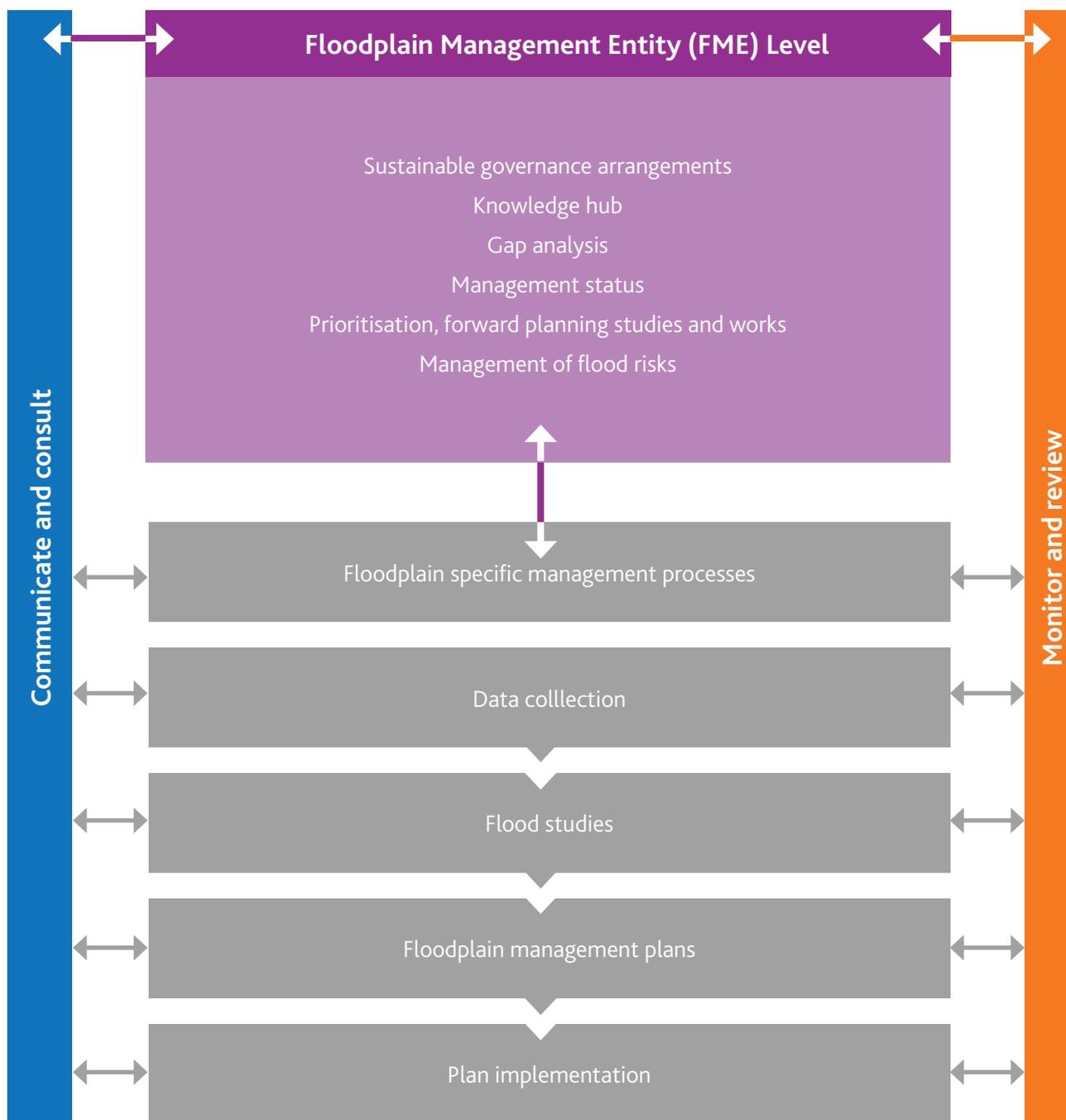
NFRAG was responsible for reviewing Australia's emergency manuals relating to FRM. This review led to the development of *Australian Disaster Resilience Handbook 7: A Guide to Best Practice in Flood Risk Management in Australia* (Australian Institute for Disaster Resilience 2017). The custodian of the Handbook (and supporting manuals relating to flood preparedness, flood warning and flood response) is the Australian Institute for Disaster Resilience.

Handbook 7 acknowledges that best practice FRM requires a cooperative, proactive, consultative and informed approach that accepts all risk cannot be eliminated and acknowledges individual responsibility for preparedness in the community. To achieve this, it proposes the FRM framework as a model for government agencies to follow (see Figure 3).

Handbook 7 also provides guidance on understanding flood probability, the roles of different stakeholders in FRM, the consequences of flooding for the community, and understanding the development capability of land that is prone to flooding. It promotes consideration of the full range of floods up to the Probable Maximum Flood.

Handbook 7 is also supported by a range of guidelines such as Guideline 7.5 which provides guidance on developing FRM information in land-use planning. It also links to other national guidance such as Land Use Planning for Disaster Resilient Communities and Flood Emergency Planning for Disaster Resilience (AIDR 2020). A wide range of guidance is available at <https://knowledge.aidr.org.au/collections/handbook-collection/>

Figure 3: Flood Risk Management Framework in Australia



Source: Australian Institute for Disaster Resilience (2017)



5. Flood risk management in Australia

5.1. Flood risk information, communication and awareness

As discussed in Section 3.2, much of the flood risk information, including mapping, rests with local councils across Australia, and in the past, this has led to a patchy coverage of flood risk understanding across Australia as it has been driven by funding grants. The Queensland Floods Commission of Inquiry (following the 2010–11 Queensland floods) noted that 80 of the 127 planning schemes in Queensland did not contain flood mapping at the time of the floods; those that did were often inconsistent and not in accordance with state-planning policy guidelines (Queensland Floods Commission of Inquiry 2012). Two key reasons for this were identified:

- Flood mapping was not mandatory
- Creating flood mapping required undertaking a flood study which is time consuming and expensive

However, considerable effort has been made in the past ten years to improve the coverage, consistency and quality of flood risk mapping across Australia. For example, the Queensland State Government has led the way in preparing flood maps for at-risk areas of Queensland, which can then be utilised by local councils to conduct more detailed flood studies. Through the Queensland Flood Mapping Program, fit-for-purpose flood maps were developed that involved:

- Catchment-wide rapid assessments, improving coverage outside towns and cities
- Flood mapping for over rural 75 towns and settlements where the relatively low population would not have justified flood mapping under previous practices; and
- Acceleration of the usual process in conducting detailed flood studies for densely populated areas

However, there are still many at-risk localities in Queensland that lack sufficient flood mapping (PwC

2015). The utility of rapid assessment mapping to inform decision making is limited.

NSW also undertook broader scale valley studies in the 1980s. These studies used available information to develop an understanding of flooding in the major valleys in NSW. The limitations of this information, as with the information from other rapid assessment techniques was understood.

In contrast to Queensland, the other two eastern states with extensive, developed floodplains (NSW and Victoria), had been promoting and supporting the understanding and risk-based management of flood risk to a level of detail to inform detailed management decisions for urban and rural communities. The detailed assessment of flood risk is suitable for consideration in setting strategic development directions and controls in land use planning and to support emergency management planning and FRM decisions. The focus of where detailed studies have been undertaken considers the potential risks of flooding in these areas. Therefore, the value of undertaking rapid assessment mapping as done in Queensland in either NSW or Victoria is questionable given their relative progress in FRM. So, there are areas in these states where flood risk is not well understood.

There has also been considerable effort to improve the quality of information available to support flood risk modelling and mapping at the national level. For example, digital elevation modelling has been conducted utilising LiDAR modelling techniques for over 245,000 km² at 25m grids and 5m grids (1m grids in most urban areas) and can be accessed online (Geoscience Australia 2018a).

