Climate change and natural disasters: Government mitigation activities and public property demand response

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ABSTRACT

The level of public response to extreme catastrophes is considerably greater than concern over climate change. This research compares the public’s responses to extreme disasters and climate change when governments intervene to mitigate long-term climate change impacts. To do so we examine the property market behaviour in response to beach erosion and cyclone damage in Queensland, Australia. The results show that the impact on the property market of the public’s response to the negative impact of cyclones is more marked than its response to the negative impact of beach erosion. The relative non-responsiveness to beach erosion can be seen as a product of both local government intervention strategies and the recreational and aesthetic attractions of beaches. This study, therefore, provides useful insights for the development of sustainable coastal development strategies.

1. Introduction

As a consequence of changing climate, the frequency of natural hazards such as floods, bushfires and intense tropical cyclones has been increasing. While climate change is a phenomenon which is evolving gradually over the long term, extreme natural disaster events are already present. Hence, the adaptation and mitigation of these events are already well recognised (IPCC, 2014). While many governments are seeking remedies, public concern is also becoming a force in the development of adaptation and mitigation measures. Over the past several decades the literature in various disciplines (see, Ford et al., 2011) has provided insights into how the public’s short-term behavioural and investment decisions change such as evidenced in farming practices (e.g. Niles et al., 2015; Wheeler et al., 2013). Nevertheless, there is a lack of research addressing climate change and natural hazard effects on the public’s long-term investment decisions, particularly where governments have attempted to mitigate their adverse impacts. In this study, we aim at bridging the gaps in the literature by comparing public’s long-term investment decision making invoked by climate change and extreme disasters as it relates to property market behaviour.

While climate change in terms of rising greenhouse gas (GHG) emissions is a steadily increasing phenomenon, the frequency of natural hazards attributed to changing climate has also been increasingly globally (Energy and Climate Intelligence Unit, 2017; van Aalts, 2006) and is negatively influencing the value of natural capital and the capacity for sustainable development (Rajapaksa et al., 2017a; Managi and Guan, 2017). The reduction of GHG emissions has been identified as the key remedy by governments and agreement has been reached by them on policies to effect these reductions (Intergovernmental Panel on Climate Change (IPCC, 2014). Indeed, most governments already have implemented mitigation and adaptation policies (Ford et al., 2011). However, public responses to climate change are less clear cut (e.g., Ray et al., 2017) and in general minimal in their effect. However, the experiencing of the increased frequency of climatic hazards (often aggravated by climate change) is shown to heighten the public’s climate change risk perceptions and increase their propensity to embrace adaptation measures (Islam et al., 2016; Capstic et al., 2015). Where the public’s response has been significant, they have moved away from
vulnerable areas where property market values would be affected. For example, after the Tohoku earthquake, despite the action taken by the Japanese government to reduce the impact of radiation, residents are still avoiding certain areas (Munro and Managi, 2017).

A reduction in the value of properties damaged by disasters is now a common phenomenon (see Ortega and Taspınar, 2018; Rajapaksa et al., 2017b). Therefore, disaster-prone areas often request policy action (Rey-Valette et al., 2018). In this paper, our research focus is specifically on beach erosion and cyclones in Australia. Approximately 85% of the Australian population resides along its coast. The unfavourable impacts of climate change contain several serious implications for the government and councils because the coastlines play a major role in Australia’s economy, environment and the life style (Department of Climate Change and Energy Efficiency, 2010). In particular, given the detrimental effects of beach erosion and cyclones on Australia’s coastlines, it has been hypothesised that these impacts would negatively affect the values of Australia’s coastal residential properties.

We use case studies of coastal properties in Queensland, Australia to test this hypothesis relating to: (1) beach erosion and (2) a cyclone. Beach erosion is a gradual process whereas a cyclone is a temporally rapid phenomenon. Employing the hedonic property pricing (HP) valuation method, this research quantifies the impacts of beach erosion and cyclones on coastal property values. More specifically, spatial HP valuation analysis is used. Our results show that extreme weather events such as cyclones negatively impact the public’s property purchasing decisions, however beach erosion does not necessarily discount property values. We suggest that the local government’s beach erosion mitigation interventions may crowd out the public’s negative perceptions.

