SYNTHESIS SUMMARY 3

Cyclones and windstorms

Cyclones and windstorms affect Australia every year, causing millions of dollars in damage. In future, the storm surge is likely to be an increasing hazard in coastal areas as sea levels rise. Cyclones may become less frequent, but those that do occur are expected to be more intense & may track further south. Adaptation can build on existing responses to prepare for future impacts of storms.

NCCARF
National
Climate Change Adaptation
Research Facility

About this summary

About this series

Between 2008 and 2013, the Australian Government funded a large nationwide Adaptation Research Grant Program (the ARG Program) in climate change adaptation. The Program was managed by the National Climate Change Adaptation Research Facility (NCCARF). It resulted in over 100 research reports that delivered new knowledge on every aspect of adaptation. The aim of the Program was to help build a nation more resilient to the effects of climate change and better placed to take advantage of the opportunities.

This series of Synthesis Summaries is based on research findings from the Program, augmented by relevant new literature and evidence from practitioners. The series seeks to deliver some of the policy-relevant research evidence to support decision-making for climate change adaptation in Australia in a short summary. It takes an approach identified through consultation with relevant stakeholders about needs of the intended audience of policymakers, decision-makers and managers in the public and private sectors.

This summary deals with cyclones and windstorms. The opening pages provide the context, including the nature and impacts of cyclones and windstorms ('Why we need to adapt'), followed by a synthesis of research findings around the impacts and adaptation response to cyclones and windstorms ('The research base …'). It concludes with a summary of how this new research knowledge might help address key adaptation policy challenges. This final section is informed by a workshop held with practitioners ('Evidence-based policy implications').

This brief was developed by NCCARF staff, with input on the policy challenges developed in workshops held in Mackay (Queensland), Adelaide (South Australia) and Cardinia Shire (Victoria) in December 2015. The workshops were attended by practitioners, policymakers and managers from within local, state and federal government organisations, community service organisations, not-for-profit organisations and universities.

The key research reports used to develop this summary are highlighted in Section 4. To see all reports from the ARG Program, please visit **www.nccarf.edu.au/adaptation-library**.

Key findings

Five principal adaptation challenges emerge from the research evidence:

1. Sustain and improve the risk message: Cyclones are a well-understood phenomena in the tropical north of Australia, and historical experience has led to the evolution of well-adapted building designs and effective messaging. These might be built upon and extended to increase reach and response within the community to deal with infrequent and more severe storms.

2. Match policy, advice and resourcing: Well-designed policies aimed at building resilience and 'build back better' can be lost in the emergency response to recover and restore the status quo as quickly as possible. Ensuring that plans are in place for upgrading before a major event, with funding identified, is likely to help overcome this challenge.

3. Understand building stock risk: The greatest weather-related risk to existing building stock is likely to be from windstorm. Governments and homeowners may need to consider if there is value in investing or encouraging investment in building assessment and retrofitting to increase resilience.

4. Build resilience to the emerging threat of storm surge: Climate change is causing sea levels to rise, and the rates of rise are expected to increase in the future. Together with storm surge, higher sea levels pose an increased risk of coastal flooding and erosion. Choices will need to be made along the Australian coastline by communities and government as to whether to protect, accommodate or retreat from these risks.

5. Prepare for infrequent severe windstorms in non-cyclone-prone areas: In southern Australia, windstorms, including East Coast Lows, are unpredictable and infrequent but highly damaging events, and, in future, cyclones may track further south. In areas infrequently affected, community preparedness (as opposed to more costly up-front approaches, such as changes to building regulations) is likely to be the most important adaptation measure.

1. Why we need to adapt

1.1 The climate context

Tropical cyclones are low pressure systems that develop over warm ocean waters (> 26.5 °C) and can generate gale force winds in the wall around the centre of the storm. Their severity is described in terms of categories ranging from 1 (weakest) to 5 (strongest), related to the maximum mean wind speed (Table 1). The impact of a cyclone is also related to factors such as the size of the cyclone (particularly the eye), the speed at which it is travelling, the location of landfall (relative to location of urban centres) and the coincidence (or not) with high tide.

Tropical cyclones affect northern Australia, with areas north from Exmouth in the west and north from Maryborough in the east the most cyclone-prone. The cyclone season runs from November to April.