Australian Rainfall and Runoff, first published by the Institution of Engineers Australia in 1958, and subsequently updated in 1977, 1987, in the 1990s and in 2019, sets out standard methodologies to be used for estimating rainfall events of given probabilities and the resultant flood events. It has been developed for Australia's climatic conditions and has undergone three major revisions based on the results of research and observation. *Australian*

Rainfall and Runoff and related Bureau of Meteorology databases along with relevant state and territory databases also contains a significant amount of data to support the understanding of flood risk around the country (Geoscience Australia 2018b). It is utilised for the estimation of design flood characteristics and is viewed as providing a standard of technical guidance that should be taken into account in flood study methodologies (Department of Environment, Land, Water and Planning 2016). However, in some states, such as NSW, some of the information and approaches outlined in *Australian Rainfall and Runoff 2019* have had to be modified as they have had a tendency to underestimate flood behaviour.

The National Flood Risk Advisory Group has also developed guidance and technical specifications to improve the scoping of studies into the understanding and management of flood risk in Australia. This work aimed to improve the quality of fit-for-purpose FRM studies. States have taken this guidance and adapted it to suit their needs, for example through the development of a brief development tool to assist in the development of fit for purpose specifications for flood projects in NSW.

Some states and territories have also provided guidance to improve the quality and standardisation of flood risk mapping associated with flood studies and plans. For example, the Victorian Government has provided guidelines (Department of Environment, Land, Water and Planning 2016) to provide a reference for flood risk mapping and flood data collection activities that align with Victorian Government policy set out in the Victorian Floodplain Management Strategy (see Section 3.1). They set a standard for flood mapping in Victoria to meet the needs of a range of users, including land use planning,

assessing risks to Aboriginal cultural heritage, insurance and emergency response.

The availability of mapping to the public in many cases is limited to flood-related planning controls, rather than risk mapping for a full spectrum of possible events, and in many cases requires payment of fees to local government to access risk information. State governments are pushing an open data agenda for newly-developed flood mapping, but there is little incentive or assistance provided for local councils to make older flood mapping datasets openly available via the various state and national open flood data portals.

The Insurance Council of Australia has led efforts to collate local government flood mapping for insurers, distributing to all ICA members both raw data collected from councils and a national address-level processed dataset, the National Flood Information Database (NFID).

The Australian Flood Risk Information Portal enables flood information, currently held by different sources, to be accessible from a single online location (Box 1). The portal hosts data and tools that allow public discovery, visualisation and retrieval of flood studies, flood maps, satellite-derived water observations and other related information from a central location. However, the portal has almost no data on it except PDFs and some post-2016 studies. There is no incentive to digitise legacy datasets, which are often restricted by consultants' licence agreements and cannot be shared publicly. State-wide flood risk mapping portals and databases in Victoria and NSW allow local councils and CMAs to upload and maintain their data; however, access is largely restricted to government use only due mainly to IP issues.



Brisbane Floods, 2013

Box 1: The Australian Flood Risk Information Portal

Following the devastating floods across eastern Australia in 2011, the Australian Government initiated the Natural Disaster Insurance Review. This review highlighted the lack of consistency across the country in the way flood risk information was collected and made available to users. The review also recognised the need for consumers to be aware of the natural hazard risks they may face, as well as the benefits of making flood risk information more readily accessible.

In response to these findings, the Government established the National Flood Risk Information Project (NFRIP) with the aim of improving the quality, availability and accessibility of flood information across Australia and, in doing so, raise community awareness of flood risks. This four-year project commenced on 1 July 2012 and delivered three products: 1) The Australian Flood Risk Information Portal, 2) Water Observations from Space and 3) the *Australian Rainfall and Runoff* guidelines. NFRIP supports the objectives of the National Strategy for Disaster Resilience (NSDR) adopted by the Council of Australian Governments (COAG) in 2011; specifically, that governments have effective arrangements in place to inform people about hazard and risk.

The Portal is available for use by engineers, insurers and planners to find out what flood mapping information exists and where, so they can better understand risks. Researchers and consultants can learn what work has already occurred in their area of interest and identify what data may be available for use in future studies. Organisations can refine the scope of planned flood studies by understanding and applying lessons learned from work undertaken in other regions. Others in the community can also use it to find out what flood information exists for the area that they live in.

The screenshot displays the Australian Flood Risk Information Portal. The page features a navigation bar with the Australian Government logo and the text 'Australia Government Governance Australia'. The main header includes the portal title 'Australian Flood Risk Information Portal' and a breadcrumb trail: 'Home > Hazards > Flood > Australian Flood Risk Information Portal >'. Utility links for 'Feedback', 'Managing Floodplains', 'Flood Modelling Guide', 'Flood Modelling Data', and 'FAQs' are visible. The search interface is divided into three sections: 'Search by Flood Study ID' with an 'AFSID:' input field; 'Select a Location' with 'By name:' and 'By selecting an area on the map:' options; and 'Refine Search' with filters for 'Study includes content of type' (All of / Any Of), 'Year study completed from:' to 'To:', 'State:', and 'Keyword:'. A 'Reset' and 'Search' button are at the bottom of the search area. On the right, a map of Australia shows flood study locations as blue and yellow dots. The map includes labels for 'Australia', 'Great Australian Bight', and 'New Zealand', and a legend for 'Flood Studies' and 'Flood Studies with GIS data'. The footer contains links for 'About the Portal', 'Floodplain Management', 'Share Flood Studies', and 'Disclaimer', along with 'Privacy', 'Accessibility', 'Information Publication Scheme', 'Freedom of Information', and 'Floods Public Search Feedback'.

Many local councils and Catchment Management Authorities (Victoria) provide flood risk data directly to the public via their websites or on request.

In some states and territories (e.g. NSW), planning certificates must be provided by sellers as an attachment to a contract of sale of land and that certificate will indicate whether flood-related planning controls apply. However, risk disclosure is limited to properties subject to flood-related planning controls and does not capture all flood-prone property. In addition, as they are only required at the point of sale they are of limited value for awareness. For example, the owner of a property is not required to provide a copy of the certificate to tenants when they lease a property.

Around 65% of properties with a known flood risk are not subject to flood-related development controls (IAG 2020) and are therefore generally not subject to flood risk disclosures. Residents in these areas are typically unaware of their flood risk and often first learn of their risk via their insurer, or through experiencing a flood event which exceeds the 1% AEP. In many cases, these properties carry considerable flood risk from events larger than the design flood event, and therefore attract significant flood insurance premiums.

5.2. Flood alerts and early warnings

The Australian Government worked with the states and territories to develop guidance to assess and design robust flood alerts and warning systems. This produced the concept of the 'total flood warning system' (TFWS) to describe the full range of elements that must be developed if flood warning services are to be provided effectively (Box 2).

The lead guiding document for the development of the TFWS in Australia is 'Manual 21 – Flood Warning' (Attorney-General's Department 2009).

In Australia, flood warning services are provided under an inter-governmental agreement. All levels of government play a part in delivering the total flood warning system services to local communities across Australia. They may all own water level (mainly states, territories and local government) and rain gauges. The states, territories and local government are a key source of information on flood classification as well as on the flood impacts to the community and the actions the community should take in response to an imminent flood threat.

To support coordination and improvement of jurisdictional flood warning services, Flood Warning Consultative Committees (FWCCs) have been established (NSW, now NSW/ACT, for example, was established in the 1980s). FWCCs are chaired by the Bureau of Meteorology with membership from responsible entities that support the coordination and improvement of flood warning services in the jurisdiction across all levels of government.

The lead organisation for predicting floods and issuing flood warnings is the Australian Bureau of Meteorology, with state and territory emergency agencies interpreting and communicating warning information to affected local communities. The majority of water level gauges relied upon for flood warning are owned by state government agencies or water supply authorities. In some cases, flood warning was not the primary purpose for the installation of a gauge and can impact on the availability and suitability of the data for flood warning.