The rest of the paper is organized as follows. Section 2 discusses literature related to climate change, natural hazards and government intervention with a special focus on beach erosion and cyclones. The spatial hedonic model and methodology is discussed in section 3. The results of the empirical analysis are then provided followed by discussion and conclusions.

2. Climate change, natural hazards and government intervention

Climate change has many impacts – including the increase of sea levels and associated increases in beach erosion (Zhang et al., 2004). In addition, it may aggravate extreme weather events such as storms and floods. Based on the International Geographical Union’s Commission on coastal environment, erosion has become prevalent on sandy beaches that make up approximately one-fifth of the world’s coastline (Bird, 1987). The Commission has noted that the causes are both, natural and directly or indirectly related to human activities.

In the next few decades, land-based activities along coastlines need to be adapted to the impacts of climate induced beach erosion to reduce the continuing impacts on the coastal environment (El-Nahry and Doluschitz, 2010). Policymakers therefore need to consider the cost of the impacts of beach erosion on coastal settlements when implementing coastal management strategies (Rehdanz, 2006a,b).

The nexus of coastal (dis)amenities and the coastal property market is based on numerous international studies using the HP valuation method. Most have customarily used beach width as a key proxy for beach quality. The main justification is that beach width provides a combination of storm protection and recreational benefits for coastal property owners (Landry and Hindsley, 2011). A study conducted by Gopalakrishnan et al. (2011) revealed that beach width positively affects coastal property values. The study indicates that the long-term net value of coastal residential property can fall by as much as 52% when the beach erosion rate triples. A similar study conducted in South Carolina investigating the effects of beach width on coastal property markets found that for a 10% increase in beach width, the corresponding coastal property value increases by 2.6% (Anning et al., 2009). Similarly, they found that the effect diminishes when the distance to beach increases. This is because coastal residents still prefer to live within proximity to the beach as long as the beach quality is at a satisfactory level (Halkos and Matsiori, 2018). From an Australian perspective, a study carried out by Anning et al. (2009) revealed a strong preference for proximity to the ocean in Sydney’s coastal regions.

Due to the increase in the rate of recurrence and intensity of tropical storms, there has been widespread destruction of coastal properties by strong winds and inundation that come together with tropical storms. The consequent negative effect on coastal property values from tropical storms and floods has serious implications for policymakers when designing coastal management strategies. Floods, the most common of natural disasters, have had particularly severe effects. Between 1985 and 2009, floods represented 40% of all natural disasters globally and accounted for 13% of deaths and 53% of the number of people affected by all natural disasters (Atreya et al., 2013). Several studies have documented the reduction of residential property values in a flood zone (Samarasinghe and Sharp (2010); Bin and Landry, 2013; Rajapaksa et al., 2016, 2017b). Bin et al. (2008) examined the effect of flood hazards on the coastal housing market of Carteret County, North Carolina. The results suggested that location within a floodplain lowers the average property value by 7.3%. In an Australian study, Rajapaksa et al. (2016) show an identifiable property value discount in flood risk areas. However, despite the flood risk, residents were found to be generally willing to stay near water bodies. Other studies indicate residents’ heterogeneity of behaviour for environmental amenities as well as disamenities. Du and Huang (2018) show that the amenity values of open spaces are heterogeneous while another study shows that residents discount flood risks differently [see, Rajapaksa et al., 2017c].