Over the period 1982–2013, Australia experienced 11 tropical cyclones on average each year.[5] However, this number is expected to change as a result of climate change. Projections for the future suggest decreases in the frequency of tropical cyclones for the region by 2100.[20] However, the intensity of those cyclones that do occur is expected to increase[11], with some possibility they will track further south.[3]

Variations in the El Niño–Southern Oscillation (ENSO) strongly influence tropical cyclone occurrence, due to changes in wind patterns and water temperatures. Fewer tropical cyclones cross the coast during El Niño years and more during La Niña years.

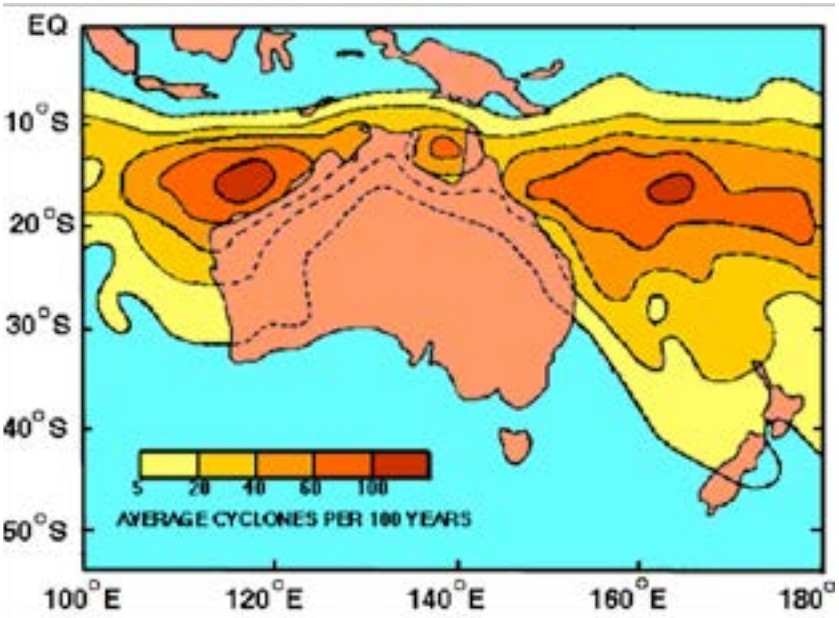


Figure 1 The average number of cyclones in areas around Australia's north. *Source: Bureau of Meteorology.*

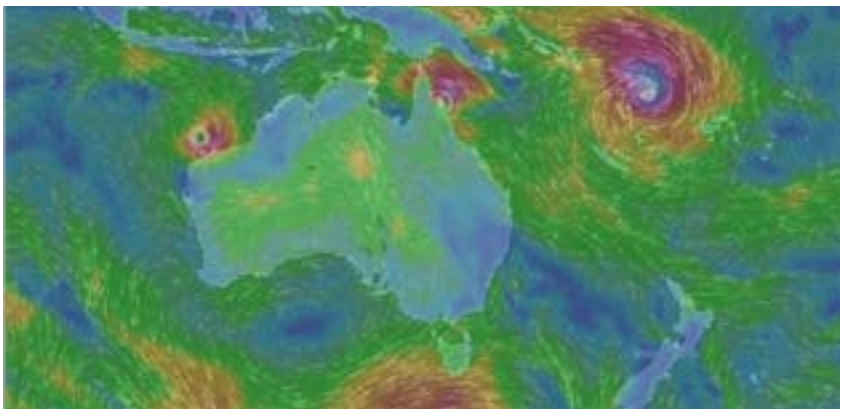


Figure 2 Cyclone Pam bears down on the Pacific, and nearby Cyclone Nathan intensifies off north-eastern Australia. Cyclone Olwyn can be seen off the coast of Western Australia, March 2015.[25]

The eastern coast of Australia is also affected by East Coast Lows (ECLs), particularly southern Queensland, New South Wales and eastern Victoria. ECLs are also atmospheric low pressure systems that can generate strong winds, heavy rainfall and prolonged rough seas. However, ECLs have much shorter lifespans than tropical cyclones and can occur any time of the year, being more common between May and August.