Although this guidance and flood warning services are in place, there is further work to be done to improve the quality and coverage of TFWS and flood alert systems across Australia. This includes recent national work coordinated by the Bureau and involving all the jurisdictions to develop a more strategic understanding of the flood warning system at both a jurisdictional and national level to support future improvements to the system. In addition, the Queensland and Victorian Governments conducted

Box 2: The Total Flood Warning System (TFWS) in Australia

According to Manual 21 (currently under review), at its simplest, the TFWS consists of six components:

1. **Prediction:** detecting changes in the environment that lead to flooding, and predicting river levels during the flood.
2. **Interpretation:** identifying in advance the impacts of the predicted flood levels on communities at risk.
3. **Message construction:** devising the content of the message which will warn people of impending flooding.
4. **Communication:** disseminating warning information in a timely fashion to people and organisations likely to be affected by the flood.
5. **Response:** generating appropriate and timely actions from the threatened community and from the agencies involved.
6. **Review:** examining the various aspects of the system with a view to improving its performance.

Manual 21 (page 7) stresses that for the TFWS to 'work effectively, these components must all be present and they must be integrated rather than operating in isolation from each other'.

extensive reviews into the devastating floods in their respective states that occurred during 2010 and 2011. The Victorian Flood Review (Victorian Government 2011) was particularly scathing in finding deficiencies in the flood warning system in that state.

The Victorian Flood Review, led by Neil Comrie AO, made 93 recommendations to improve flood warning and associated services throughout the state. Numerous recommendations were made in relation to the adequacy of flood predictions and modelling, and the timeliness and effectiveness of warnings and public information. Using these recommendations, the Victorian Government has made several improvements in predicting floods, mapping them and creating efficient, accurate warnings (Department of Environment, Land, Water and Planning 2019).

Of particular concern in Australia is the provision of warning systems for flash flood scenarios (which can relate to both fluvial and pluvial flooding). Flash flooding in Australia is defined as flooding that occurs within six hours of the start of the rain that causes it (Bureau of Meteorology 1996). The Victorian Flood Review (Victorian Government 2011) identified five areas of concern for flash flooding in that state:

- The lack of definitive state policy and direction on roles and responsibilities – the roles of the Bureau of Meteorology, as well as other flood warning system stakeholders, in delivering forecasts and warnings of conditions that likely lead to actual flash flood events are not as clear as they need to be.
- Local government’s ability, in terms of financial and technical capacity, to establish, maintain and operate an effective flash flood warning system with regard to both technical and social aspects; unless there is active participation from local government, the framework breaks down.
- A key tool in extending the warning lead time available in flash flood catchments is weather radar and at least timely access by local communities and agencies to raw information on the likelihood of rainfall likely to lead to flash flooding.
- Awareness within the at-risk community that flash flooding is a credible risk and of the circumstances that may give rise to an event.
- Dissemination of meaningful and timely pre-scripted warning messages– that clearly impart essential information and elicit appropriate responses – to those at risk from flash flooding.

There has been improvement in some of these issues across Australia in subsequent years. For example, although the Bureau of Meteorology does not take

responsibility for flash flood warning systems, it coordinates the national Flash Flood Advisory Resource (FLARE), which it developed in partnership with the jurisdictions, to provide support to flood risk managers, emergency agencies, local councils and others. FLARE is an authoritative resource created to assist agencies in designing, implementing and managing fit-for-purpose flash flood warning systems.

However, the provision of warning systems for flood-affected communities is largely dependent on government grant funding and the funding contributions of local councils. Therefore TFWS development is implemented inconsistently across Australia and not necessarily in the communities that need it most: those with the least flood warning lead times and the highest flood risks.

5.3. Emergency preparedness measures

As outlined in section 3.3, each state and territory government has established emergency response agencies as well as overarching emergency or disaster management legislation and plans in which the roles of various agencies are set out. The emergency and disaster management plans at state, regional and local levels include detailed flood emergency preparedness plans. These plans focus on the development of appropriate response strategies for the community in light of the flood problem and identifying the varying roles and responsibilities in delivering these plans.

Community response consistent with the plans requires community engagement and advice on these plans. For example, the NSW State Emergency Service’s FloodSafe program targets businesses and households. However, social research conducted in some flood-affected Australian communities shows that there are generally low levels of community and business flood preparedness (Dufty 2020). For example, state and territory emergency agencies via community flood education have encouraged individuals, families and businesses to have written flood emergency plans as part of their preparedness actions but the uptake has been very low (< 10%) in most communities researched (Dufty 2015). In some flood prone areas, the uptake rate of flood insurance can be below 50% (Dufty 2020).

5.4. Risk reduction measures

Handbook 7 (Australian Institute for Disaster Resilience 2017) identifies three categories of risk reduction measures:

- Measures to modify flood behaviour (structural measures), e.g. levees, detention/retarding basins
- Measures to modify property (non-structural and structural measures), e.g. zoning and development control, voluntary purchase, voluntary house raising

- Measures to modify response (non-structural measures), e.g. community flood education and engagement, flood warning systems, emergency management planning.

Traditionally, **levees** have been used across Australia to reduce the frequency of fluvial flooding in towns. They are often the most economically attractive measure and they may also have significant social advantages for the community over other measures. For events up to their design flood, levees can provide significant reductions in damage and allow communities to function and potentially support surrounding rural areas, during long-duration floods, provided the structural integrity of the levee is not compromised. Regular and ongoing maintenance of these is essential to ensuring their structural integrity. Levees may need to be upgraded to maintain the current level of protection particularly where climate change can lower the level of protection provided by a levee over time and where the viability of the community and infill development rely on the protection provided by the levee.

Temporary barriers are also used in some parts of Australia and have proven to be the most cost-effective flood mitigation strategy for existing risks in certain circumstances (BNHCRC 2020). Temporary barriers are relocatable systems erected in response to a flood threat. They can be part of a long-term strategy to manage flood risk if designed to be erected each time a flood occurs that threatens the area.

Artificial detention basins provide temporary storage for floodwaters as a means of reducing peak downstream flows, often to offset the impact of land use changes on flows. They are used across small catchments in many urban areas across Australia.

There has been considerable controversy, particularly in the past ten years, about the use of major **dams** for flood mitigation. 'The primary purpose of most dams in Australia is to provide a secure water supply. They are, therefore, generally kept as full as possible and cannot be relied upon to provide significant volume capacity to mitigate a flood threat, as this is not their design purpose' (Australian Institute for Disaster Resilience 2017). There are, however, a number of dams in Australia that are designed with some flood mitigation component. They mitigate flooding by absorbing some of the flood volume in 'air space' kept free from water supply needs (Australian Institute for Disaster Resilience 2017).

In 2010 and 2011, Australia experienced some of its most costly flood events, with large areas of Queensland declared disaster zones. At the time of the Queensland floods, there was significant scrutiny of how Wivenhoe Dam (providing drinking water to Brisbane) was operated, even though it was part of the engineering

system designed to mitigate flood risks. Individual flood operations engineers were criticised for making poor decisions. The managers of the dam operator were blamed for not drawing down the dam at the beginning of the wet season despite a long drought immediately prior to the floods (Entura 2018).

As a result of an investigation into flooding in the Hawkesbury-Nepean Valley (Infrastructure NSW 2017), the NSW Government released the Hawkesbury-Nepean Valley Flood Risk Management Strategy, which recommends to raise Warragamba Dam, Sydney's main drinking water supply, to create a flood mitigation zone of about 14 metres. The potential benefit is a risk reduction of around 75% of AAL across 25,000 homes (Infrastructure NSW 2017). However, the possible expansion of dam capacity has caused considerable public criticism, as it may significantly impact biodiversity and Indigenous sacred sites (The Guardian 2019). A similar proposal for 23 metres of flood mitigation capacity at Warragamba Dam was rejected by the NSW Government in 1995.

5.5. Property-level protection measures

The key property protection measure used in new property in Australia is exclusion of water by the use of **minimum floor levels** of habitable buildings and associated sub-floor structural requirements, above the defined flood event by a freeboard. This key flood-related development control can influence the protection provided to properties by limiting the frequency of above floor flooding. These controls are generally reflective of the knowledge of flooding and the standards set for development at the time the property was constructed. They may change over time as more is known about flooding and associated risks to communities and where decisions on development standards change.