In response to climate change and frequent disasters, Australia’s current adaption and mitigation policies relating to beach erosion include coastal protection works such as breakwaters, groynes and seawalls (Short, 2009). Although such measures have proven useful to a certain extent, they ‘harden’ the coast and affect natural systems related to beach erosion and formation (Short, 2009). As a consequence, these defences can further exacerbate erosion. An example is that seawalls can deflect and concentrate wave induced erosion. Equally, groynes prevent movement of sediments thereby leading to further erosion down a coastline (Short, 2009). In Australia, a number of policies have already been adopted which include ongoing research exploring options to minimise the impacts of severe weather events using observation of past events and their effects, testing of new building practices and better prediction of future climate and severe weather patterns (CSIRO, 2013). These initiatives are designed to prepare businesses and coastal communities to become more resilient to the impacts from severe weather events in the future.

3. Empirical analysis

3.1. Study area

In Australia where approximately 50% of its coast is composed of sand and mud, there is extreme susceptibility to shoreline erosion (Short, 2009). Although beach erosion in most of the coastline is a natural process with usually minimal or no impact on human settlement and coastal infrastructure, there are a few significant localities such as Australia’s major cities in which the dynamic nature of shorelines has become a major and expensive problem. This is related to human interference and/or encroachment on shorelines (Short, 2009). For example, research indicates that some of the beaches in the Sunshine Coast’s coastal suburbs, which are the main areas of study of this research are at risk of being decimated in less than a hundred years’ time if no action is taken by the local government (Holznagel, 2008). In particular, places such as Mooloolaba and Alexandra Headland (two of the seven chosen study areas in this study) are listed as areas which are likely be destroyed by beach erosion in less than a hundred years’ time.

While projections of tropical cyclones in the Australian region are
uncertain, the available studies suggest that there may be an increase in the proportion of tropical cyclones in categories 3–5 in Australia (Department of Climate Change and Energy Efficient, 2009; Department of Environment, 2013). By 2030, projections show that there may be a 60% increase in severe storm intensity and a 140% increase by 2070 (Department of Environment, 2013). Such an increase would pose major risks to coastal cities and communities whose planning guidelines and building codes do not take into consideration the risk of severe cyclones (Department of Climate Change and Energy Efficient, 2009).

Cyclone Yasi, which hit Queensland in the first week of February 2011, was one of the most powerful cyclones ever to have affected Queensland (Bureau of Meteorology, 2011; CSIRO, 2013). The hardest hit coastal communities included Tully, Mission Beach, Innisfail and Cardwell, all of which were selected as study sites for this paper. Cyclone Yasi left 150,000 homes without power and the estimated damage cost was reported to be around AUD3 billion (Colgan et al., 2011). Apart from damaging several coastal suburbs in Northern Queensland, other economic effects of Cyclone Yasi included a 14.5% and 16% increase in fruit and vegetable prices respectively in the March quarter 2011 (ABS, 2011). Given the extent of damage caused by this and other cyclones, the Sunshine Coast has been identified as one of the world’s climate change ‘hotspots’ (Department of Environment, 2013).

3.2. Data collection and variables

For this study we collected a total of 1413 property transaction records. For the first case study - which estimates the impacts of beach erosion on the Sunshine Coast’s coastal property values - a final dataset was collected consisting of 913 individual real estate sales transactions representing houses sold between January 2006 and December 2012. Three suburbs namely Buddina (320 observations), Alexandra Headland (204 observations) and Moooloolaba (389 observations) were chosen for the analysis given these suburbs were officially declared as erosion prone by the Sunshine Coast Council on January 2012. The study areas for the storm surge analysis were selected based on cyclone reports published online by the Australian Bureau of Meteorology, which identified the suburbs that had been damaged the most by Cyclone Yasi. These study areas include Tully, Innisfail, Mission Beach and Cardwell. All residential properties selected from these four towns in Northern Queensland had been badly damaged by Cyclone Yasi in 2011. For this analysis, a total of 500 real estate sales transactions from 2003 to 2012 were included.