ECLs develop rapidly off the Australian eastern coast, with the ability to intensify overnight, making them very difficult to predict. Recent research suggests that their frequency may decrease over the coming century.[6]

Table 1: Tropical cyclone severity categories. *Source: Bureau of Meteorology.*

Category	Sustained winds (km/h)	Strongest gust (km/h)	Typical effects	Examples of cyclones
1 Tropical Cyclone	63–88	Below 125	Damaging winds	Alessia (2013)
2 Tropical Cyclone	89–117	125–164	Destructive winds	Nathan (2015)
3 Severe Tropical Cyclone	118–159	165–224	Very destructive winds	Justin (1997)
4 Severe Tropical Cyclone	160–199	225–279	Very destructive winds	Tracy (1974), Larry (2006)
5 Severe Tropical Cyclone	Over 200	Over 280	Very destructive winds	Yasi (2011), Pam (2015)

1.2 Key risks

A great deal was learned about preparing for cyclones following the landfall of category 4 Cyclone Tracy at Darwin in 1974. The storm left 94% of housing uninhabitable and approximately 40 000 people homeless. Seventy-one people died, and a further 650 were hospitalised or injured. In economic terms, Cyclone Tracy was one of the costliest natural disasters in Australia's history, with estimates of losses ranging from $2 billion to $4 billion (in present day values). In almost all cases, wind was the principal cause of structural damage. Insurance losses due to cyclones in northern Australia over the last 20 years amount to an average of $115 million a year.[19]

Tropical cyclones are dangerous because they produce destructive winds, heavy rainfall with flooding and damaging storm tides (Figure 4) that can inundate low-lying coastal areas. In the case of Cyclone Tracy, the damage and loss of life could have been worse if landfall had coincided with high tide.

Figure 3 A series of five East Coast Lows affected the NSW coast round Newcastle in 2007. During the storm, the coal carrier Pasha Bulker became grounded on Nobby's Beach. Photo: © Philip J. Rosenberger III.

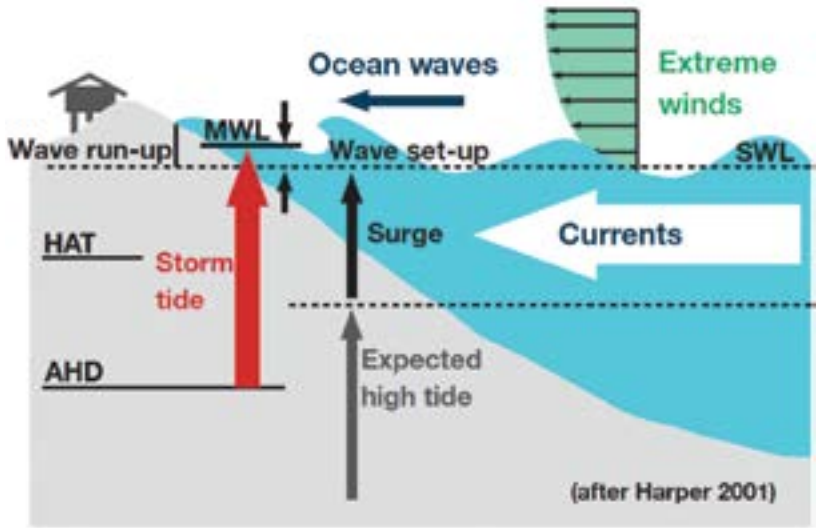


Figure 4 A 'storm tide' occurs when a storm coincides with a high tide. Factors influencing the height of the storm tide are a high astronomical tide, storm surge, wave run-up and sea level. Sea level rise will increase the overall height of storm tides. MWL = Mean water level, SWL = Stillwater level, HAT = Highest astronomical tide, AHD = Australian Height Datum. *Source: After Harper.*[9]

Infrastructure

Infrastructure damage can result from the impact of wind itself, or through objects the wind propels. The longer a given structure is exposed to strong winds, the more likely it is to fail. Exposure, local topography and upwind shielding (e.g. surrounding vegetation and buildings) can all affect the wind load on individual buildings.[12]

Loss of roof cladding is common and can result from either the fatigue failure of cladding around fasteners or a sudden increase in internal pressure when a windward wall is pierced by flying debris.[12] Loss of the roof allows ingress of rainwater, leading to further damage of house contents. In many windstorms, the major damage is from rainwater rather than from wind. Other damage includes the loss of wall cladding, windows and doors.[12]

People

Deaths can occur during cyclones and windstorms, and in the past these numbers have been very high (e.g. 300 people died in Bathurst Bay, Queensland, during Cyclone Mahina in 1899). Nowadays, the number of deaths associated with tropical cyclones has drastically decreased, but psychological damage and indirect consequences (e.g. loss of public health infrastructure, equipment and services for patients affected by chronic illness) remain an issue.[14]

