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North Queenslanders' Perceptions of Cyclone Risk and Structural Mitigation Intentions
Part I: Psychological and demographic factors

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Executive Summary

In 2014, the Cyclone Testing Station (CTS) at James Cook University (JCU) and Suncorp began investigating cyclone resilience in North Queensland. The effort began with a review of claims data from Cyclones Yasi (2011) and Larry (2006) to identify key drivers of losses in cyclones. That work led to an investigation of engineering strategies for mitigation and the cost-benefit analysis for implementing them. Although cost-benefit of engineering strategies can be favourable, they have not seen widespread adoption by Queenslanders. To investigate behavioural drivers of mitigation and how adoption may be increased, the CTS partnered with Health and Behaviour Change in the Tropics (HABITT) at JCU. In 2016 the group commenced a three-year research project to examine behavioural aspects of homeowner decision-making toward cyclones and develop a decision-support tool (e.g. web or mobile app) to promote mitigation. The project is supported by Suncorp and Queensland Government (Advance Queensland) as part of a commitment to improve cyclone resilience in Queensland. This report is the first of two (i.e. Part I) from the behavioural research and it details findings related to demographic and psychological factors influencing mitigation behaviours.

Past research has found that a wide variety of psychological and demographic factors can influence mitigation behaviours related to various extreme weather events (e.g., flood, earthquake, etc.). However, the understanding of these factors specifically in the cyclone context is limited. Project stakeholders were keen to understand why resilience measures are not widely adopted currently and how they can be in the future. Informed by a review of the literature, a survey was constructed to address this knowledge gap and identify factors influencing cyclone mitigation behaviour in North Queensland. The survey was distributed electronically to people living from Rockhampton to Cairns and received 550 responses (both homeowners and non-homeowners). Key findings of the analysis are provided below.

<u>Risk Perception</u>

- Overestimation of wind speeds experienced from past severe cyclones corresponds to an underestimation of expected damages in future severe cyclones. For example, if one believed Cyclone Yasi brought Category 4 winds to Townsville (when in fact wind speeds in Townsville were estimated at Category 2) it is likely that person does not have an accurate understanding of how destructive Category 4 cyclones can be.

- Based on a seven-point scale ranging from very low to very high, 90% of respondents indicated that damage from a Category 1-2 cyclone was expected to range from very low to somewhat low. Wind speeds for TC Marcia (2015) were Category 2 in Yeppoon and Category 1 in Rockhampton with insured losses over $500M.

- **Key Finding:** 45% of respondents felt that damage from a Category 3-4 cyclone would range from *very low to somewhat low*. To put this in context, Cyclone Tracy (1974) was a Category 4 cyclone and wind speeds for TC Yasi (2011) were Category 4 in Mission Beach and Category 2 in Townsville with insured losses over $1.4B.

- **Recommendation:** The risk perception results highlight a disconnection between the level of damage homeowners expect and the level of damage possible for a given category of cyclone, which may have important implications to mitigation investment decisions. To address this, wind speed estimates and information about the level of damage that occurred in a given post code could be better communicated after severe wind events to help people understand property damage potential in relation to specific wind speeds. Methods of immersive communication (e.g., augmented or virtual reality) could also be used to convey how damaging different cyclones can be to both the home and everyday life (e.g., relocation, mental health, loss of sentimental items).

Current Mitigation Intentions and Understanding

- An important aim of the survey was to explore the current cyclone mitigation intentions (i.e. likelihood) of Queenslanders and reasons why intentions may be lower than desired.
- Most (87%) homeowners did not have cyclone shutters installed on their home and reported (on average) that they would need a $1400 (lump sum) rebate from government to consider installing them given a $3000 cost (i.e. 47% rebate).
- **Key Finding:** Most (~65-75%) homeowners that didn't already have the upgrades installed, reported being somewhere between extremely unlikely and neutral about installing shutters, roof replacements or roller door upgrades in the next five years.
- **Recommendation:** Low levels of intentions to install the above mitigation items were associated with misguided risk perceptions and inadequate understanding of both the effectiveness and true cost (i.e. time, effort, hassle, etc.) of installing them. This suggests two opportunities for improving future programs: a) better education on the effectiveness of mitigation upgrades and b) structuring of the programs such that homeowner time and effort are minimized (i.e. make mitigation easy).
- **Recommendation:** Compared to other mitigation upgrades, respondents were more uncertain about whether they had shed and roof upgrades installed (even when presented with pictures). Roofing details in particular can be difficult to explain in laymen terms, yet damage investigations and claims analysis clearly identify roofs as a key area of vulnerability (especially for pre-1980s housing). Future efforts should prioritize the development of easy-to-interpret graphical displays (e.g., within a web or mobile app) for cyclone-relevant construction features (e.g., roof) with easy steps on how to find them in a given home.

Factors that Influence Mitigation Intentions

- Due to their relative ease to identify and understand, the mitigation intentions for cyclone shutters were investigated in greater detail. A range of factors were associated with increases in intentions to install shutters (e.g., older age, planned length of time in the house, perceived cyclone risk, etc.), suggesting that a one-size-fits-all mitigation program may not be as effective as one that captures and caters to the unique situation of different individuals.
- **Key Finding:** Of all factors investigated, perceived effectiveness (e.g., in reducing damage, having utility for other purposes, increasing property value, etc.) and the visual appeal had the strongest positive (i.e. increasing) relationship with intentions.
- **Key Finding:** Perceived cost of installing cyclone shutters (e.g., money, effort, "hassle factor" of engaging contractors, required knowledge and cooperation from others, etc.) had the strongest negative (i.e. decreasing) relationship with intentions to install shutters. However, this relationship was weaker than the positive relationships of perceived effectiveness and visual appeal, suggesting that understanding the benefits (not just the costs) is a critical part of homeowner decision-making processes.
- **Recommendation:** Messaging about mitigation upgrades should demonstrate that installing them will reduce damage and provide (if applicable) additional utility (e.g., increased security, energy efficiency, increased real-estate value).

- **Key Finding:** Homeowners that were aware of others' mitigation efforts were statistically more likely to install shutters in the next five years.
- **Recommendation:** The literature shows that social influence is an important component of decision-making. More than 50% of homeowners in this study reported being unsure if their friends, family or neighbours installed any of the property upgrades. A communication strategy or program that allows homeowners to see their cyclone mitigation status relative to others in the community may promote mitigation action.

The intent of this report is to provide critical insight that can improve the collective understanding of how Queenslanders think about and prepare for cyclones. It is anticipated that the findings of this work will be used to inform a broader effort to create a more cyclone resilience NQ. This is not an exhaustive study and one of the key outcomes is highlighting the fact that there is much more to learn. As next steps, the project team will be developing a software application that homeowners can use to better understand their risk for cyclones. The findings herein will be incorporated to optimize the efficiency/effectiveness of the application. However, the findings in this report touch on other important sectors who have an important role including government, building industries, engineers, BoM and digital/tech.

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1. Introduction

Individuals living in cyclone-prone areas are vulnerable to an increased potential for property damage. For example, Cyclone Debbie in 2017 caused over $1.7B in insured losses including almost 60,000 residential building and contents claims (ICA, 2018). Many of the building damages (Figure 1) could have been avoided with appropriate mitigation upgrades before the event. Structural upgrades and preparedness activities have been shown to effectively reduce property damage caused by cyclones, however these activities have associated costs and adoption by homeowners is not widespread (Smith et al, 2016). To promote more widespread use of mitigation activities, it is important to understand the factors that facilitate or impede an individual's decision to upgrade property or perform preparedness activities. Past research conducted in the U.S. has found that a variety of psychological and demographic variables can predict variation in the likelihood of homeowners engaging in cyclone mitigation behaviours (i.e. cost is likely not the only, or even the prevailing, factor in a homeowner's mitigation decisions). Moreover, studies conducted in Europe have found that similar factors can predict a variety behaviours aimed at mitigating flood damage. However, similar research investigating cyclone mitigation behaviour specifically for Australians is lacking.