In this study we hypothesised that property values are discounted due to extreme weather events and beach erosion. Hence we included distance to beach (LogBeach), distance to water bodies (LogWaterBody) and a dummy variable for cyclone (ExtremeWeatherEvent) with other control variables. After an extensive literature review (see, for review, Sirmans et al., 2005), selected structural variable characteristics were included – specifically, number of bedrooms (Bedroom), number of bathrooms (Bathroom), number of garage (Garage) and land size (LogLandSize). All four were expected to have a positive influence on residential sales prices. In this study, the neighbourhood explanatory variables were represented by the road distance in metres to the nearest school (LogSchool) and the road distance in metres to the nearest shopping mall (LogShoppingMall). Lastly, weekly median household income (LogRealMedian) was also included as a neighbourhood explanatory variable in this study to capture the demographic and socioeconomic aspects of each individual suburb.

The most important environmental characteristics in this research was the impact of beach erosion on the Sunshine Coast’s coastal property values. Therefore, in order to estimate its impact on residential property values, the direct distance in metres to a beach (LogBeach) was included. Another environmental explanatory variable included in this study was the road distance in metres to the nearest park (LogPark). Proximity to parks or open spaces have been shown to have a positive influence on residential property values because of its recreational and leisure values (Poudyal et al., 2009b).

Next, the direct distance in metres to the nearest water body (LogWaterBody) was included as an environmental explanatory variable. Based on the literature it was hypothesised that living close to a water body increases residential property values (Rajapaksa et al., 2016). A dummy variable (ExtremeWeatherEvent) was added to capture the effects of extreme weather events - such the 2010–2011 Queensland floods, as well as the 2011 kin. tides event - on Sunshine Coast’s residential property values. This variable provides a means of accounting for the before-and-after effects of extreme weather events that could potentially have an impact on Sunshine Coast’s residential property values (‘1’ if property was sold after the extreme weather event and ‘0’ otherwise).

In order to estimate the impacts of cyclones on Tully, Innisfail, Mission Beach and Cardwell’s residential property values, a dummy variable Cyclone was included as an environmental explanatory variable in the estimation to capture the before-and-after effects of Cyclone Yasi. Cyclone is a dummy variable that takes the value of 1 if the residential property in Tully, Innisfail, Mission Beach or Cardwell was sold after 2011 (Cyclone Yasi incident) and takes the value of 0 otherwise. Apart from the explanatory variables, nine year dummy variables were also created for this analysis and which are used to account for the volatility in terms of the housing market and which may influence property values (see, Athukorala et al., 2016). For instance, D2004 takes the value of 1 if the residential property was sold in 2004 and takes the value of 0 otherwise (Table 1).

3.3. Methodology

The extensive utilisation of the HP valuation method in measuring and quantifying the impacts of environmental externalities on residential property values is testament to its reliability as an evaluating tool for estimating the implicit marginal contribution of environmental externalities. HP analysis allows consistent estimation of the marginal contribution of each individual housing characteristics (Malpezzi, 2002; Baranzini et al., 2008; Lewis et al., 2008) as well as environmental amenities (see, Mei et al., 2017; Poudyal et al., 2009a) and disamenities (see, Rajapaksa et al., 2016; Bin and Landry, 2013). In its simplest algebraic form, the HP valuation method is basically a functional relationship between the price $P_i$ of a heterogeneous good and its quality characteristics which are represented by a vector ‘$x_i$’ as;

$$P_i = f(x_i, \beta) + u_i$$

In the context of this research, the heterogeneous good is defined as the coastal residential property with a price of $P_i$, and the vector ‘$x_i$’ consists of the residential property’s structural, neighbourhood and environmental characteristics. ‘$\beta$’ signifies a vector of coefficients that reflect the influence of the different characteristics while the error term ‘$u_i$’ is generally assumed to be identically and independently distributed. In relation to this study, the estimated marginal effects of the specific variable can be used to evaluate the benefits or losses arising from the marginal changes in the supply of environmental goods (Tyrvainen and Miettinen (2000)). These implicit prices provide valuable information about residents’ willingness to pay for an environmental externality. The general functional form can be estimated using an OLS estimator as follows.