Ecosystems

The adverse effects of tropical cyclones on coral reef ecosystems are well documented. As much as 34% of the coral mortality recorded between 1995 and 2009 in the Great Barrier Reef (GBR) has been attributed to severe storms.[13] Cyclone Yasi (2011) was responsible for one of the greatest losses of coral cover in recent years, damaging almost 15% of the entire GBR Marine Park.[1]

Rainforest ecosystems are also affected by tropical cyclones. Although intact forests seem to cope very well with cyclonic disturbance, others – such as forest remnants, littoral rainforests and riparian vegetation – show signs of greater susceptibility and post-disturbance weed invasion.[21]

2. The research base informing adaptation to cyclones and windstorms

Australian communities have significantly improved their responses to tropical cyclones, and there is evidence of successful adaptation. As a result, the average cost of damage caused per tropical cyclone has dramatically decreased from $43 million in the 1970s to about $11 million in the 2000s.[16] There were no deaths from Cyclone Yasi, even though it was a category 5 severe tropical cyclone when it crossed on to land.[2]

2.1 Building, infrastructure and urban design

In areas that are likely to be affected by windstorms and tropical cyclones, buildings designed and constructed to withstand extreme windspeeds are crucial to minimising injury, deaths and destruction of infrastructure.[12]

In 1974, the devastating impacts of Cyclone Tracy highlighted the problem with designing buildings based on the everyday performance of a structure, rather than to withstand extreme events. Differences were also found between the performance of low-set houses and their high-set counterparts and between engineered (e.g. commercial buildings) and non-engineered structures (e.g. housing). As a result of these differences, engineering-based standards now apply to the design of all housing at the national level. If a cyclone such as Tracy occurred today, structural damage would be reduced by up to 85%.[12] Development of world-leading, wind-resistant design practice in Australia is a clear example of successful adaptation.[12]

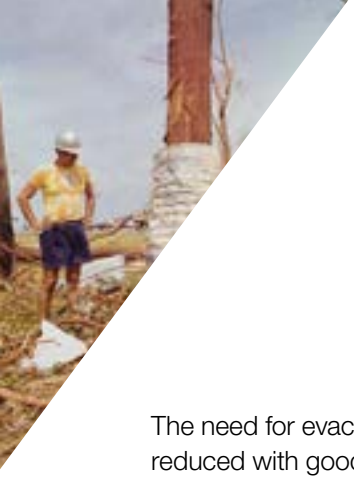
An analysis of insurance claims following cylones Yasi and Larry showed that the majority of damage was to roofs or windows or via water ingress.[16] It also identified the buildings most vulnerable to major damage as those built between 1925 and 1981 – confirming the positive outcome of new building codes. However, the report did point out that a significant number of contemporary houses experienced major damage, and suggested that modern housing may not be performing as expected under the National Construction Code.[16]

Regular review of building codes (including thresholds such as design wind speeds) and land use zoning in cyclone-prone regions to ensure they reflect new or evolving climate hazards and risks, and using the most current information and techniques, will minimise the risk of failure under extreme wind conditions. The current Building Code of Australia does not specify the material durability of structural elements, leading to concerns about decay and corrosion and performance over time under extreme wind loads. A lifetime inspection and maintenance program for buildings in cyclone-prone regions could help address this issue.[12]

Further building resilience could be achieved through retrofit measures, including structural roof upgrades for homes constructed before 1980, upgrades to opening protections (e.g. windows and doors) for homes of all ages and an increased emphasis on regular building maintenance. In Florida, a government initiative called 'My Safe Florida' provided free wind inspection reports that gave advice to homeowners on how to protect themselves and their homes against windstorm damage, as well as an assessment of what they could save on insurance premiums if they undertook the recommended actions. A grant program to help residents make the recommended improvements accompanied the program.[7]

2.2 Behaviour and health

The way people prepare for and behave during and after severe storms, particularly cyclones, can affect their recovery – even survival. It is crucial to follow the advice of emergency service providers, including when making decisions such as whether to stay at home, attend public shelters or evacuate the area.