Figure 1. Severe roofing damage from Cyclone Debbie in 2017 due to inadequate load capacity at the batten to rafter connection

Informed by a review of the international literature, a questionnaire was constructed to measure the factors deemed important for predicting mitigation behaviour in Queensland. In 2016 a paper version of the questionnaire was piloted at an annual cyclone preparedness event in Townsville ("Cyclone Sunday"). The questions were subsequently revised into an electronic survey distributed more broadly across North Queensland in 2017. This report presents the methodology and findings of that broader survey, building on a series of prior write-ups detailing the methodology of survey (Scovell et al, 2016b; Scovell et al, 2017), review of supporting literature (Scovell et al, 2016a) and background motivation for the work stemming from analysis of insurance claims data and engineering research (Smith and Henderson, 2015a, b; Smith and Henderson, 2016).

The report is broken into four main Sections. Section 2 explains the survey methodology and questionnaire development. Section 3 provides the survey results, broken into key factors of interest identified from the literature including demographics, experience with previous events, risk perception and social influence. Section 4 discusses where the respondents stand currently in terms of mitigation status and intentions for the future. Sections 5 and 6 include analyses that examined how respondents' wind speed estimates compared to actual values from Cyclone Yasi and which factors had the strongest relationship to respondents' intentions to install cyclone shutters in the next five years. Sections 7-9 provide conclusions, discussion for future work and a glossary of key terms respectively.

2. Survey Method

The questionnaire used in this study builds on a previously tested version. Based on literature review, the preliminary questionnaire was developed and piloted in 2016 at the annual "Cyclone Sunday" event in Townsville (Figure 2). The pilot was conducted using paper survey and received 72 responses. The intent was not to make inferences about the broader population, but rather to test appropriateness of the questions. In general, the questions were adequate but several key areas of improvement were identified including added pictures to help describe mitigation upgrade items, skip-logic to reduce the survey length and the use of a seven point Likert Scale rather than a five point scale for questions that ask respondents to rate likelihoods.

Figure 2. James Cook University research team (fluorescent shirts) distributing the pilot questionnaire to Queenslanders at the annual "Cyclone Sunday" event in Townsville

The revised version of the survey, which is the subject of this report, was distributed more broadly across North Queensland and made available for residents to complete between 30 June 2017 and 19 November 2017. Like the pilot version, it assessed a variety of demographic and psychological factors as well as cyclone mitigation behaviours/intentions. Information about the study was shared via North Queensland radio stations, TV news and newspaper articles. Additionally, a Facebook page was created, which provided information about the study and a link to the survey. The Facebook page was shared via pages such as Wally's Weather and the OZ Cyclone Chasers. The results provided in Section 3 are based on analysis of the broader 2017 electronic survey.

3. Survey Results

To provide framework for the analysis, questions and responses were grouped to investigate six different factors that were identified in the literature as having a role in the mitigation decision process. Those factors include demographics, construction details of the home, experience with previous cyclone events, risk perception and social influence. Each factor is discussed in the sections below. Although a total of 551 respondents were recruited for the survey, quality control procedures for the data resulted in varying sample sizes for individual questions. The applicable sample size is included in each of the Sections below.

3.1. Demographics

Demographic summary information for the sample is as follows:

- 171 (31%) males, 380 (69%) females.
- An average age of 45 years (SD=13), ranging from 18 to 78 years.
- Most were married (60%), homeowners (70%) and almost half of the sample (45%) had at least one dependent child.
- The median household income category was $80000 - $125000 and a Bachelor's Degree was the most commonly reported level of education (31%).

Respondents were most commonly from the Townsville (31%), Cairns (19%) or Mackay (18%) regions. However, there was a spread of respondents ranging from Cairns to Rockhampton, as seen in Table 1.

Table 1: Frequency distribution of the respondents' locations (n=550)

Location Clusters	N
Cairns to Ingham	131 (24%)
Townsville to Home Hill	190 (35%)
Whitsunday Region (Bowen to Midge Point)	82 (15%)
Mackay to St Lawrence	106 (19%)
Rockhampton & Yeppoon	41 (7%)

3.2. Housing Details

The questionnaire begins with basic questions about the respondents' home. The age of construction for a home is often used to estimate construction features (and therefore vulnerabilities) when more detailed information is unavailable. The most well-defined shift in construction features came in the aftermath of Cyclone Tracy which resulted in at least 100 fatalities and extreme damage to housing in December 1974 (Figure 3), especially in the Northern suburbs of Darwin (Walker, 1975). Major changes to design and building standards of houses were implemented during the reconstruction, focused heavily on improving life-safety. The resulting Queensland Home Building Code (HBC) was introduced as legislation in 1982. By the mid-1980s it is reasonable to presume that houses in the cyclonic region of Queensland were being fully designed and built to its requirements. However, an analysis of Suncorp claims data (Smith and Henderson, 2015a) estimated that 40% of homes in North Queensland were built prior to the 1980s. Of the 385 homeowners in the electronic survey, 119 (31%) reported that their house was built before 1982 (17 were unsure). This means that approximately 30-40% of homes in North Queensland are built prior to modern building codes and therefore are not at the current life safety standards for Australian housing.

Figure 3. Housing damage in Darwin following Cyclone Tracy 1974 (credit: Fairfax Photos)

Another important shift in building construction standards occurred in 2012 for garage doors. Based on damage investigations from Cyclone Yasi (Boughton et al, 2011), the Cyclone Testing Station found that garage doors performed poorly despite wind speeds being below design level (250 km/h) in most of the affected areas. As a result, the Australian standard AS/NZS 4505 (Standards Australia, 2012) went into effect in 2012 requiring wind locks on all garage door installations. However, homes constructed prior to this are likely at higher risk of garage door related failures. In the current survey, 318 (83%) of 385 homeowners reported that their house was built before 2012. Sheds are another key aspect of the property that have been identified as vulnerable to cyclone related damage and losses. Of the 318 homeowners in the survey, 264 (69%) had a shed, 156 (58%) of those were wind-rated and 221 (84%) were anchored to a concrete slab.

3.3. Experience with Previous Events

Research has found that past experience with threatening events usually relates to changes in behaviour for future events (Weinstein, 1989). The majority of studies that have investigated past experience with extreme weather events have found that it relates positively with future mitigation behaviour especially if such experience increases the individual's perception of risk (Mishra & Suar, 2007; Tierney et al., 2001). These findings have been supported in the cyclone mitigation research (Lindell & Hwang, 2008; Trumbo, Lueck, Marlatt, & Peek, 2011). However, this is not always the case. Research looking specifically at cyclone experience has also found the following:

- Experiencing at least one cyclone relates weakly to subsequent structural mitigation of buildings but experiencing cyclone related damage does not appear to relate to subsequent mitigation behaviour at all (Peacock, 2003).
- In a different study, the experience of distress due to cyclones related to an increase household preparedness but the experience of damage was found to have no effect on subsequent cyclone household preparedness. The same study also found that past distress only promoted preparedness when the last cyclone was experienced four years ago compared to seven years ago (Sattler et al., 2000). This suggests experience may only relate to increased mitigation behaviour for a certain amount of time before the experience is forgotten.