$$lnP = \alpha + \sum \beta_i x_i + \varepsilon$$

where, $x_i$ is a vector of explanatory variables (structural, neighbourhood and socio-economic variables), $\beta_i$ - vector of coefficients - describe the implicit prices of the corresponding explanatory variables and $\varepsilon$ is a

1 For example, Athukorala et al. (2016) used a similar approach to capture the impact of bushfire on property value in North Queensland suburbs.
if $d_{ij}$ is the distance between $\varepsilon_i$ and $\varepsilon_j$. The distance can be estimated using

$$w_{ij} = \begin{cases} 1 & \text{if } d_{ij} \leq D \\ 0 & \text{otherwise} \end{cases}$$

where, $d_{ij}$ is the distance between ‘$i$’ and ‘$j$’ and ‘$D$’ is the band of spatial dependence. The distance can be estimated using ‘$x$’ and ‘$y$’ coordinates.

Generally, two types of spatial models – spatial lag model and spatial error model - are estimated in the literature. The spatial lag model can be expressed as:

$$p = \alpha + \sum \beta_i x_i + u$$

where, $\lambda$ is the coefficient of the spatially correlated error and ‘$Wu$’ the spatially lagged error term.

4. Results

The empirical analysis of this study is based on two case studies: the impact of beach erosion and cyclones on the property market.

4.1. Impact of beach erosion

The mean sale price of the selected sample which is used to gauge the effects of beach erosion, is AUD 706,283 (SD = 412,457). The average number bedrooms, 3.6, varies from 1 to 7. All houses have at least one bathroom and a garage. The land size varies from 110 $m^2$ to 1574 $m^2$. The closest house to a beach is 2.2 m and the furthest in the sample was 1770 m from the beach (see, Table 2).

We estimated two models to capture the effect of beach erosion on the property market. In the first model the log value of distance to the beach (LogBeach) is the most interesting variable whereas in the second model we introduced another dummy variable (D400), to capture the impact of a property being within 400 m of a beach. The estimated models are statistically significant and show relatively higher explanatory power (Adj R-sq = 0.60). Following OLS estimation, the models were tested for spatial autocorrelation. The Lagrangian Multiplier (LM) statistics indicated the presence of a spatial lag effect.

Most of the explanatory variables across all eight SLE models were

<table>
<thead>
<tr>
<th>Table 1</th>
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<tbody>
<tr>
<td>Variable description.</td>
</tr>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>Bedroom</td>
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<tr>
<td>Bathroom</td>
</tr>
<tr>
<td>Garage</td>
</tr>
<tr>
<td>LogLandSize</td>
</tr>
<tr>
<td>LogBeach</td>
</tr>
<tr>
<td>D400</td>
</tr>
<tr>
<td>LogWaterBody</td>
</tr>
<tr>
<td>LogSchool</td>
</tr>
<tr>
<td>LogPark</td>
</tr>
<tr>
<td>LogShoppingMall</td>
</tr>
<tr>
<td>LogRealMedian</td>
</tr>
<tr>
<td>Extreme/WeatherEvent</td>
</tr>
<tr>
<td>Cyclone</td>
</tr>
<tr>
<td>D2004</td>
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<tr>
<td>D2005</td>
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<td>D2006</td>
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<td>D2007</td>
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<td>D2008</td>
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<td>D2009</td>
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<td>D2011</td>
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<tr>
<td>D2012</td>
</tr>
</tbody>
</table>