The need for evacuation is much reduced with good building codes, at least for those outside a likely inundation area.[10] However, when evacuation is required, it means being separated from community members, sometimes from family support, and can delay the physical and mental recovery processes. The adverse effects of evacuation (e.g. depression, weight gain, lack of energy) are worse than the psychological effects on those who remain in an impact area. Participating in the clean-up and restoration efforts gives people who stay a sense of empowerment and being part of a community. The social networks they establish can contribute to both individual and community resilience.[10]

2.3 Vulnerable regions and individuals

The extent of damage from windstorm depends in part on a region's vulnerability, which in turn depends in part on factors such as population size, transport links, education levels and income, as well as the more obvious topographic and building durability factors. People who have never experienced a disaster before are less knowledgeable and therefore more vulnerable.[23] Indigenous people consider themselves better able to cope and recover from tropical cyclones than non-Indigenous residents because they do not greatly rely on material possessions and, in general, could be more self-sufficient.[10] Nevertheless, itinerant individuals may remain vulnerable due to a lack of shelter and connection to communities. Culturally appropriate emergency management response strategies specifically targeting Indigenous Australians and culturally and linguistically diverse communities may need to be tested.[8]

2.4 Finding the right pathways to communicate

Early cyclone warnings are extremely important in minimising damage and risks to lives. Surveys of residents affected by Cyclone Yasi showed that most did take cyclone warnings seriously, especially if they had previously experienced a disaster.[23] Nevertheless, some residents started preparing late for the cyclone, although no adverse consequences were reported.

Communications can be interrupted for days after a windstorm event or a cyclone. This was the case with the *Pasha Bulker* storm, which was in fact a series of five ECLs that affected the coast of Newcastle during June 2007. The importance of establishing a standard procedure for communication was acknowledged in the review of the event, particularly to provide emergency information during the disaster. Formal arrangements were made after the storm with local ABC Radio to provide emergency information in case of future disasters.[24]

The battery-powered radio remains the most useful information source during windstorms and cyclones. Power outages greatly limit access to television and web-based emergency services and can affect mobile phone services too. It is important that as much locally specific information and advice as possible be included in announcements, otherwise residents assume that warnings do not apply to their suburbs.[24] Providing the most accurate information is essential, as false alarms can appear to be cries of 'Wolf!', which hinder preparation before a storm or cyclone.[12]

2.5 Strategies for service providers (assistance, emergency management, insurance)

The impacts of Cyclone Tracy highlight the importance of emergency management that restores infrastructure and provides for people's physical needs but that also retains community cohesion and resilience in the longer term. The federal Natural Disasters Organisation, created just months before Cyclone Tracy struck, was effective in its work with respect to the former, but less so with respect to the latter.

Much has been learned from this incident about structuring an emergency response organisation. The peak body Emergency Management Australia provides resources, finances, training and research for emergency management, but it does not respond directly to emergencies. Direct response lies with individual states and territories, each with its own structure and frameworks for coordination.

Preparedness

Emergencies call for a shared responsibility between emergency services and residents. It is essential that efforts focus on increasing communities' and individuals' resilience and preparedness. For example, although residents are advised to maintain stocks of basic supplies, water and non-perishable food for at least three days after a windstorm or cyclone, surveys following the *Pasha Bulker* storm showed that residents lacked emergency equipment (e.g. battery-operated radios, batteries and emergency contact lists) and hence access to news updates, warning information and a means of communication during the disaster.[24]

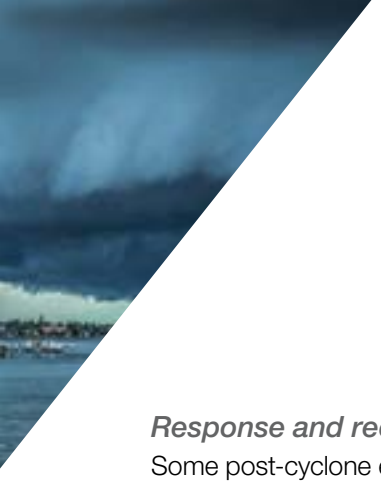
Other preparations include cleaning up property and having debris collected before a disaster to reduce wind-borne missiles and therefore property damage. Analysis of insurance claims lodged with Suncorp Insurance following Cyclone Yasi showed that 29% of claims could have been prevented by adequate preparation (e.g. securing outdoor furniture, sheds, shade sails, etc.).[16] Investment in community awareness to promote this preparedness has been estimated to give an average return of $10 for every dollar spent.[22]

The experience of the *Pasha Bulker* storm highlighted the need to have a list of pre-identified facilities that could act as disaster recovery centres (DRCs) after an emergency event.[24] DRCs are very important as they provide services that include financial assistance, outreach services, temporary accommodation and insurance information to affected residents. DRCs must meet specific criteria, such as having good parking options and large enough rooms and being in an accessible location (e.g. not at risk of being cut off by flooding).