One of the reasons that not all studies have found a positive link between past experience and subsequent mitigation behaviour, is that in some cases experience may lead to complacency. If damage levels are low, an unrealistic optimism may lead to the judgement that two cyclones will have the same (not severe) effect when in reality the storm impacts can be very different (Baker, 1991). In the current survey, almost all (92%) the respondents had experienced at least one cyclone. Of those individuals, approximately 60% reported some property damage from those experiences. Additionally, respondents generally had experience with more than one cyclone: 77% experienced two or more cyclones and 29% had experienced five or more cyclones. Moreover, a majority of the sample experienced Cyclone Yasi (68%) and of these individuals 43% reported damage from Yasi. The key takeaway is that Queenslanders are relatively well experienced when it comes to cyclones. The awareness of cyclones as a natural hazard risk of living in North Queensland appears to be adequate. However, this doesn't necessarily imply accurate understanding of potential damages from cyclones which is an important aspect of overall risk perception. This is discussed further in the next section.

3.4. Risk Perception

Multiple studies have found a relationship between risk perception and evacuation for cyclones but few studies have investigated how risk perception relates to cyclone mitigation. The cyclone evacuation studies investigating risk perception have found that those who perceive a personal vulnerability to potential damage are likely to evacuate (Baker, Broad, Czajkowski, Meyer, & Orlov, 2012; Villegas et al., 2013). The few studies that have investigated the influence of risk perception on cyclone mitigation behaviour also found that risk perception is important (Lindell & Hwang, 2008; Peacock, 2003).

One study asked participants about their perception of risk and if they had implemented the specific cyclone mitigation measures including, reinforced roof rafters, reinforced doors to the house and garage, purchased materials for temporary storm shutters and installed permanent storm shutters. The researchers found that higher risk perception was one of the most important factors that related to increased application of these mitigation measures (Lindell & Hwang, 2008). Other studies have also found similar results of higher risk perception relating to increased mitigation response (Ge, Peacock, & Lindell, 2011; Peacock, 2003; Sattler et al., 2000). Based on these findings, perception of risk was established as important for cyclone mitigation behaviour and therefore investigated in the NQ survey. Specifically, respondents' perceptions of cyclone likelihood and expected damage were examined.

3.4.1. Cyclone Likelihood

Respondents were asked how likely (on a seven point scale) they believed that in the next five years a Category 1 or above, Category 3 or above and Category 5 cyclone would occur. Most commonly people reported that experiencing a Category 1+ cyclone in next five years was "extremely likely". Furthermore, respondents most commonly said that a Category 3+ cyclone was "moderately likely" and a Category 5 cyclone was "slightly likely". Figure 4 shows the response data for 527 participants. In general, the respondents appear to understand that the risk of cyclone occurrence is relatively high in North Queensland. This is consistent with a prior survey conducted by Suncorp (Figure 5) and discussed in Harwood et al (2016). The public perception of how likely a cyclone is to occur appears to be relatively accurate. However, this does not necessarily imply adequate public understanding of the expected damages from cyclones.

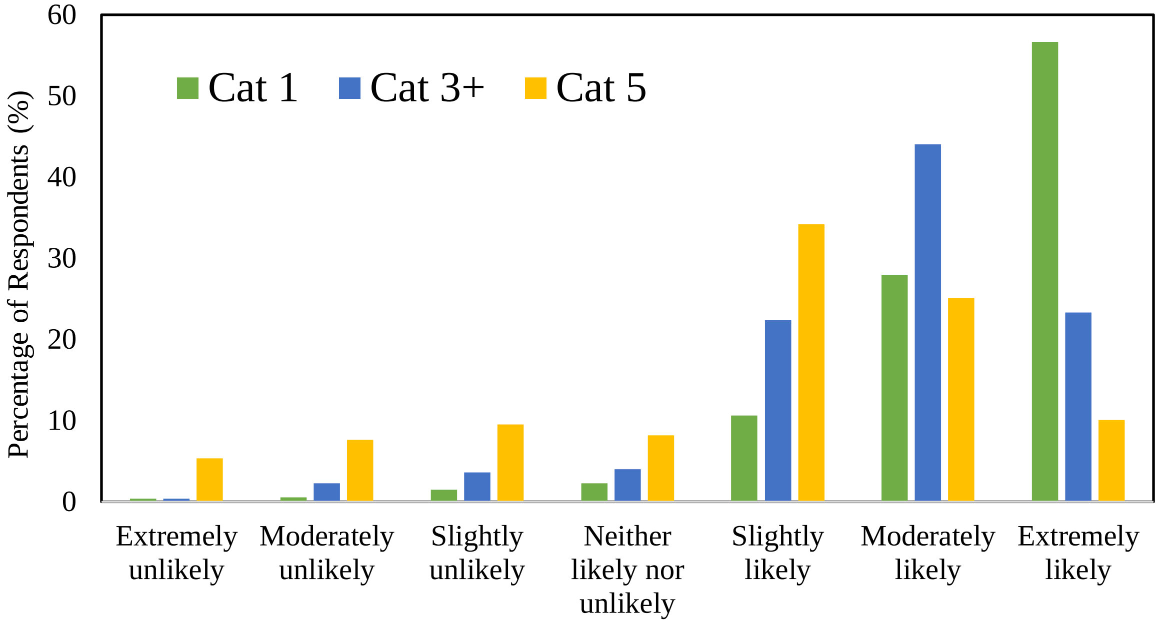

Figure 4. Frequency distribution of respondents' perceived likelihood that a cyclone (of given intensity) will occur

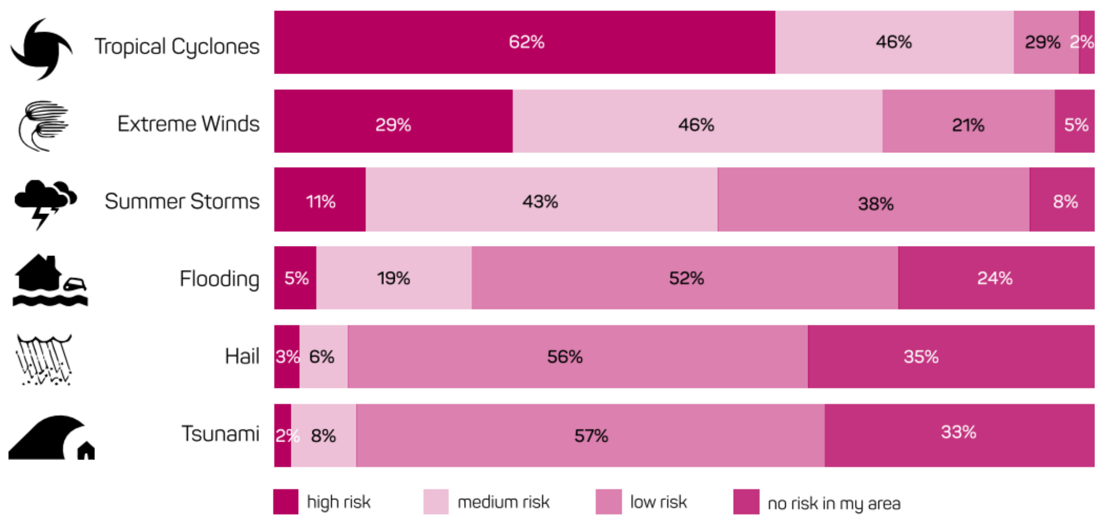

Figure 5. Results of a Suncorp customer survey (n=65) in North Queensland to determine perceived natural hazard risk (Harwood et al, 2016)

3.4.2. Expected Damage

Respondents were asked what level of property damage they would expect if a Category 1-2, Category 3-4 and Category 5 cyclone were to occur next week. They were asked to assume that they perform their usual levels of household preparedness. Figure 6 shows the results for 527 respondents. Most commonly, respondents expected future damage to their property from a Category 1-2 cyclone to be "very low". Most expected "medium" damage for Category 3-4 and "very high" damage for Category 5. However, there was a large amount of variability in responses for Category 5 damage predictions (more than other category predictions). This finding suggests poor understanding of how damaging severe cyclones can be, which is to be expected considering the relatively lower frequency of severe cyclones.