In the spatial error model it is assumed that the spatial effect is correlated with the error term. The spatial error model can be expressed as;

$$p = \alpha + \sum \beta_i x_i + u$$

$$u = \lambda Wu + \varepsilon$$

where, $\lambda$ is the coefficient of the spatially correlated error and ‘$Wu$’ the spatially lagged error term.
beaches, the risks of erosion hazards are reduced and hence, residential property values are likely to increase. Although statistically significant at the 1% level, the coefficient sign of LogBeach showed a negative relationship between residential property prices and the direct distance to beach, conflicting with the hypothesis of this study. For instance, for every one-unit increase in direct distance to the beach, residential property values decrease by 0.23%. The results also imply that the property price increases when it is close to a water body. Thus, where there is good beach quality, resident’s desire living closer to it in spite of the climate change induced beach erosion. It can be assumed that an important reason is that recreational and aesthetic advantages in living close to beaches far outweigh the threat of beach erosion. Other than beach, some properties are located close to inland water bodies (i.e. rivers, lakes) which exert amenity values for property owners. We included the distance to water bodies as a control variable (LogWaterBody). The statistically significant results of variable LogWaterBody also imply that people are particularly willing to live close to water bodies. These results are in line with previous research: Rajapaksa et al. (2016) show that people are willing to live close to a river in spite of flood risk. Globally, Kummu et al. (2011) show the majority of people prefer to live close to water bodies and that such a habitat preference is most prominent in Australia.

It is important to note in the context of this study that selected suburbs were declared as erosion prone by the Sunshine Coast Council only in 2012 (Department of Environment and Heritage Protection, 2013). Moreover, there was a lag in this announcement taking full effect and in reaching out to all residents living in those three suburbs. The most probable reason then for the negative relationship between LogBeach and residential sales prices in the three suburbs under study was that residents were well-aware of the mitigation policy that had already been implemented by the Sunshine Coast Council. The Council is already monitoring about ten locations in the Sunshine Coast and is also spending approximately AUD$2.4 million to pump 125,000 cubic metres of sand onto the beach between Alexandra Headland and Maroochydore in an effort to mitigate beach erosion in that area (Sunshine Coast Daily, 2013b). The council activities, therefore can be seen as adding stability to the property market. The results are comparable to previous research. The development of infrastructure facilities and other amenities reduce the negative impacts of climate change on property markets (Rajapaksa et al., 2016). However, contradictorily, Munro and Managi (2017) found that active decontamination action by the Japanese government is not good enough to move people back to affected areas by the nuclear accident.

The properties in beach erosion prone areas are also affected by extreme weather events and hence we included a control variable to capture such events. The coefficient sign for ExtremeWeatherEvent is, however, negative and significant as hypothesised. This demonstrates the fact that residential properties that were sold after extreme weather events such as the 2010–2011 Queensland floods and the 2011 kin. tides had a lower value than residential properties that were sold before these extreme weather events. Several studies on the impacts of flood hazards on residential property prices have shown similar results (Rajapaksa et al., 2016; Bin and Landry, 2013). The variable D400 does not show a significant impact.

### 4.2. Impact of cyclones

Of the 500 transactions selected to analyse the impact of cyclones on the property market, at least 16% occurred after the cyclone (i.e Yasi). This information is used to create the before and after variable: cyclone. The average house sale price was AUD 280,087 with an average of 0.605 and 0.605. The land size varied from 414 m² to 2000 m². The year-dummy variables depicted the number of transitions occurring in each year (i.e. D2012).