A problem with property-level schemes in Australia is that they are generally poorly tracked. As a result, governments find it difficult to understand their effectiveness and insurers find it difficult to price for them. Inevitably, the onus is on the current homeowner to keep the memory of the works alive. Knowledge of the age of the building, as well as the required minimum flood-related development controls in place when the building was constructed, can assist in understanding a property's likely standard of flood resilience. But again, this data is not broadly available.

Flood proofing buildings whose floor levels do not meet current standards may involve using materials that are flood compatible (i.e. are resistant to damage by floodwaters) or temporary measures. They may include a range of built-in automatic and manual barrier systems that aim to prevent water penetration into the building during a defined flood event (Australian Institute for

Disaster Resilience 2017). Individual landowners usually pay for flood proofing houses in Australia.

The Flood Resilient Homes Program is an initiative developed by Brisbane City Council to encourage property owners to implement flood proofing on existing buildings where it is not practical to modify flood behaviour. This pilot program is designed to help residents prepare for, and recover from, fluvial flooding events. The program consists of a free in-home service, a free tailored property report and an incentive scheme for eligible properties.

The floor level of an individual property can be raised to reduce the frequency of above-floor flooding, the scale of losses and clean-up required, and the post-flood trauma and stresses on individuals. There have been several **house-raising schemes** in flood-prone communities across Australia. House-raising is generally best suited to timber-framed and clad structures. Single or double brick, or slab-on-ground structures are often impractical or cost-prohibitive to raise (Australian Institute for Disaster Resilience 2017).

Since the 1980s a range of floodplain risk management plans developed by local councils in NSW have also identified house raising undertaken on a voluntary basis as an adopted management measure to reduce property damage in some local areas. This has resulted in shared financial assistance arrangements to owners to raise properties voluntarily in some areas over the last few decades.

Insurance claims data show mixed success with house raising. Subsequent homeowners may not know about the intent of the renovation, retrofitting the undercroft that has been created with habitable rooms or using it to store valuable goods (even when it is not permitted by local government development controls).

House buyback aims to remove the people and the structure from the floodplain. It involves either removing or demolishing the house and rezoning the land to a more flood-compatible purpose. It is generally an expensive option and, as such, is generally targeted to specific locations and scales of problems (Australian Institute for Disaster Resilience 2017). There are several house buyback schemes across Australia, normally instigated by local councils and typically with financial assistance from state and sometimes the Australian Government. Their rate of implementation is generally quite slow due to the reluctance of home owners to sell or the lack of available funds when the house comes on the market.

Land swap schemes are still novel but gaining traction in Australia (Mosely, 2020), particularly following major events such as the Grantham Floods (2011) and the South Murwillumbah Flood as a result of ex-Tropical Cyclone Debbie (2017).

5.6. Prevention through development planning and land use

Planning laws are developed by each of the states and territories and then implemented by local councils. In Australia, planning laws tend to give local councils a degree of flexibility to identify areas that are at flood risk and set requirements for development in those areas. For example:

- Under Queensland's State Planning Policy (Queensland Government 2017), local governments can designate 'flood hazard areas' and define the flooding level for those areas. If an area is designated a 'flood hazard area', then development in that area is subject to Mandatory Part 3.5 ('Constructions of buildings in flood hazard areas') under the Queensland Development Code. Guidance notes that '...inclusion of events greater than and less than the traditional 1% AEP in the flood hazard overlay is encouraged'. However, it is not compulsory. For example, the Moreton Bay Regional Council uses the following 'defined flood event': 'The higher of the 1% Annual Exceedance Probability event for storm tide or river and creek inundation to the planning horizon year 2100 allowing for the fully developed catchment, an allowance for climate change (20% increase in rainfall intensity), predicted sea level rise (0.8m) and blockages to drainage systems (as specified in the Queensland Urban Drainage Manual)'.
- Under NSW's Flood Prone Land Policy and Flood Development Manual (NSW Government 2005), local councils are responsible for determining the appropriate flood-planning levels (FPL) for land within their local government area in consideration of the flood risk. The local council may then impose development controls in those areas. Whilst the level of flooding used to determine the residential FPL is a decision of the local council, the Manual highlights that FPLs for typical residential development would generally be based around the 100-year flood (1% AEP) plus an appropriate freeboard (typically 0.5 m). Since 1986 the Manual has promoted a merits-based approach and the 2001 revision introduced the requirement to consider risks for the full range of events up to the PMF.

Local Environment Plans in NSW are prepared by local councils to identify the zonings and development controls that apply to the development of land in their area of application. In NSW, there has been concern expressed about how flood-relative development controls are being articulated in the Local Environment Plans prepared by local councils. For example, Grech and Bewsher (2014) noted that 'There has been an alarming trend in the way that standard flood planning maps have evolved from the earliest version produced for Liverpool LEP 2008 to the more recent version seen in Rockdale LEP 2011...This is

the movement away from depicting actual flood risk to depicting a patchwork of properties subject to a flood-related control on specifically residential development'. Similarly, concern has been expressed that planners have limited understanding of how flooding standards are determined, although this appears to be less of an issue in Queensland (Grech and Bewsher 2014).

As with house raising schemes, flood planning controls stipulating only minimum floor levels to mitigate flood risk can result in buildings, particularly residential buildings, with ground floor levels well above the ground level. Subsequently, the created under croft space is converted to living space or storage space resulting in valuable assets well below the stipulated flood-planning level. This practice is not consistent with planning schemes.

To support the improvement in the consideration of the full range of flood risk in setting and implementing strategic directions for communities, the National Flood Risk Advisory Group and Australian Institute of Disaster Resilience supported the development of guidance to support ADR Handbook 7. Guide 7.5 ('Flood information to support land use planning') provides advice on the variation of flood-related development constraints (flood function, extent, hazard, and range and the difficulty in emergency response) across the full range of flood behaviour into four Flood Planning Constraint Categories (FPCCs). This guide also provides advice on considering how to use this information to make decisions on where to develop, what type of development to locate where and the development controls necessary to limit the growth of flood risk to new development. The aim is to ensure that development is compatible with the flood risk at the location.

In addition, the AIDR recently released a handbook, *Land Use Planning for Disaster Resilient Communities*, which provides principles and guidance for considering natural hazards in land use planning. Several key points are:

- the recognition that any new development in areas affected by hazards creates a risk
- land use planning arrangements are only able to limit the growth in this risk
- effectively strategic land use planning requires a multi-disciplinary approach bringing together land use planners, natural hazard managers and emergency managers

5.7. Disaster risk financing measures for government

State and territory governments have primary responsibility for disaster risk financing, but in some circumstances receive co-funding from the Australian

Government. The arrangements have been in place under various names for many decades.

The Natural Disaster Resilience Program (NDRP) was formed in 2009, under a National Partnership Agreement for Natural Disaster Resilience. The NDRP is a grant funding program that is equally funded by the Commonwealth and state and territory governments. The NDRP encourages the Government to work together with volunteers, the private sector and non-governmental organisations to enhance local communities to be more resilient to natural disasters.

The Australian Government is looking to diversify risk financing arrangements through the Natural Disaster Risk Reduction Framework and will pursue collaborative commercial financing options for disaster risk reduction initiatives (Department of Home Affairs 2018).

A pilot program is underway for a Resilience Investment Vehicle, supported by the Australian Government. This is a collaboration of IAG, NAB, CSIRO and member agencies of the Australia-New Zealand Emergency Management Committee (ANZEMC) Mitigation and Risk Sub-Committee (EMA, NSW OEM and QRA). The pilot aims to explore how both public and private capital could be directed to finance new or adapt existing infrastructure that builds community resilience to natural hazards under a changing climate.

Funding from states and territories for FRM projects involves local councils submitting projects with a requirement of partial funding from councils. This process favours those local councils that have their own funds available for FRM, rather than being based on the highest flood risk areas in each state and territory. It results in incomplete flood risk assessment and planning across some parts of Australia. However, some funding arrangements recognise this potential, with NSW offering higher funding ratios to low financial capacity councils in NSW to enable them to more readily afford FRM projects for their communities.