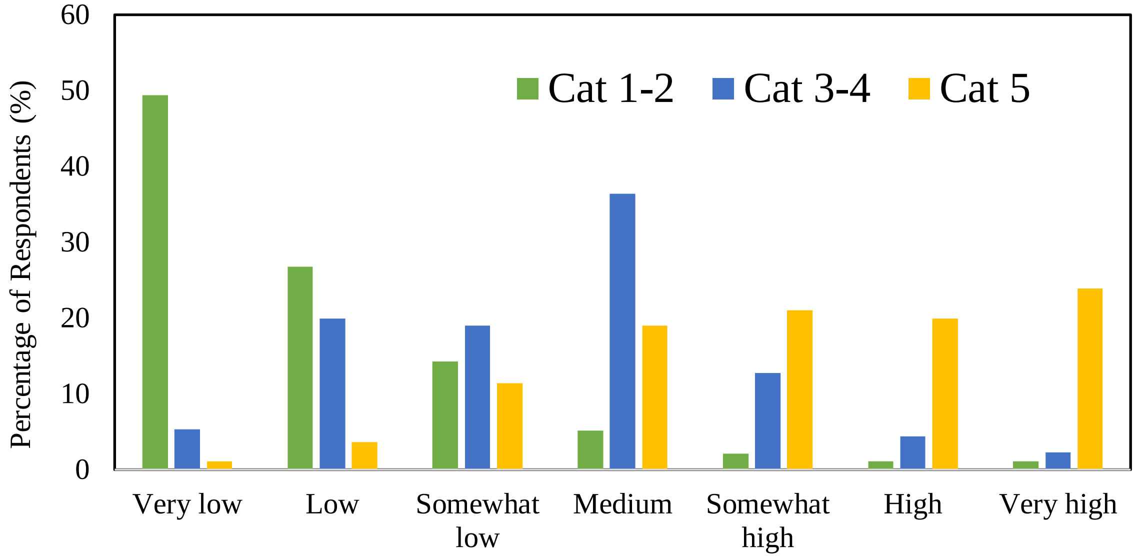

Figure 6. Frequency distribution of respondents' perception of the level of damage that will occur for a given category of cyclone

Smith and Henderson (2015b) detail and provide examples of typical damages and cost for varying categories of cyclone. Where possible, the survey results were placed in the context of recent cyclone events in North Queensland:

- 90% of respondents felt that damage from a Category 1-2 cyclone would range from "very low" to "somewhat low". Wind speeds for TC Marcia (2015) were Category 2 in Yeppoon and Category 1 in Rockhampton with insured losses over $500M. TC Marcia was the third most costly cyclone in Australian history (ICA, 2018).
- 45% of respondents felt that damage from a Category 3-4 cyclone would range from "very low" to "somewhat low". Wind speeds for TC Yasi (2011) were Category 4 in Mission Beach and Category 2 in Townsville with total insured losses over $1.4B. TC Yasi was the second most costly cyclone in Australian history (ICA, 2018). Cyclone Tracy (1974) was also a Category 4 cyclone.
- 35% of respondents felt that damage from a Category 5 cyclone would range from "very low" to "medium". TC Marcia is the most recent example of a Category 5 cyclone, however it crossed the coast in a relatively unpopulated area (Shoalwater Bay) and decayed (i.e. lessened in intensity) significantly before it reached areas with greater population.

The results highlight a disconnection between the level of damage homeowners expect and the level of damage possible for a given category of cyclone. In other words, Queenslanders understand that cyclones are a threat but do not necessarily understand the damage potential of the threat. One method of addressing this would be to provide wind speed estimates combined with information about the level of damage that occurred in a given post code after severe wind events to help Queenslanders understand property damage potential in relation to specific wind speeds. Methods of immersive communication (e.g., augmented or virtual reality) could also be used to convey the damage inflicted by cyclones to both the home and the occupant's general wellbeing (e.g., relocation, mental health, loss of sentimental items).

3.5. Social Influence

Social connectedness includes the shared experience, reciprocity and trust individuals have toward one another within a community (Cocklin & Alston 2002, Malecki 2011). For example, homeowner cost-benefit evaluation of an action can be influenced by who is recommending the action (Pennings & Grossman 2008, Ramirez, Antrobus & Williamson 2013). In a survey of Florida homeowners, 40% of respondents reported being more likely to undertake improvements to their home if others in the community were also strengthening their homes (Sink 2008). This is consistent with findings from Ramirez and colleagues (2013), that suggests people are more likely to respond in a manner similar to those with whom they have connections and trust (i.e. neighbours and friends) than unfamiliar entities (e.g. hypothetical exemplars in promotional materials). Therefore, understanding and leveraging the nature of relationships individuals have within communities can increase the effectiveness of strategy implementation.

For the NQ survey, just over half (53%) of the homeowners were unsure if their friends, family or neighbours installed any of the property upgrades and only 19% knew of a friend, family or neighbour who had installed one of the upgrades. This highlights a gap in communication within the community regarding cyclone mitigation and provides an area of focus for future mitigation messaging and programs.

4. Current Mitigation Status and Future Intentions

Section 3 provided results exploring five key factors in the mitigation decision-making process. Section 4 discusses survey questions that directly asked respondents about their current status and future intentions toward various mitigation items. For deadlocks, metal screens and shutters, they were also asked why they had installed the item. Table 2 and Table 3 show the current status of the 385 homeowners for general and roof-related mitigation items respectively. The proportion of participants that were unsure or didn't answer questions was much higher for roof-related mitigation items (26-56%) than for general items (5-19%). This shows a lower education level in general for roof-related details about the home and is likely due in part to the fact that roof-related items often require access to the attic space and are therefore less frequently encountered by homeowners. Since the roof is a critical component of overall cyclone vulnerability for the home, development of tools and education materials to facilitate the understanding and self-assessment of roof details is recommended.

Most homeowners (86%) did not have cyclone shutters installed. A similar percentage of homeowners (71%) with pre-2012 properties did not have roller door bracing installed on their property (it was assumed that they had not replaced the roller door with a new one after 2012). As discussed in previous engineering reports on claims analysis (Smith and Henderson, 2015a, b), these are two key areas of vulnerability during cyclones and therefore should be a focus of future mitigation efforts in Queensland. Sheds have also been identified as common drivers of insured loss. The majority of shed owners reported their shed is anchored to the foundation (84%) and/or wind-rated (58%).