Panel ‘b’ of Table 4 compares the descriptive statistics before and

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedroom</td>
<td>0.045***</td>
<td>0.045***</td>
</tr>
<tr>
<td>Bathroon</td>
<td>0.133***</td>
<td>0.133***</td>
</tr>
<tr>
<td>Garage</td>
<td>0.0375***</td>
<td>0.0375***</td>
</tr>
<tr>
<td>LogLandSize</td>
<td>0.546***</td>
<td>0.546***</td>
</tr>
<tr>
<td>LogBeach</td>
<td>0.253***</td>
<td>0.253***</td>
</tr>
<tr>
<td>LogWaterBody</td>
<td>-0.164***</td>
<td>-0.164***</td>
</tr>
<tr>
<td>LogPark</td>
<td>0.117***</td>
<td>0.117***</td>
</tr>
<tr>
<td>LogSchool</td>
<td>0.0112</td>
<td>0.0112</td>
</tr>
<tr>
<td>LogShoppingMall</td>
<td>0.0395***</td>
<td>0.0395***</td>
</tr>
<tr>
<td>LogRealMedian</td>
<td>0.266***</td>
<td>0.266***</td>
</tr>
<tr>
<td>Buddina</td>
<td>-0.18***</td>
<td>-0.18***</td>
</tr>
<tr>
<td>Mooloolaba</td>
<td>-0.257***</td>
<td>-0.257***</td>
</tr>
<tr>
<td>ExtremeWeatherEvent</td>
<td>-0.256***</td>
<td>-0.256***</td>
</tr>
<tr>
<td>Constant</td>
<td>8.82***</td>
<td>8.82***</td>
</tr>
<tr>
<td>rho</td>
<td>-0.511***</td>
<td>-0.511***</td>
</tr>
<tr>
<td>Adj R-Squared</td>
<td>0.605</td>
<td>0.605</td>
</tr>
<tr>
<td>Robust LM Error</td>
<td>1.19</td>
<td>1.19</td>
</tr>
<tr>
<td>Robust LM Log</td>
<td>53.4***</td>
<td>53.4***</td>
</tr>
</tbody>
</table>

Note: *, ** and *** denote variables of 10%, 5% and 1% levels of significance, respectively.
after' cyclone Yasi. As the results show, the selected variables are not different before and after the cyclone. However, the average sale price is less after the cyclone.

Property transaction data from four cyclone-affected suburbs (by cyclone Yasi) were considered as a case study. In line with previous literature, the impact of the disaster was captured by before and after cyclone Yasi) were considered as a case study. In line with previous literature, the impact of the disaster was captured by before and after cyclone Yasi. As the results show, the selected variables are not different before and after the cyclone. However, the average sale price was negative and statistically significant (1%) level. For every one-unit increase in the direct distance in metres to the beach, residential property values decrease by 15%–18%. The estimated results were different to the first model – the value for beach is comparatively low. The amenity value depends on the beach quality (i.e. beach width) and

The impact of the cyclone is most severe close to the beach but also different ways – as a dummy variable and using time dummies. The model 2 in Table 5, includes year dummy variables instead of cyclone variable to observe property price dynamics. Despite slight changes in coefficients, most of the variables in ML estimates also are as expected. For instance, _Bedroom and Bathroom_ were statistically significant at the 1% and 5% levels respectively. Either an additional bedroom or bathroom will increase property values by 8%. The second model shows that an additional garage space exerts a positive impact on property value – increasing property values by 4%. Unlike the first case study, land size does not show any significant impacts on property values. In terms of the neighbourhood explanatory variables, LogSchool is statistically significant and the coefficient sign positive. This implies that the level of competition for school admission

### Table 4a

Descriptive statistics of a selected sample for measuring the impact of cyclones.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. dev.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sale price</td>
<td>280,087.2</td>
<td>196,397.4</td>
<td>24,900</td>
<td>160,000</td>
</tr>
<tr>
<td>Bedroom</td>
<td>3.104</td>
<td>1.044</td>
<td>685</td>
<td>13</td>
</tr>
<tr>
<td>Bathroom</td>
<td>1.432</td>
<td>0.755</td>
<td>326</td>
<td>8</td>
</tr>
<tr>
<td>Garage</td>
<td>1.849</td>
<td>0.981</td>
<td>235</td>
<td>6</td>
</tr>
<tr>
<td>LandSize</td>
<td>946.304</td>
<td>204.193</td>
<td>412</td>
<td>2000</td>
</tr>
<tr>
<td>School</td>
<td>2571.97</td>
<td>1245.88</td>
<td>160</td>
<td>8900</td>
</tr>
<tr>
<td>Park</td>
<td>1333.696</td>
<td>1285.787</td>
<td>44</td>
<td>7700</td>
</tr>
<tr>
<td>Cyclone</td>
<td>0.16</td>
<td>0.366973</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D2004</td>
<td>0.108</td>
<td>0.31091</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D2005</td>
<td>0.072</td>
<td>0.258747</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D2006</td>
<td>0.154</td>
<td>0.36311</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D2007</td>
<td>0.152</td>
<td>0.35931</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D2008</td>
<td>0.068</td>
<td>0.251998</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D2009</td>
<td>0.118</td>
<td>0.322931</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D2010</td>
<td>0.084</td>
<td>0.277666</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D2011</td>
<td>0.092</td>
<td>0.289315</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D2012</td>
<td>0.068</td>
<td>0.251998</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 4b