Furthermore, a large proportion of Australia's disaster funding (including that to states and territories) is attributed to disaster recovery rather than mitigation including FRM. 'The Australian Government post-disaster support to state and territory governments should be reduced, and support for mitigation increased' (Productivity Commission 2014). In addition, there is a significantly lower level of funding from the Australian Government to non-fire disaster management including FRM, compared to fire-related funding (Productivity Commission 2018).

Risk finance for the private sector (e.g. residences, businesses) is covered by flood insurance.

5.8. Flood insurance and other risk transfer solutions in Australia

Flood insurance coverage for households is estimated by the Insurance Council of Australia to be over 93% (Insurance Council of Australia 2016). However, this high level of coverage is a recent phenomenon. Table 2 provides a summary of flood insurance in Australia. Until 2008, residential flood insurance was broadly unavailable in the eastern states of Australia, which are home to most of Australia's population and the majority of flood risk.

Table 2: Summary of flood insurance in Australia as of June 2020	
Risk-based approach	Yes
Compulsory terms	Voluntary. Banks generally require evidence of insurance cover before granting a mortgage, though this requirement is typically not actively enforced through the life of the loan.
Public or private	Private
Policyholder programmes	Flood cover is a standard inclusion for home insurance policies, with some providers offering the option to remove flood cover. Flood cover is available under business and commercial insurance packages.
Incentivising risk reduction	Reductions in flood insurance premiums are applied following completion of risk reduction projects.
Market penetration and coverage	Flood insurance coverage for households is estimated to be over 93%. Information on flood insurance uptake by businesses is limited.
Insurance-backed securitisation of cat and green bonds	Limited

Source: The Geneva Association

Historically, flood risk was considered uninsurable due to a lack of consistent and reliable flood mapping, lack of floodplain risk management and the absence of investment in flood mitigation. Flood cover was initially not offered on Australian insurance policies until the inclusion of flood as a 'standard cover' in the Insurance Contracts Act 1984 led to insurers to explicitly excluding flood cover (with the exception of the relatively low-risk and low-population Western Australia, South Australia and the Northern Territory) (Mason 2011). Some insurers introduced limited cover for stormwater (i.e. non-riverine) inundation while still excluding flood; however, definitions and coverage varied and often led to confusion in the wake of events.

Following the improved quality and availability of flood hazard mapping and in response to heavy criticism following major flooding events in the 1990s and 2000s, a number of insurers began offering standard flood insurance coverage from 2008 (Mason 2011).

The adoption of a standard definition of 'flood' in 2012 followed and has also played a significant role in expanding coverage, although some insurers will still offer coverage on an "opt out" basis (e.g. permitting opt out for riverine flooding) (AXCO 2018). The current definition of flood that is used in Australia is '...the covering of normally dry land by water that has escaped or been released from the normal confines of (a) any lake, river, creek or other natural watercourse, whether or not altered or modified, or (b) any reservoir, canal or dam.'

Flood insurance in Australia is priced based on the level of risk to the insured asset, and is therefore heavily reliant on the availability and quality of flood hazard mapping. The industry's broad roll-out of flood cover was facilitated by the Insurance Council of Australia, which coordinated the collation and processing of flood hazard maps from local governments into the National Flood Information Database (NFID). The NFID was first published in 2008, and it is available to all members of the ICA, alongside the underlying raw hazard data collected by the ICA. Ongoing updates to the NFID have increased coverage of government-sourced hazard mapping to around 56% of Australian addresses, with a further 32% of addresses flagged as likely nil risk, leaving only around 11% of addresses with unknown flood risk. Insurers are not required to use the NFID in pricing flood risk, and other sources of flood risk data are becoming increasingly available as local and state governments shift towards open data platforms, and improvements to the power and accessibility of flood modelling technology create a market for specialist risk modelling firms.

Flood insurance is available throughout Australia, though insurance affordability remains a concern in high-risk flood regions, as pricing reflects the high underlying risk. The insurance industry is a strong advocate for improvements in land use planning and risk reduction programs to address the affordability challenge, with insurers typically reducing flood insurance premiums after completing risk reduction projects.

Numerous reviews into the insurance industry have found that pricing is appropriately aligned with risk. The Australian Government Actuary (2014) reviewed the prices of home and contents insurance in North Queensland in 2014 and concluded that there was no evidence to suggest that the methodology employed by insurers in setting technical premiums was unreasonable. The Senate Economics References Committee Inquiry Report (2017) noted that 'there have been several government and industry reviews relating to premium increases in home and strata insurance. These reviews have consistently found that, despite notable increases, premiums remain commensurate with the level of risk'.

Catastrophe bonds in Australia are not widely used and are typically for earthquake and tropical cyclone risk. For the latter, these bonds cover incidental flooding as part of a named cyclone event but not standalone flood events explicitly. Only one catastrophe bond has been issued to explicitly cover flood risk in Australia: in February 2019 by Orchard ILS Pte Ltd (Singapore) on behalf of IAG.

5.9. Reconstruction approaches

Australia has prepared National Principles for Disaster Recovery (Australian Institute for Disaster Resilience 2020), supported by Australian and New Zealand government departments and recovery support agencies. These principles promote a community-focussed recovery. 'Community-focused recovery is essential. Disasters can deeply impact people's lives and livelihoods, and helping communities recover from disasters can be challenging and complex. Every community is unique and will have its own history, values and experiences. They will also have their own distinct challenges. Our role in recovery is to support and build capacity; to remove barriers, to enable, and to use local knowledge and strengths. We can help a community recover from the sense of loss and uncertainty they experience, so they can live a life they value' (Australian Institute for Disaster Resilience 2020).

Reconstruction is part of the recovery phase in disaster management. A main ethos in Australian reconstruction is to 'build back better' (Prime Minister of Australia 2020), which is allied with transformation to build resilience (Mannakkara & Wilkinson 2012).

A large proportion of post-flood reconstruction is funded by the Australian Government and the flood-impacted state and territory governments. For example, after 2019 floods in Townsville and other parts of northern Queensland, the Australian Government and Queensland Government funded a joint recovery package totalling AUD 242 million, including AUD 135 million for reconstruction of damaged infrastructure (Queensland Reconstruction Authority 2019).

A flood levy was a temporary reconstruction tax (one year only) imposed by the Australian Government that helped to fund the reconstruction of Queensland, following the 2010–

11 Queensland floods. The levy applied to all Australians who had a taxable income of more than AUD 50,000 a year. As a result of funding from the Australian Government and Queensland Government and from the private sector, an estimated AUD 11.8 billion (including insurance payments) was mobilised within three months, representing 75% of the estimated damage and losses which was already above the 45% average of disaster coverage in developed economies (World Bank 2011).

Reconstruction after a disaster may occur in different ways in different states. For example the Queensland Reconstruction Authority was established under the Queensland Reconstruction Authority Act 2011 following the floods and Cyclone Yasi which struck Queensland during December 2010 and January 2011. The Authority is charged with managing and coordinating the Government's program of infrastructure reconstruction and recovery within disaster-affected communities.

Australia is a wealthy country and has shown from recent floods (e.g. 2010–11 Queensland Floods) that it can build back better, particularly its public infrastructure (e.g. roads, rail networks, public utilities). For example, the Queensland Reconstruction Authority highlights a range of infrastructure and other resilience-building projects that it has funded and supported during the past ten years (Queensland Reconstruction Authority 2020).

The Queensland Betterment Fund is a Queensland Government initiative supported by the Australian Government. The AUD 80 million Betterment Fund was launched in the immediate aftermath of Tropical Cyclone Oswald, which caused damage in excess of AUD 2.4 billion to large areas of Queensland. The Fund allows local governments to restore or replace essential public assets damaged by Tropical Cyclone Oswald with a more disaster-resilient standard than their pre-disaster standard to achieve greater long-term social and economic benefits for affected communities (Carroll 2015).