Table 2. Installation status of general cyclone mitigation features, where N (%) denotes the number of homeowners within each installation category

Mitigation Item	Not Installed	Installed During Build	Previous Owner Installed	Current Owner Installed	Unsure	No Answer
All Homeowners (n=385)						
Deadlocks	135 (35%)	63 (16%)	99 (26%)	67 (17%)	5 (1%)	16 (4%)
Metal Screens	174 (45%)	51 (13%)	89 (23%)	49 (13%)	6 (2%)	16 (4%)
Cyclone Shutters	333 (87%)	4 (1%)	7 (2%)	14 (4%)	1 (<1%)	26 (7%)
Pre-2012 Homeowners (n=318)						
Roller Door Brace	227 (71%)	5 (2%)	14 (4%)	20 (6%)	7 (2%)	47 (15%)
Homeowners with sheds (n=264)						
Shed: Anchoring	25 (9%)	43 (16%)	105 (40%)	73 (28%)	11 (4%)	8 (3%)
Shed: Wind-rated	59 (22%)	38 (14%)	51 (19%)	67 (25%)	36 (14%)	14 (5%)

Failure of doors and windows are also important drivers of loss during cyclones (Figure 7), often leading to additional damage by water ingress (Boughton et al, 2017; Boughton et al, 2011). Properly installed deadlocks on doors can reduce the likelihood of dominant opening failures (Thomson et al, 2018). Similarly, metal security screens that are properly tested to the Cyclone Testing Station standards can protect windows and doors from debris impact failure. From the survey responses, a large number of Queenslanders have deadlocks (59%) and/or metal screens (49%) installed. However, it is interesting to note that most said they had installed them for security reasons, not for cyclone resilience purposes. Conversely, only 14% of homeowners had cyclone shutters. A key difference between shutters and deadlocks/metal screens may be perceived utility of the items. Cyclone shutters are seen as only being useful during cyclones whereas the deadlocks and metal screens have use (i.e. for security) year-round. Demonstrating the use of cyclone mitigation items in other every-day contexts may help to increase the perceived utility of the upgrade.

Figure 7. Door bolt and hinge failure from Cyclone Yasi in 2011 (left) and wind-borne debris failure of impact-resistant glass door from a tornado during Hurricane Harvey in 2017 (right)

Homeowners with a pre-1982 house were asked about the mitigation status of their roof (Table 3). Of the 136 asked, 46% claimed to have had a full roof replacement (either themselves or previous owner) including cladding replacement, batten to rafter connections and rafter to top-plate connections. Another 25% said they hadn't had a full replacement and 26% were unsure or didn't answer the question. Although it is encouraging that almost half of these pre-1982 homes have been upgraded to the current life-safety standard of Australian building codes, it also highlights another area of needed improvement in the other 28-54% that have not and are therefore at higher risk of structural failure in a severe wind event.

Table 3. Installation status of cyclone mitigation roof upgrades, where N (%) denotes the number of homeowners within each installation category

Roof Upgrade Mitigation Item	Not Installed	Previous Owner Install	Current Owner Installed	Unsure	No Answer
Pre-1982 Homeowners (n=136)					
Full Replacement	38 (28%)	29 (21%)	34 (25%)	23 (17%)	12 (9%)
Sarking Install	53 (39%)	3 (2%)	17 (13%)	35 (26%)	28 (20%)
Pre-1982 Homeowners without complete replacement (n=69)					
Frame Strapping	25 (36%)	14 (20%)	1 (1%)	23 (33%)	6 (9%)
Overbatten System	38 (55%)	2 (3%)	0 (0%)	22 (32%)	7 (10%)

Homeowners with a pre-1982 house that had not had a full roofing upgrade already, were asked whether frame strapping, an overbatten system or sarking had been installed (Table 3):

- 1% reported having an overbatten installation. The overbatten system is described in HB 132.2 (Standards Australia, 1999). The small proportion of installs is not surprising given feedback from the building community and homeowners that HB 132.2 is not widely used and the overbatten system has been reported as being aesthetically unpleasing to homeowners (Smith et al, 2015).
- 39% said that sarking was not installed and a further 46% were either unsure or didn't answer the question. This is a very important area of focus for future mitigation programs as sarking has been shown to dramatically reduce the likelihood of water ingress, a leading cause of insured losses during cyclones.

Homeowners in Table 2 and Table 3 who either did not have mitigation upgrades installed or were unsure, were asked about their intentions to install the same upgrades in the next five years. The most common response was "extremely unlikely" for all the mitigation items included (Figure 8). More specifically:

- 77% of homeowners were extremely unlikely to neutral about installing shutters in the next five years.
- 65% of homeowners were extremely unlikely to neutral about a full roof replacement in the next five years.
- 74% of homeowners with roller doors installed before the more stringent wind-design code requirements (effective from 2012 onward) were extremely unlikely to neutral about adding aftermarket bracing in the next five years.

The low levels of intention to mitigate by the installation of these items can be explained by the perceived high cost of the installation/upgrade in light of the underestimated extent of future damage reported by the sample (see Figure 6).

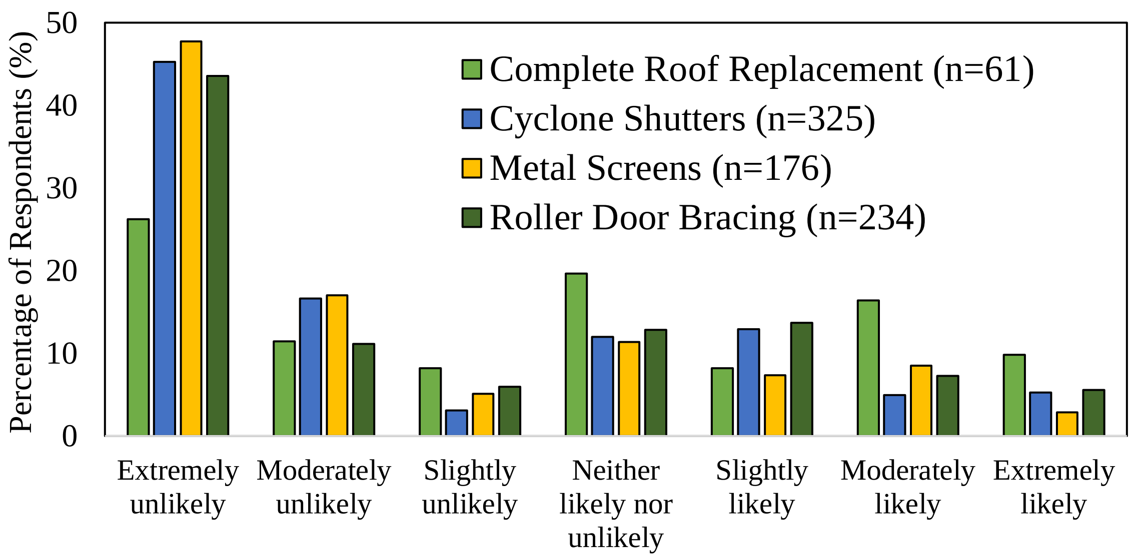

Figure 8. Frequency distribution of respondents' intentions to install four key cyclone mitigation upgrades

5. Wind Speed Perception for Cyclone Yasi

To investigate the ability of Queenslanders to accurately estimate the wind speeds they experienced during severe wind events, respondents were asked a series of questions about Tropical Cyclone Yasi (TC Yasi). TC Yasi made landfall 3rd February 2011 with the eye passing over the Mission Beach region. The maximum wind gusts at the standard 10 m reference height in flat open country (i.e. Terrain Category 2 per AS/NZS 1170.2), were estimated to be 120 to 225 km/h (Figure 9), across the area stretching from Townsville to Innisfail. The range of wind speeds across the impacted region is equivalent to ~50-90% of typical housing ultimate limit state design wind speed which is nominally 250 km/h. The localities away from the Mission Beach to Cardwell region experienced gust wind speeds towards the lower end of the stated range (Boughton et al, 2011). Wind speeds in Townsville for example, were in the order of 120-140 km/h (Category 2 equivalent wind speed). Respondents were asked to nominate the highest cyclone category (1-5) of winds that their city experienced during TC Yasi. A description of the wind speed range for each category and typical damages based on the Beaufort Scale was provided for reference (Table 4).