Table 2 Benefit–cost ratios estimated by Queensland insurer Suncorp for adaptation measures to improve the resilience of houses in North Queensland (referred to as 'mitigation' in the strategy).

Adaptation option	Estimated cost per household	Total benefit per household †	Benefit-cost ratios	Payback period‡
Community awareness campaign*	$55–$136	$440–$820	3.2–14.8	<1–6 years
Opening protection – self-installed (low cost scenario)	$1660	$1990–$6400	1.2–3.9	4–21 years
Roofing option – strapping only (low cost scenario)	$3000	$12 900–$38 800	4.3–12.9	2–4 years
Roofing option – over-batten system (medium cost scenario)	$12 000	$13 500–$39 400	1.1–3.3	5–37 years

**Government funded campaign, applied per household. † Net Present Value over 50 years. ‡ Payback period refers to the number of years required for the value of benefit to outweigh the cost of adaptation options applied across all parties. Source: Modified from Build to Last. A Protecting the North initiative.[17]*



Response and recovery

Some post-cyclone emergency services seem to be more valued by residents than others. For example, faster resupply of fresh food and re-connection of utilities were the two most valued services identified by residents affected by Cyclone Yasi, and there is evidence that they are willing to pay more for these services.[4] Hospitals, aged care and health care facilities are a priority when re-establishing services post-disaster. Debris clean-up is also essential, as it causes road blockages that prevent access to the most vulnerable people and can obstruct storm water systems, worsening flooding.[24]

Locally provided assistance enables families and communities to stay together.[12] However, taking this approach means that an influx of specialists and/or volunteers from other areas can be expected. Further research into coordinating this influx is required, as it may cause additional problems for people providing emergency services.[4] For example, extra personnel will put further pressure on services that might be scarce after a storm, such as accommodation.

A role for insurance providers

Insurance claims from cyclones are an increasing cost to insurance companies.[19] This can drive up insurance premiums and be a barrier to consumers seeking to insure their properties. The Australian Treasury has recently examined rising insurance costs in northern Australia as a result of cyclone damages in recent years. They note that reducing the risk of damage is the only way to reduce insurance costs and outline a number of options to encourage investment in adaptation and resilience options, including strengthening building standards, improving retrofits, public works, increased sharing of risk with householders and making insurance premiums more responsive to increased resilience.[19]

Suncorp Insurance, a Queensland insurance company, has proposed a public–private partnership ('Protecting the North') that aims to build resilience in cyclone-exposed properties in North Queensland to reduce claims. It has developed a cost–benefit analysis to support investment by Suncorp (through supporting privately funded retrofits), by government (improved community awareness, incentives for retrofits through building and planning approvals) and by individuals (self-investment in improved resilience).[17] Suncorp has also introduced discounts on premiums for property owners in cyclone-prone areas who invest in strengthening homes against cyclone damage.[18]

3. Evidence-based policy implications

ADAPTATION CHALLENGE 1:
Sustain and improve the risk message

Cyclones are a well-understood phenomena in the tropical north of Australia, and historical experience has led to the evolution of well-adapted building designs and effective messaging. These might be built upon and extended to increase reach and response within the community to deal with infrequent and more severe storms.

While existing seasonal public information programs in cyclone-prone areas are well established, climate change may mean new information is needed to deal with more intense storms, and that these programs need to encompass new locations.

Targeted messaging can be used to reach community members with no or less personal experience to draw upon. This might include strategies such as a welcome pack for new residents distributed through real estate agents or through workplaces. Education programs for school children may filter up information to parents as well as build a resilient younger generation.

People who have past experience of an event have improved resilience and response.[23] For those without past experience, case studies and other people's personal accounts can be a useful surrogate.

Understanding why residents do not respond to warnings and information may help when designing improved communication products. For example, are there language or cultural barriers that prevent response? These could be addressed by circulating culturally sensitive information products in appropriate languages or in a format for those with vision impairment.

Research shows that regardless of information and communication, people may still behave in ways that may affect whole-of-community wellbeing and safety in emergency situations.[24] For example, people still bring their pets to cyclone shelters, despite notification that most emergency shelters do not allow them. Understanding why people behave as they do is essential to designing a response. It seems likely that people bring their pets because they have nowhere else to take them. In that case, should shelters be able to accommodate pets?

ADAPTATION CHALLENGE 2:
Match policy, advice and resourcing

Well-designed policies aimed at building resilience and 'build back better' can be lost in the emergency response to recover and restore the status quo as quickly as possible. Ensuring that plans are in place for upgrading before a major event, with funding identified, should help overcome this challenge.