It should be noted that Australia provides substantial funding to neighbouring Indo-Pacific countries to aid disaster recovery and reconstruction activities. The Department of Foreign Affairs and Trade (DFAT) is responsible for leading the Australian Government's response to international humanitarian crises. Between July 2016 and June 2017, Australia contributed to humanitarian assistance in 44 countries, including in Myanmar, Syria, Iraq, Afghanistan and Fiji. During this period, Australia provided total assistance of over AUD 342.3 million, including funds redirected from bilateral programs (Department of Foreign Affairs and Trade 2020).

An increasingly mature and responsive private flood insurance industry has enabled residents and businesses to build back better after recent flood events (section 4.8), e.g. the 2019 Townsville Flood (Insurance Council of Australia 2020).



6. Towards an all-of-society approach to flood risk management

6.1. Cross-governmental collaboration

The main collaboration across the three levels of government in Australia is via FRM funding arrangements outlined in section 4.

As discussed in section 4.3, NFRAG was established to facilitate national coordination and cooperation in best-practice FRM. It brings together technical representatives actively involved in FRM in their jurisdictions with other key stakeholder groups. It provides a basis for sharing experiences and for collaborative efforts to improve FRM practices and outcomes in Australia. This has led to the continued development of national guidance, such as ADR Handbook 7 and its guides, to improve FRM outcomes for Australian communities. NFRAG has engaged with relevant industry sectors through its jurisdictions as part of a range of projects and initiatives.

The emergency management arrangements in Australia also require cross-government collaboration through state, regional and local emergency and disaster committees that implement emergency plans when required. These arrangements include the establishment and use of emergency operations centres and evacuation centres.

6.2. Cross-sectoral collaboration

One of the main avenues for cross-sectoral collaboration in FRM is through the professional body, Floodplain Management Australia (FMA). Established in 1961, FMA is 'committed to promoting appropriate development within floodplain areas, and helping reduce the risks of flooding to life and property' (Floodplain Management Australia 2020). Members include over 140 councils, catchment management authorities, businesses, representatives of the insurance industry and professionals involved in all aspects of urban and rural floodplain risk management.

In 2006, in partnership with the NSW Office of Environment and Heritage (now the Environment Energy and Science Division of the Department of Planning, Industry and Environment), FMA initiated industry workshops at their annual conferences to support a deep dive into specific flood-related topics. These workshops continue at annual conferences today. In addition, in 2009 this partnership led to the initiation of Australia's only industry-based FRM course tailored to the needs of technical and land use planning staff and elected council representatives. The program is conducted by the University of Technology-Sydney, and participants regularly include practitioners from outside NSW. This course is transitioning to support online delivery which will improve the accessibility of the subject.

The FMA has members in all states and territories of Australia, and in 2013 established the National Flood Risk Managers Working Group to develop a framework for national cooperation and advocacy for FRM. It holds an annual conference in venues around Australia, quarterly workshops in Brisbane and Sydney, and provides submissions to state and federal governments on proposed policies and strategies.

The Bushfire & Natural Hazards Cooperative Research Centre is conducting research to build a disaster-resilient Australia. From July 2013, AUD 47 million over eight years in Australian Government funds under the Cooperative Research Centres Program have been matched by support from state and territory government organisations, research institutions and NGOs. It coordinates a national research effort in hazards, including bushfires, flood, storm, cyclone, heatwave, earthquake and tsunami. The research program has developed under the direction of the researchers and end-user agencies. The research has three major themes covering 12 clusters of projects, most of which span the priorities of those working in a multi-hazard environment.

The Australasian Fire and Emergency Service Authorities Council (AFAC) is the peak body for public-sector fire, land management and emergency service organisations in Australia and New Zealand. Its members are public- and private-sector organisations, representing a workforce of over 250,000 emergency management professionals, both volunteers and career staff. However, AFAC does not have representation from flood risk managers.

The Australian Institute for Disaster Resilience works with the jurisdictions and experts in their chosen field to develop, maintain and share knowledge and learning to support a disaster-resilient Australia, including FRM. Building on extensive knowledge and experience in Australia and internationally, it works with government, communities, NGOs, not-for-profits, research organisations, education partners and the private sector to enhance disaster resilience through innovative thinking, professional development and knowledge sharing. The AIDR is supported by its partners: the Australian Government Department of Home Affairs, AFAC, the Australian Red Cross and the Bushfire & Natural Hazards Cooperative Research Centre.

As promoted by Handbook 7 (Australian Institute for Disaster Resilience 2017), as part of FRM in Australia, many local councils have floodplain management committees or similar, comprised of council staff and elected representatives, emergency agencies, other government agencies and in some cases, representatives of the community. The aim of these committees is to advise on local FRM including the development of flood studies and floodplain risk management studies and plans.

Although the National Strategy for Disaster Resilience (see section 3.3) espouses the concept of 'shared responsibility' between governments and at-risk communities and Handbook 7 promotes community engagement in FRM, in most at-risk communities across Australia there is little interest and involvement in FRM, unless property values or other personal matters appear to be threatened (Dufty 2020). This is in line with the generally low flood-preparedness levels across Australia and prevailing unwillingness to self-evacuate during a flood (Dufty 2020).

There are several possible reasons for this lack of collaboration between governments and communities in FRM. Firstly, there is only a small proportion of the budgets of Australian flood emergency agencies (< 2%) assigned to community flood education and engagement that is designed to improve community preparedness and recovery levels (Dufty 2020). Secondly, the culture of emergency agencies is largely directed at a top-down ('command and control') approach and a participatory approach ('bottom-up') with communities can be challenging (Webber et al. 2016). Lastly, there tends to be prolonged drought between wetter years (a pattern that will be exacerbated by climate change – see section 2.2) in many parts of Australia and residents and businesses tend to downplay flood risk during these drier times (Dufty 2020).



7. Conclusions: Successes, continued challenges and lessons learned

As a wealthy developed country with a relatively small population, Australia has been able to resist, recover and rebuild after many devastating floods. Its emergency management arrangements and services are well-practiced across hazards and internationally recognised. High quality national and state guidelines and frameworks for FRM activities are in place; however, there are significant variations at local levels in the maturity, resourcing and standard of implementation of floodplain risk management in communities.

FRM in Australia has several strengths and weaknesses as discussed in this report. These are summarised in Table 3.

Table 3: Strengths and weaknesses of the current FRM system in Australia

Strengths	Weaknesses
<ul style="list-style-type: none"> Funding devolved to local flood risks and FRM projects Strong collaborative national efforts leading to national guidance through the National Flood Risk Advisory Group and Engineers Australia FRM guidance provided to local councils and others in the flood industry via national ('Managing the Floodplain Handbook' and <i>Australian Rainfall and Runoff</i>) and jurisdictional guidance documents that support the consideration of the full range of flood risk in decisions Broader related guidance such as Emergency Planning for Disaster Resilience and Land Use Planning for Disaster Resilient Communities through collaborative efforts led by the AIDR Consideration of future risks in FRM including climate change High insurance penetration and private-sector involvement in risk transfer Strong flood industry collaboration through the professional body, Floodplain Management Australia The Australian Government's Manual 21 provides guidance for the development of Total Flood Warning Systems (currently being updated) Internationally-recognised emergency services in each state and territory Bureau of Meteorology provides a range of flood warning services across Australia 	<ul style="list-style-type: none"> Strong reliance on flood recovery and reconstruction funds and not mitigation Disproportionately low government funding allocated to FRM compared to other hazards such as bushfire and structural fire hazards Generally low community participation in FRM Generally low community flood preparedness levels Funding for FRM largely dependent on grant funding to local councils and not necessarily to the highest risk areas Some high-risk flood areas of Australia have not yet been studied, and therefore limited flood information may be available 100-year flood zones are often used as benchmarks for much of the local government planning in Australia Total flood warning systems not in place in some high-risk communities including those experiencing flash flooding

Note: Strengths and weaknesses vary across jurisdictions
Source: *The Geneva Association*

Although there are numerous strengths, as listed in Table 3, the main core weakness in Australia's FRM is that much of the flood risk assessment, mapping and implementation of FRM options are largely dependent on funding availability from the Australian, state and territory governments and the ability of local government to provide contributions. The limited availability of funding has led to a patchy approach to assessment and understanding of flood risk across Australia. While many jurisdictions have a strong understanding of local flood risk and a prioritised plan for flood risk reduction, the patchwork of information at a national and state level can lead to overall funding distribution not necessarily aligning to the overall highest priority flood risk areas nationally.