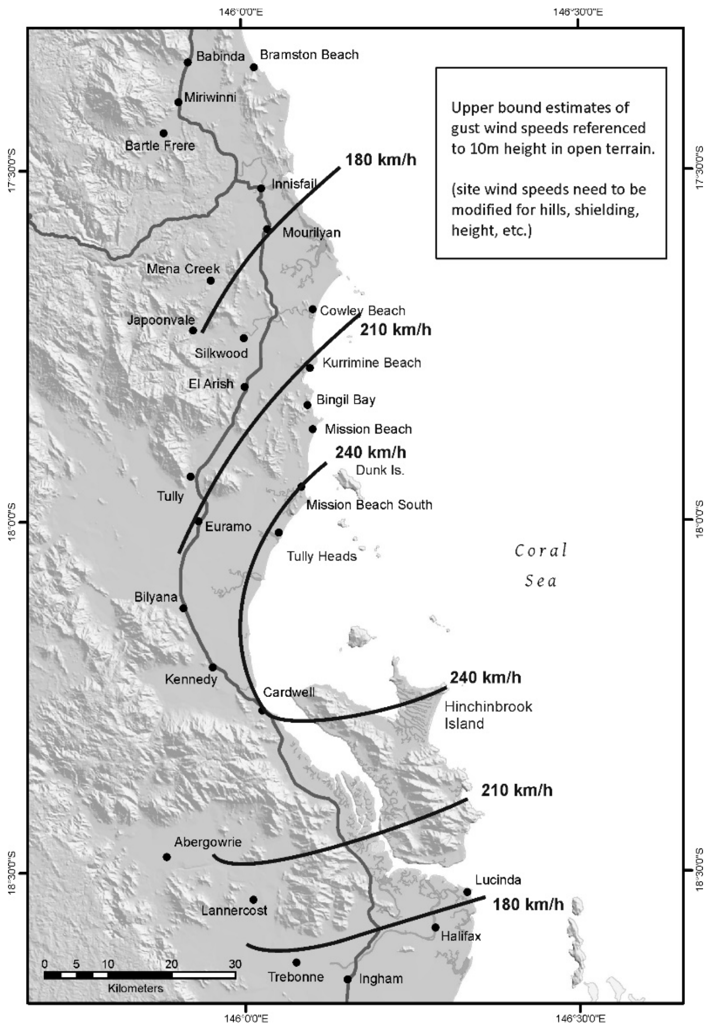

Figure 9. Approximate contours of maximum 3-second gust for Cyclone Yasi in the areas nearest landfall (topographic effects not included)

Table 4. Scale and reference information provided to respondents when asked to estimate the Category of winds they experienced during Cyclone Yasi in 2011

Category	Wind Gusts over flat land	Beaufort Scale	Damage Potential
Five *(severe tropical cyclone)*	More than 280 km/h	12 (Severe Cyclone)	Extremely dangerous with widespread destruction.
Four *(severe tropical cyclone)*	225 – 279 km/h	12 (Severe Cyclone)	Significant roofing loss and structural damage.
Three *(severe tropical cyclone)*	165 – 224 km/h	12 (Severe Cyclone)	Some roof and structural damage.
Two *(tropical cyclone)*	125 – 164 km/h	10 & 11 (Storm and violent storm)	Minor house damage.
One *(tropical cyclone)*	90 – 125 km/h	8 & 9 (Gales and strong gales)	Negligible house damage.

The degree to which people overestimated TC Yasi wind speeds for their city was calculated by subtracting the actual wind speed estimate (provided by CTS analysis) in the respondents' city from the wind speed estimated by the respondent. For example, if wind speeds in Townsville were estimated at Category 2 by CTS and the respondent estimated Category 5, the overestimate (as shown in Figure 10) would be three categories. Negative scores in Figure 10 indicate cases where the respondent underestimated TC Yasi's wind speed in their city.

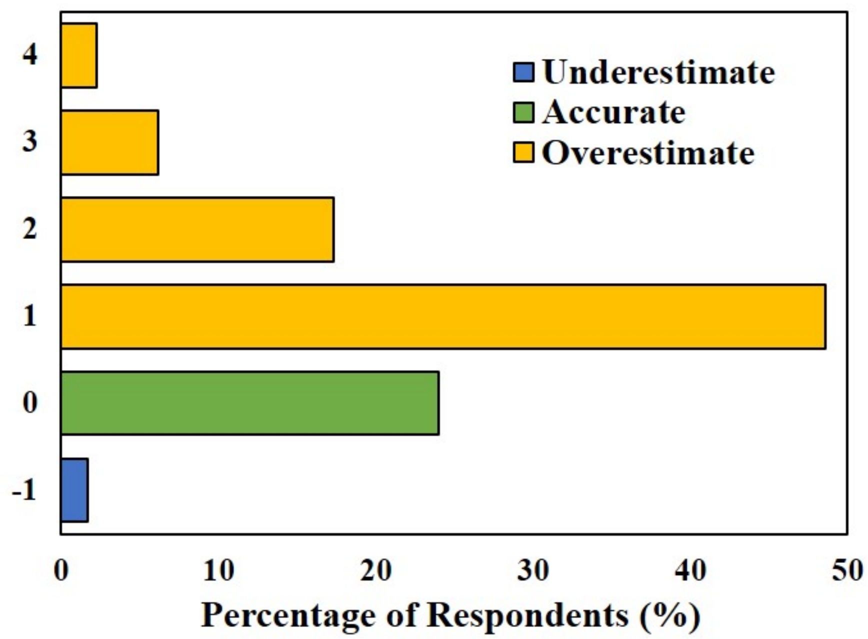

Figure 10. Respondents' wind speed overestimation for Cyclone Yasi based on frequency distribution of margin of error reported

Of the 179 individuals living between Townsville and Cairns in this sample, most (74%) recalled TC Yasi's wind speed as being at least one category higher than the actual wind speed category in their location. Furthermore, more than 25% overestimated the winds they experienced during Yasi by two or more categories. These findings are supported by past research that found on average that people tend to overestimate the wind speeds they experience (Agdas et al, 2012). From these results, there are two potential implications. Firstly, people tend to overestimate the winds they experience and therefore may not have a clear understanding of how strong winds in severe cyclones (i.e. Category 3+) can be. Second, homeowner perceptions of the wind speeds they experience are likely to be influenced by media reports, which tend to focus on the areas of highest wind speed (i.e. landfall location) but are broadcasted well beyond the most severely affected areas.

Linking the Figure 10 results from TC Yasi back to expected levels of damage for a given category of cyclone (Section 3, Figure 6), a weak negative correlation ($r = -0.15$, $p = 0.02$) was found between how much respondents overestimated wind speed and how much damage they predicted would occur from a 3-4 Category cyclone. A slightly stronger negative correlation ($r = -0.31$, $p < .001$) was also found when comparing TC Yasi overestimates to predicted damage from a Category 5 cyclone. These results suggest that the more people overestimated the wind speeds experienced from Cyclone Yasi, the less damage they expect from high category cyclones in future (Category 3-5). This further establishes a need to ensure that during and after cyclone events, homeowners are provided with accurate information about the wind speeds that were present in the local area where they experienced the storm and any damages.

6. Mitigation Intentions for Cyclone Shutters

To investigate how the factors in Section 3 effect mitigation intentions of the respondents, questions related to cyclone shutters were analysed in more detail. Shutters were chosen because of their effectiveness as a mitigation upgrade that can be installed on most homes and the majority of homeowners in the sample did not have them (87%). This provided a large enough sample size to examine the effect of several different factors on mitigation intentions.