In the face of a natural disaster, there are immediate pressures on government to be seen to be providing funding and support. This can mean that emergency responses (e.g. emergency payments for immediate repairs and lodging) act to restore the status quo rather than contributing to 'build back better' adaptation programs.

While many essential services can (and must) be restored within days or weeks, rebuilding property or non-essential infrastructure may take months to years. To rebuild and maintain community coherence and resilience, provision of support through the rebuilding phase is needed. These storm-affected communities need ongoing access to resourcing, communication and support during this period, as well as mechanisms for ensuring the recovery process incorporates adaptation principles. For example, if a house is destroyed by cyclone and storm tide inundation, a replacement building should withstand cyclonic windspeeds and have the floor raised above projected flood levels.

Cyclones have a large financial cost to individuals, governments and insurers, and all three may be challenged to meet these costs and at the same time to adapt, or 'build back better'. The business case for investment by all parties to improve the resilience of housing needs to be explored. Public–private partnerships are one means of encouraging investment in adaptation with the potential to offer benefits to all partners (e.g. the case of Suncorp Insurance described in Section 2.5).

ADAPTATION CHALLENGE 3:
Understand building stock risk

The greatest weather-related risk to existing building stock is likely to be from windstorm. Governments and homeowners may need to consider if there is value in investing or encouraging investment in building assessment and retrofitting to increase resilience.

The recent Treasury taskforce on Northern Australia Insurance Premiums[19] considered the merits of developing collaborative research partnerships to investigate and implement low cost actions to reduce cyclone damage, such as roof strengthening and preventing water ingress, with one aim being to reduce insurance premiums without the need for government intervention.

Newer buildings are built to standards that can better withstand cyclonic windspeeds, but older houses remain at risk from wind damage. For these older buildings, there needs to be a balance between the cost of meeting more stringent building codes, the financial resources of the homeowner and the market value of the property.

If the decision is made not to impose requirements to upgrade on existing houses, there are still ways to reduce their vulnerability. Low interest loans that only fall due once the property is sold could be offered for upgrades (e.g. structural upgrades to roofs, windows and doors). Older housing stock could be mapped and risk-assessed to target evacuation warnings. The community could be engaged to improve residents' understanding of and responsibility for their risk.

With the potential for increased cyclone intensity, design testing, material testing and analysis are likely to be ongoing. This might potentially include inspection and maintenance programs for buildings in cyclone-prone regions. An increased emphasis on building maintenance is likely to improve the resilience of building stock.

ADAPTATION CHALLENGE 4:

Build resilience to the emerging threat of storm surge

Climate change is causing sea levels to rise, and the rates of rise are expected to increase in the future. Together with storm surge, higher sea levels pose an increased risk of coastal flooding and erosion. Choices will need to be made along the Australian coastline by communities and government as to whether to protect, accommodate or retreat from these risks.

With increasing sea levels, more coastal properties will be at risk of storm tide inundation during cyclones and storms. In some cases, essential infrastructure (e.g. sewerage infrastructure, hospitals) will be exposed to increased risk. Flood mapping will help identify areas at risk, and an assessment can help determine the need and business case to relocate the facilities.

When planning new developments in cyclone-prone areas, future impacts – including stronger winds and greater risk of inundation – can usefully be considered at the stage of development approvals and more widely in planning policy. Provisions might include revisions to the height of floor levels or use of designs that accommodate through-flow of floodwater. It may also mean that some areas, such as low-lying coastal areas, should not be used for residential purposes, or indeed for any development that brings together groups of vulnerable people (e.g. aged-care facilities, hospitals or schools).

ADAPTATION CHALLENGE 5:

Preparing for infrequent severe windstorms in in non-cyclone-prone areas

In southern Australia, windstorms, including ECLs, are unpredictable and infrequent but highly damaging events, and, in future, cyclones may track further south. In areas infrequently affected, community preparedness (as opposed to more costly up-front approaches, such as changes to building regulations) is likely to be the most important adaptation measure.

If cyclones track further south as a result of climate change, developing warning and advisory programs for residents in areas that may be newly affected is likely to become more important.