Furthermore, FRM funding that is made available is grossly disproportionate to the funding provided for flood recovery and reconstruction and for disaster management related to bushfire and structural fire hazards.

FRM in Australia faces the dual challenges of urbanisation and climate change impacts, such as more frequent and intensive flood-producing rainfall events and sea level rise. Many of Australia's increasingly large urban areas contain vulnerable populations, including immigrants from other countries who have not experienced flooding and are not aware of the risk of flooding. The impacts of climate change are factored into local FRM planning and there is consideration of adaptation for flood future risks. On the other hand, development continues to occur across Australia's high risk floodplains, including the heavily-populated Hawkesbury-Nepean River system in western Sydney.

Another challenge is involving at-risk communities in FRM. Although there have been attempts to do this by local councils and emergency agencies, there is far more work required to engage communities meaningfully in FRM and lift flood preparedness levels. Also, the funding and support for community flood education and engagement in emergency service budgets is very low compared to that for response and recovery activities.

Considerable lessons learned from Australian floods have led to improvements in FRM. For example, the 1955 Maitland Flood instigated the first flood mitigation act in NSW (the *Hunter Valley Flood Mitigation Act*), the precursor to today's Floodplain Management Program and the starting point for what would become the NSW State Emergency Service. There have been significant improvements in flood warning services as a result of inquiries into the 2010–2011 Queensland and Victoria Floods.

Flood insurance is now readily available to residents and businesses throughout Australia, though insurance affordability remains a concern in high-risk flood regions, as pricing reflects the high underlying risk. Improvements in land-use planning and risk-reduction programs to

address the affordability challenge would help reduce the high cost of flood insurance in many parts of Australia.

The National Flood Risk Advisory Group has been successful in facilitating national coordination and cooperation in best practice FRM. This has led to the continued development of national guidance, such as ADR Handbook 7 and its guides to improve FRM outcomes for Australian communities. NFRAG members continue to contribute to a wide range of related guides and cross-jurisdictional initiatives.

Flood warning consultative committees are supporting the continual improvement of flood warning systems for Australian communities.

The professional industry body, Floodplain Management Australia, has been successful in bringing together many of the different stakeholders in FRM including local councils, state and territory government agencies, the Australian government (e.g. Australian Bureau of Meteorology), consultants, insurance companies and politicians.

There are few monitoring and review processes in place for assessing/measuring the impact of risk communication, risk reduction, risk prevention, risk financing and risk-transfer decisions and for providing feedback to improve the different components of FRM in the country. Holistic FRM evaluation is generally limited to grant-funded projects, although some organisations such as Catchment Management Authorities in Victoria have monitoring and evaluation frameworks for their FRM strategies.

In conclusion, opportunities for improvement to FRM in Australia may include:

- **Further collaborative efforts** (flood risk managers, emergency managers and land-use planning) to minimise the growth of flood risk in the future development of floodplains, particularly those at high risk.
- **Increases in FRM funding** in Australia, with a rebalancing from response and recovery to mitigation, and an improved share of overall hazard related funds to flood.
- **Proactive strategies and resourcing** to improve FRM and flood resilience in the highest priority flood risk areas of Australia.
- **Increased resourcing and effort to improve community participation** in FRM and raise community flood preparedness levels across Australia.
- **Broader consideration of the full spectrum of possible flood events** (rather than a single design flood event) in FRM, emergency management and land-use planning.

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Annex 1: Overarching questions used for mapping and analysing the evolution of flood risk management

1. What is the evolution of flood risk in the country?

- a. What are the types of flood risk, who is at risk and why?
- b. What are the underpinning causes of flood risk?
- c. What are the socio-economic impacts?
- d. Is flood risk growing? What are the drivers of rising flood risk in the country?
- e. Has addressing financial and social risks associated with floods become a national concern for people, businesses and the government? In what ways?

2. Is reliable flood risk information available and accessible to support decision-making?

- a. What are the underpinning data sources for flood risk analysis (hazard, exposure and vulnerability)?
- b. Are there official flood risk maps and are they publicly available? What types of information are being developed? What are the strengths and weaknesses of the official flood risk maps? How often they are updated?
- c. Are there other sources of flood risk information? Who is processing and providing flood risk information? What types of information is being developed? To whom is this information provided? How is this information provided to target stakeholders?
- d. Is flood risk information provided to target stakeholders? E.g. people, businesses, community organisations, different government agencies, local government and utilities? Are these maps decision-relevant?
- e. Has the level of risk (e.g. high, medium, low) been identified in different regions? Is this information

used to zone the regions according to the level of risk? What are the fundamental assumptions?

- f. Are there targeted risk communication programmes? If yes, who provides them?
- g. What are the benefits, challenges and concerns associated with available risk information and the way it is being provided?
- h. What is the level of flood risk awareness in the country among different stakeholders? Is risk information impacting decisions (e.g. by people, businesses and government)?
- i. Are there any mechanisms for monitoring, assessing and incorporating the changing risk landscape (hazards, exposures, and vulnerability) in the risk maps? Are the underpinning causes of the changing risk landscape investigated and monitored (e.g. climate change, development patterns and practices?) What are the main challenges and concerns?

3. How is FRM governed in the country, and how is it evolving? How are different stakeholders engaged in the system?

- a. Who are the key stakeholders with official responsibility to manage floods and their impacts?
 - i. Who has official responsibility for FRM in the country? Is this reflected in national to local legislative processes (e.g. government at national, state and local levels, the insurance sector, banking and mortgage lenders, public utilities, the media, NGOs and other community-based orgs, homeowners)? What are their roles?
 - ii. Who is responsible for addressing the needs and challenges faced by the most vulnerable groups of the population?

- iii. What is the perception of homeowners, businesses and other stakeholders in terms of who is responsible? Does the existing system require that homeowners and business owners manage their own flood risks? Please describe.

4. What is the approach to risk reduction (existing risks) and risk prevention (new risks), particularly in relation to rising risks associated with climate change and other socio-economic drivers?

- a. Is FRM considered an integral element of socio-economic planning, budgeting and development in the country? Is FRM an integral element of climate adaptation policies and decisions, as opposed to being a stand-alone objective?
- b. Have (or are) disaster risk reduction and risk prevention plans been (or being) developed, implemented and supported/enforced by public policy and regulatory frameworks (at all levels of government)?
 - i. Who is responsible for the development and implementation of these measures? Are the interlinkages of these measures considered part of the overall development and risk management strategy? Or are they implemented in isolation?
 - ii. Is there a dedicated budget supporting these plans? How is the budget allocated between levels of government?
 - iii. Are there incentive mechanisms to promote and enable the implementation of risk reduction and risk prevention by different stakeholders (homeowners, businesses, community-based organisations, local, state and federal governments, public and private utilities, etc.)?
 - iv. Is there a process for monitoring and evaluating the impacts of these measures to improve them over time (what level, by whom, how)? For example, monitoring the impact of retrofitting for residential homes, businesses, government assets, infrastructure (public or privately owned) and communities; or the impact of floods on homes and buildings built based on new building code standards versus old ones?

5. Are early warning systems and emergency preparedness in place and if so, how is this helping to reduce risks (reducing loss of life, livelihoods and economic damage)?