To investigate the value of monetary incentives on mitigation behaviour, homeowners were asked the minimal amount of money they would need to be reimbursed to pay for cyclone shutters. Homeowners were asked to assume that it will cost $3000 (including labour) to install cyclone shutters on all of their windows. Then they were asked how much of that $3000 cost would need to be reimbursed for them to install shutters. On average, people said they would need to be reimbursed $1357 to consider installing shutters. But most commonly, homeowners said they would need to be reimbursed the whole purchase amount ($3000) to consider installing cyclone shutters. The responses to this question suggest that homeowners are not willing to have out-of-pocket expenses for mitigation activities.

6.1.1. Comparative t-tests

Variables (e.g., sex, number of children) associated with the various factors from Section 3 (e.g. demographics, previous experience, etc.) were compared with how likely respondents said they were to install window shutters based on the same seven point scale used in Figure 8. Table 5 shows the results of the statistical comparison (independent samples t-test) where:

- *n* is the sample size for the variable
- *mean* is the average likelihood for the variable on the seven point scale (i.e. 1 = extremely unlikely, 4 = neutral, 7 = extremely likely)
- *std. dev.* is an indication of how scattered the responses were from the mean value
- *t-value* is an indication of how different the shutter intentions were for the two variables. A larger *t-value* indicates a larger difference in intentions, *t-values* closer to zero indicate smaller differences in intentions. For example, the strongest difference in intentions of any of the compared variables was demonstrated between respondents who sought information vs those who did not (Table 5) (*t-value* = -3.72).
- *p* is a form of statistical evidence to determine if a difference between group means is due to random chance or not. A *p value* of less than .05 is the conventional cut-off point where it is deemed there is enough evidence to suggest that there is a significant difference between the group means. For example, a significant difference was found between people who had sought information vs people had not as the *p-value* for this t-test was less than .05 (Table 5).

As shown in Table 5, there was a significant difference in intentions based on social influence, having children and information seeking behaviour. Specifically, homeowners with no dependent children, with friends/family that installed mitigation upgrades or that had previously sought out mitigation information reported a greater intention to install cyclone shutters in the next five years. In contrast, there was no statistically significant difference in intentions based on sex, cyclone experience or damage experience.

Information seeking and social influences are known to have the effect of increasing the likelihood of mitigation behaviour. Although it may be counterintuitive, the irrelevance of previous cyclone experience is also consistent with several studies in the literature (see Section 3.3). This may be due to the length of time since the last cyclone experience (i.e. amnesia bias) or due to escaping damage in the last cyclone experience. For example if a homeowner in Townsville had very minor damage from TC Yasi which they believed was a Category 4 event, they may feel their home is already sufficiently strong to withstand a similar event in the future

Although several factors were identified as having a significant role in mitigation behaviour, it is important to note that on average the estimates of likelihood for all the groups were less than a value of four (i.e. between "unlikely" and "neutral"). Therefore, the overall likelihood of Queenslanders in our sample installing mitigation upgrades in the next five years appears to be low (see Figure 8) unless significant changes in the mitigation culture are made.

Table 5. Comparative statistics for intentions to install shutters for various respondent grouping variables. Note: shaded areas represent groups that were statistically different in their intentions toward installing shutters in the next five years

Variables	**n**	**Mean**	**Std. Dev.**	***t-value***	**p**
Sex					
Male	106	2.80	2.02	.88	.38
Female	219	2.60	1.91		
Children					
No children	158	2.91	2.00	2.18	.03*
Children	167	2.44	1.87		
Experience					
No experience	26	2.54	1.99	-.34	.73
Experience	299	2.68	1.95		
Damage Experienced					
No Damage	98	2.8	1.95	.67	0.5
Damage	199	2.63	1.95		
Social Influence					
No	89	2.21	1.72	-.3.07	<.01*
Yes	62	3.29	2.36		
Information Seeking					
Not sought	87	2.05	1.75	-3.72	<.01*
Sought	238	2.89	1.97		

6.1.2. Correlational analysis

Correlational analysis was used to investigate the relationship between shutter intentions and the psychosocial factors discussed in Section 3. Demographics and experience are shown in Table 6 and risk perception is shown in Table 7. Table 8 includes the analysis for several additional psychological factors. Descriptions for each of the variables assessed can be found in the glossary (Section 9). It is to be noted that for correlations, magnitude and sign are important. The magnitude of the absolute value of the correlation represents how strong the relationship is between shutter intentions and the variables. Basically the closer to a value of plus or minus 1 the value of the correlation is, the stronger the relationship is between the variables. The sign indicates whether variables change in the same or in a different fashion. Here, positive values indicate that increases in a variable (e.g., age) correspond to increases in shutter intentions. Negative correlations indicate that increases along a variable (e.g., education) correspond to decreases in shutter intentions.

Table 6 shows the correlations between variables. Significant relationships are identified by blue shading. Though these are weak relationships, homeowners that plan to stay in their house longer (73% of homeowners planned on living in their home for at least the next six years), are older or have lived in their current location longer were more likely to install shutters in the next five years. These three variables are generally aligned with a long-term thinking mindset, which has been identified by other researchers as an important component in the valuation of preparing for low frequency high consequence events (Meyer and Kunreuther, 2017). The results also indicate that homeowners with more years of formal education are less likely to install cyclone shutters. This is counterintuitive, since traditionally the financial aspects of mitigation have been assumed to be most important and those with higher education tend to be more affluent. However in this study, income was shown to have little correlation with shutter intentions. Years living in North Queensland, number of cyclones experienced, the amount of household damage experienced and the extent of emotional experience also did not relate to intentions to install cyclone shutters.

Table 6. Correlations between shutter intentions and demographic and experience variables

Demographic/Experience Variable	**Intention to Install Shutters**
Tenure plan	.12*
Age	.13*
Income	-.10
Years location	.13*
Years NQ	.09
Education	-.14*
No. of cyclones exp	.02
Damage severity	.06
Emotional Experience	.03

**p<0.05, **p<0.01*

Table 8 shows correlations calculated between shutter intentions and variables related to risk perception. Dual process risk is an assessment of risk perception that considers how people perceive risk both rationally (e.g., likelihood and severity) and emotionally (e.g., fear and worry). Risk perception refers to perceived likelihood of a cyclone damaging property, affecting life, ability to work or physical/mental health. Cyclone likelihood and damage severity are as discussed for Figure 4 and Figure 6 respectively. Weak positive correlations were found for the risk perception, cyclone likelihood and cyclone damage severity variables. The strength of these correlations is similar to that of the demographic and experience variables (Table 7). The results suggest that homeowners who have a higher perception of cyclone risk, likelihood or damage severity are more likely to install shutters in the next five years. Furthermore, it seems that perceiving cyclones as more likely and severe relates to shutter intentions to the same degree as perceiving other negative cyclone related outcomes as well (reduced ability to work and negative physical/mental health outcomes).

Table 7. Correlations between shutter intentions and risk perception variables

Risk Perception Variable	Intention to Install Shutters
Dual Process Risk	.06
Risk Perception	.14*
Cyclone Likelihood	.12*
Cyclone Damage Severity	.14*

**p<0.05, **p<0.01*

Correlation analyses were also performed between several additional variables and shutter intentions (Table 8). Descriptions for each variable are included in the glossary (Section 9). All except cyclone knowledge (i.e. how knowledgeable homeowners said they were about cyclone risks, preparation and potential damages) and reliance on government (i.e. how likely respondents thought government was to provide financial assistance for cyclone related property damage) had a significant relationship with intentions to install shutters in the next five years.