In areas experiencing infrequent, high intensity windstorms, residents may have little or no experience of severe storms. In these areas an 'all hazards' emergency approach (i.e. standard emergency response strategies that can be followed in a range of emergency situations) might help in the immediate response. Preparedness, however, tends to be specific to particular types of disasters (e.g. flood preparedness differs from preparations for bushfire and extreme heat), and planning is likely to consider if there is a cost benefit to investing in adaptation measures (e.g. new or retrofit building design). For communities where there is only a small probability of high intensity windstorms occurring, the extra expense of building housing to meet higher windspeeds is unlikely to be justified.

Unintended negative consequences of adaptation may occur without due care. For example, policies of tree planting can change after severe storms in an effort to reduce future damage, but trees may be an important measure for cooling cities.

4. Key information and references

NCCARF-supported research is marked with an asterisk*

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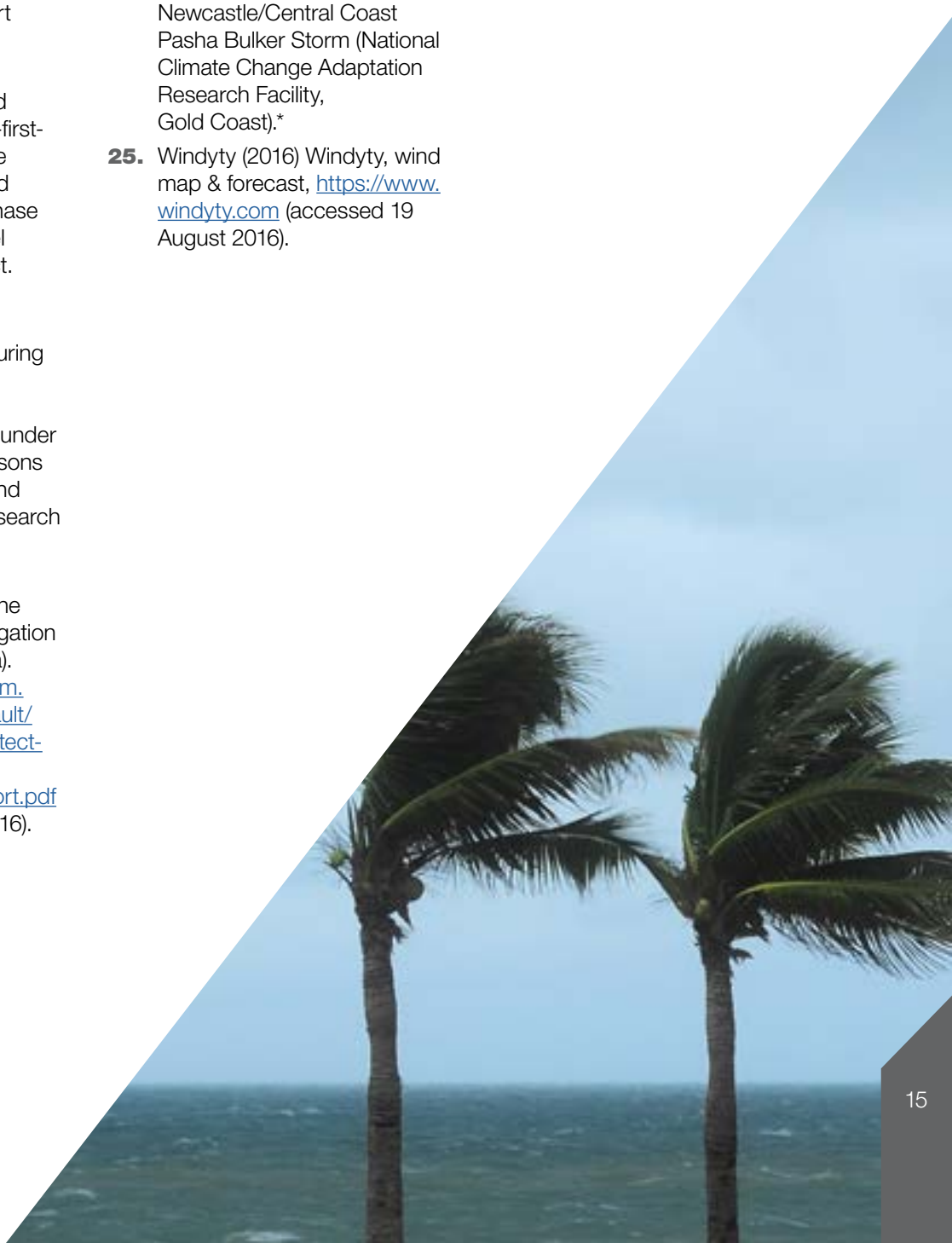

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