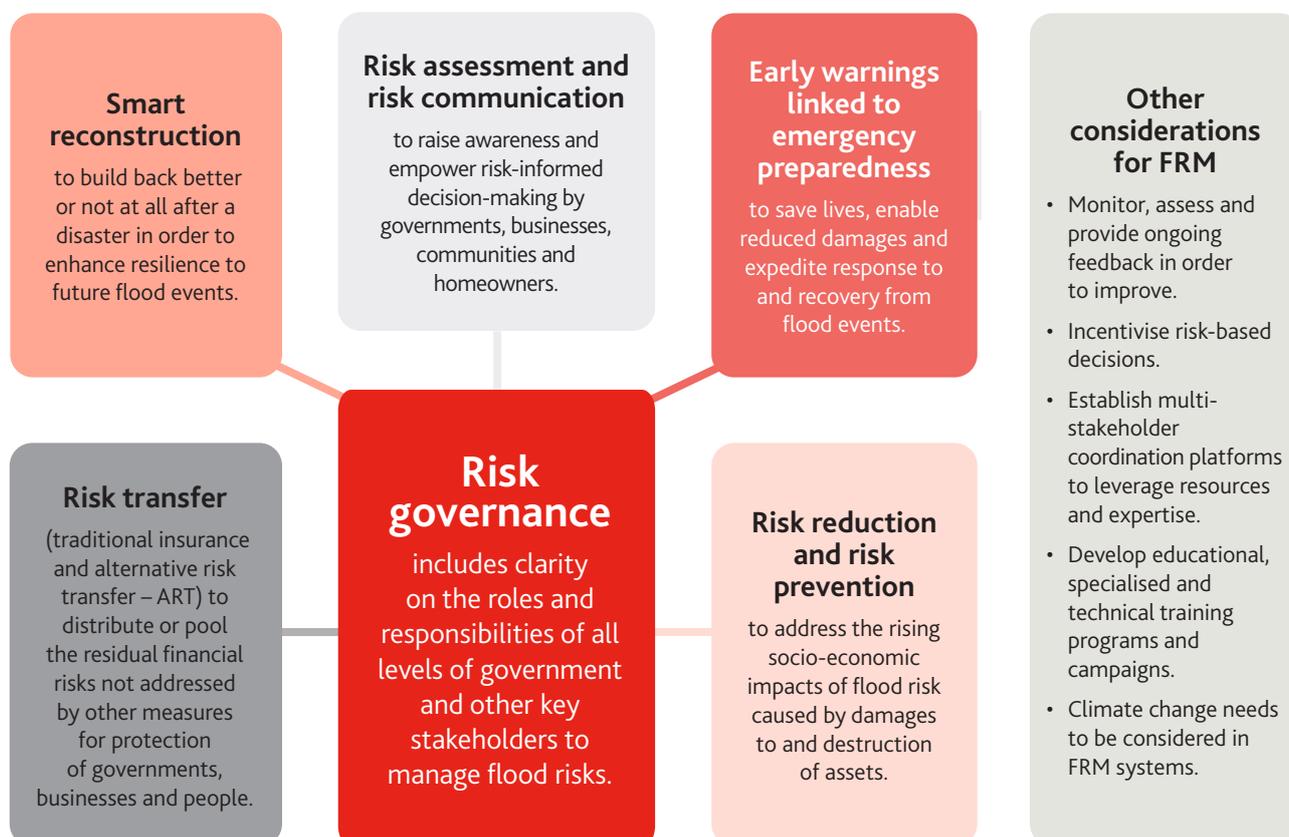
- a. Who is responsible for developing and issuing the alerts and warnings? Are these warnings accessible, understood and responded to by different stakeholders?
- b. Who is responsible for ensuring alerts and warnings are linked to emergency preparedness on the ground?
- c. What is the receptivity of the general public, businesses and communities to these warnings?
- d. Are warnings leading to increased risk awareness, reduction of property damage and expedited response to and recovery from flooding?
- e. What types of actions are being taken by government (at all levels), businesses, communities and people, based on warnings, to reduce risk?

6. Are those that are directly impacted by floods incorporating risk financing and contingency planning in their budgets and plans to increase financial resilience and expedite their ability to respond to floods (e.g. government (all levels), businesses, people)?

- a. Is the government taking a strategic approach to its financial protection by combining financial instruments? E.g. prioritising cheaper sources of funding, ensuring that the most expensive instruments are used only in exceptional circumstances, using pre-planned budgetary instruments, contingent financing and risk transfer measures (e.g. risk pools) and insuring public assets?
- b. How has post-disaster aid funding been approached and appropriated?
- c. Does the country remain reactive (focused on post-disaster response and recovery) or is it strategically considering the need to build resilience to reduce current risks and prevent new risks? Describe in more detail with examples.
- d. Have post-disaster aid programmes undergone any reforms or modifications to incentivise and/or enable risk reduction and prevention and help with the expansion of insurance for the protection of people, businesses and government?
- e. Does the government arrange for any contingency plans to protect its budget to ensure access to cheaper funds in case of disasters?

- 7. Is there an active flood insurance market in the country? Is the value proposition of the insurance sector leveraged in building flood resilience in the country? Is the value proposition of the insurance sector understood by governments, businesses and people?**
- a. What is the status of insurance in the country? Is it provided as a national government service, through the private insurance market or a combination (public–private partnerships, PPPs)?
 - b. What is the nature of the insurance programmes (insurance pools, integral part of home insurance or separate insurance products)? Is the insurance delivery:
 - i. Risk-based?
 - ii. Mandatory versus voluntary?
 - iii. Incentivising risk reduction through reduced premiums or other mechanisms (please describe)?
 - iv. Aimed at residents, SMEs, businesses, government?
 - v. Market-based or enabled through policies and regulatory frameworks (if so, how)?
 - c. Is there insurance-backed securitisation of cat and green bonds?
 - d. What is market penetration and coverage?
 - e. Is the insurance programme sustainable?
 - f. What is the receptivity of government in engaging with the insurance sector?
 - g. Is the insurance industry proactively engaged with government and other stakeholders to address strengthening of flood resilience? Please describe.
 - i. Is the insurance industry engaged with government in reviewing flood risks to residents, business, government, and infrastructure and identifying innovative market-based solutions?
 - ii. Is the insurance industry developing innovative risk transfer measures (with or without collaboration with the government?). Are these solutions available, accessible and affordable and are they being used by those at risk to distribute or pool the residual economic risks?
 - iii. Are insurance solutions (by industry, government or both) incentivising behavioural change (e.g. insurance solutions available to residents, SMEs, etc.)?
 - h. Are the government (at all levels) and/or the insurance industry engaged with customers and businesses to educate about risks, preventive mechanisms and the benefits of insurance?
- 8. Following a disaster, are there systematic mechanisms to revisit, re-evaluate and decide on reconstruction plans and decisions?**
- a. Are there formal mechanisms and legislation in place to enforce the need to build back smarter (e.g. build back using updated building codes, relocate and do not build at all if the region(s) has been identified as a high-risk zone)?
 - b. Are there efforts to reconsider land zoning in high-risk regions that experience recurrent risks? Are there any government plans for buyouts and relocation from high-risk zones? Have these programmes and their impact been assessed?
- 9. Are there monitoring and review processes in place for assessing/measuring the impact of risk communication, risk reduction, risk prevention, risk financing and risk transfer decisions and for providing feedback to improve the different components of FRM in the country?**
- 10. Overall:**
- a. Is the FRM approach transitioning toward a greater focus on flood resiliency? E.g. is the approach focused not only on reducing current risks but also prevention of future risks linked to factors such as climate change?
 - b. Is the approach characterised as fragmented (i.e. engaging many organisations with different but disconnected roles and initiatives) or is it evolving towards a holistic all-of-society approach (leveraging all components of the system)?
 - c. Is there any evidence of cultural/behavioural change towards active management and reduction of risk (e.g. people, businesses, communities and all levels of government)? Is it linked to the level of risk? Are there incentives for this change?

Annex 2: Framework for assessing flood risk management systems



Source: The Geneva Association

As the world deals with the COVID-19 pandemic crisis, the potential compounding effects of weather-related extreme events, such as floods, tropical cyclones and wildfires, could significantly challenge a country's emergency management capacities and slow down its socio-economic recovery. Floods are the most concerning and costly weather-related hazard globally. Part of a major study on flood risk management (FRM) in five mature economies (the U.S., England, Germany, Australia and Canada), this report takes an in-depth look at the FRM system in Australia – governance, institutional frameworks, stakeholder engagement and implementation of different components of the FRM system based on a holistic framework – against an analysis of the changing risk landscape.

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