Table 8. Correlations between shutter intentions and additional variables

Variable	Intention to Install Shutters
Response Efficacy	.38**
Response Cost	-.13*
Self-efficacy	.11*
Visual Appeal	.38**
Hazard Intrusiveness	.19**
Cyclone Knowledge	.03
Reliance on Government	-.07

**p<0.05, **p<0.01*

Response efficacy (i.e. how useful respondents thought shutters were) and visual appeal had the strongest relationship (0.38) with shutter intentions of all the variables assessed, including demographic and risk perception variables. The strength of the response efficacy variable was three times that of the response cost variable. This implies that when homeowners consider mitigation upgrades, the perceived effectiveness of the upgrade generally holds more weight in the decision than the perceived cost. Further, the visual appeal of shutters also had a much stronger relationship with intentions than perceived cost. These results are in contrast the focus of many mitigation programs to date that emphasize reducing the cost of installing upgrades (Smith et al, 2016), not increasing their utility to homeowners. The extent to which respondents thought and talked about cyclones (i.e. hazard intrusiveness) and how equipped they felt to organise the shutter installation (i.e. self-efficacy) also had a significant positive relationship with their shutter intentions.

7. Conclusions

This study recruited a sample of 550 Queenslanders to investigate the role of various factors in decision-making towards cyclone mitigation upgrades. Results were used to investigate why mitigation intentions are low and which factors (or variables) play a key role in the decision-making process.

Key Finding: It was shown that 74% of Queenslanders overestimate the wind speeds experienced in their post-code during TC Yasi. This highlighted the need to ensure that during and after cyclone events, homeowners are provided with accurate information about local wind speeds and associated damages.

Key Finding: It was found that in general the intention of homeowners to install cyclone shutters in the next five years is low. It seems reasonable to assume this characterisation also applies to more involved upgrades like roof replacement and/or structural connection upgrades. Table 9 shows a summary of variables investigated in this study and the estimated effect on mitigation intentions.

Table 9. Summary of effects for variables investigated in a survey of North Queensland homeowners (note: assumes shutter intentions can be extrapolated to other upgrades)

Variable (assume each is increasing)	Relationship with Mitigation Intentions
Level of education	Slight decrease
Response cost (perceived time, effort, $ cost, etc.)	
Dependent children	Slight increase
Friends/family with mitigation upgrades	
Information seeking behaviour	
Age	
Number years living in the home to date	
Number planned future years in the home	
Perceived cyclone risk	
Perceived cyclone likelihood	
Perceived likelihood of cyclone damage	
Self-efficacy (perceived ability to organise the upgrade)	
Hazard intrusiveness (i.e. perceived impact on life)	
Visual appeal	Moderate Increase
Response efficacy (i.e. perceived benefit of the upgrade)	

Experience

Key Finding: Surprisingly, there was no significant difference in shutter intentions between homeowners who had experienced damage and those had not. There was also no correlation with higher levels of damage experienced and shutter intentions. This result is surprising in relation to the literature as it would be expected that people who had experienced damage would be more motivated to prevent it in future. There are some explanations for why this result may have occurred:

1. Homeowners may not have perceived damage to be severe enough to consider structural upgrades. That is, they may not have been significantly inconvenienced by the damage (both financially and emotionally).
2. Damage experienced may not have been damage that shutters could have prevented.

Risk Perception

Key Finding: Results suggest that people are overestimating the likelihood of cyclones in the next 5 years but tend to underestimate the damage potential. This is particularly true when higher category events are considered. This is evident in the high degree of variability in the responses for expected Category 5 damage (relative to other categories) which is likely explained by the fact that most people have not experienced Category 5 wind speeds, even if they believe they have experienced a Category 5 cyclone.

Recommendation: It is important to consider how to appropriately realign people's perception of risk so they can accurately predict and appreciate the potential cyclone damage to their property in such an event.

Mitigation Knowledge

Key Finding: In comparison to other mitigation strategies, a relatively high percentage of homeowners were unsure if their shed or roof was designed for high speeds (even though they were provided with pictures). Being unsure about cyclone mitigation status is a barrier for these people as they are likely unaware that they should be considering structural upgrades.

Recommendation: Results suggest that people may need more information about how to assess the structural rating of their roof and shed so they can identify if they need to pursue upgrades.

Mitigation Intentions

Key Finding: Results indicate that on average, homeowners reported relatively low intentions of installing cyclone shutters and roller door upgrades in the next five years.

Recommendation: Further research needs to be done to understand why even the most proactive individuals are still not considering installing these specific measures.

8. Discussion and Future Work

Findings from this study suggest future mitigation programs should focus on response efficacy, which may include developing mitigation upgrades that have utility for other purposes as well (e.g., security, increased real-estate value, etc.). Closely related to this may include improvements in the visual appeal of the upgrades (e.g., cyclone shutters). Future work should focus on understanding how people perceive the costs and benefits of specific mitigation compared to others. This will allow further insight into why installing an upgrade like cyclone shutters is unpopular. Furthermore, as pre-1982 houses without upgraded roofs are particularly vulnerable, follow up studies should focus on how to encourage roof upgrades for different demographic groups in this category of homeownership. In this case, it may be beneficial to use more open-ended questions to find any additional barriers/facilitators that have not been identified in past research.

Recommendation: As highlighted in this report, there seems to be a disconnection between actual cyclone severity and perceived severity. It is, therefore, important to change perceptions about cyclone severity. As discussed, tools like virtual reality could be useful at changing perceptions but the efficacy needs to be tested. Future research could use an experimental design to see if being exposed to a virtual reality cyclone scenario changes the accuracy of perceptions about cyclone severity.

9. Glossary

Experience

Emotional Experience. The extent to which cyclones in the past have caused feelings of stress, fear, helplessness, depression or dread. Response scale: 1 to 4 (none to high)

Risk Perception Factors

Dual Process Risk. Perceived cognitive risk (how people think about cyclone risk) and emotional risk (how people feel about cyclones). Response scale: 1 to 7 (strongly disagree to strongly agree).

Risk Perception. Perceived likelihood of a cyclone damaging property, affecting life, ability to work or physical/mental health. Response scale: 1 to 7 (extremely unlikely to extremely likely).

Cyclone Likelihood. Perceived likelihood of all category cyclones occurring in the next five years. Response scale: 1 to 7 (extremely unlikely to extremely likely).

Cyclone Damage Severity. Perceived extent of damage to property if three types of cyclones were to occur next week (Category 1-2, Category 3-4 or Category 5). Response scale: 1 to 7 (extremely low to extremely high).

Psychological Factors

Response Efficacy. Perceived efficacy of shutters for reducing damage, increasing family safety and increasing property value as well as the utility of shutters for other purposes. Response scale: 1 to 7 (Strongly disagree to strongly agree).

Response Cost. Perceived cost of shutters in terms of money, time and effort, knowledge/skill required and cooperation from others required. Response scale: 1 to 7 (Strongly disagree to strongly agree).

Self-efficacy. Perceived ability of the respondent (or a family member) to organise the installation of shutters. Response scale: 1 to 7 (Strongly disagree to strongly agree).

Hazard Intrusiveness. Frequency of thinking and talking about cyclones. Response scale: 1 to 7 (Strongly disagree to strongly agree).

Cyclone Knowledge. Knowledge about cyclone risks, damage types and protective actions. Response scale: 1 to 7 (Strongly disagree to strongly agree).

Reliance on Government. Perceived likelihood of government financial assistance for homeowners who have received cyclone related property damage. Response scale: 1 to 7 (extremely unlikely to extremely likely).

Information Seeking. Has the respondent actively looked for information about cyclone risks since living in North Queensland? Responses: Yes or No.

Social Influence. Does the respondent know of any friends, family or neighbours that have installed cyclone mitigation upgrades? Responses: Yes or No.

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