Comparison of descriptive statistics before and after the cyclone.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. dev.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Sale</td>
<td>280143.3</td>
<td>204722.3</td>
<td>24900</td>
<td>1600000</td>
</tr>
<tr>
<td>Bedroom</td>
<td>3.065</td>
<td>1.05198</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Bathroom</td>
<td>1.411</td>
<td>0.700733</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Garage</td>
<td>1.845</td>
<td>1.00231</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>LandSize</td>
<td>947.354</td>
<td>209.0196</td>
<td>414</td>
<td>2000</td>
</tr>
<tr>
<td>School</td>
<td>2613.05</td>
<td>1232.46</td>
<td>160</td>
<td>8900</td>
</tr>
<tr>
<td>Park</td>
<td>1345.648</td>
<td>1283.791</td>
<td>44</td>
<td>7700</td>
</tr>
<tr>
<td>After Sale</td>
<td>279792.5</td>
<td>146106.8</td>
<td>70000</td>
<td>930000</td>
</tr>
<tr>
<td>Bedroom</td>
<td>3.2</td>
<td>1.011228</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Bathroom</td>
<td>1.537</td>
<td>0.992933</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Garage</td>
<td>1.862</td>
<td>0.867759</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>LandSize</td>
<td>940.787</td>
<td>177.7857</td>
<td>473</td>
<td>1534</td>
</tr>
<tr>
<td>School</td>
<td>2354.375</td>
<td>1300.469</td>
<td>210</td>
<td>6800</td>
</tr>
<tr>
<td>Park</td>
<td>1269.575</td>
<td>1302.454</td>
<td>180</td>
<td>5600</td>
</tr>
</tbody>
</table>

### Table 5

Impacts of cyclones.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sale price</td>
<td>OLS</td>
<td>ML</td>
</tr>
<tr>
<td>Bedroom</td>
<td>0.0818***</td>
<td>0.0799***</td>
</tr>
<tr>
<td>Bathroom</td>
<td>0.0902**</td>
<td>0.0793**</td>
</tr>
<tr>
<td>Garage</td>
<td>0.0328</td>
<td>0.0298</td>
</tr>
<tr>
<td>LogLandSize</td>
<td>0.0809*</td>
<td>0.0853</td>
</tr>
<tr>
<td>LogBeach</td>
<td>−0.129***</td>
<td>−0.158***</td>
</tr>
<tr>
<td>LogSchool</td>
<td>0.147***</td>
<td>0.169***</td>
</tr>
<tr>
<td>LogPark</td>
<td>0.0929***</td>
<td>0.116***</td>
</tr>
<tr>
<td>LogRealMed’a</td>
<td>0.151</td>
<td>0.205*</td>
</tr>
<tr>
<td>Cyclone (Yasi)</td>
<td>−0.203***</td>
<td>−0.294***</td>
</tr>
</tbody>
</table>

Note: *, ** and *** denote significant variables at 10%, 5% and 1% levels of significance, respectively. The standard error value for each variable is found in parentheses.
major cyclone. The answer to this research question can be found in the
Cyclone variable. We hypothesised that residential property prices
would fall following the event of a major storm or cyclone.

As estimated, the coefficient sign of Cyclone in the HP regression
models was found to be negative, which confirmed the hypothesis in
this study. The results show that after cyclone Yasi, real property values
decreased by 20% (Model 1). As an alternative, we included year
dummies instead of the cyclone variable in Model 2. Although all
dummy variables show positive and significant coefficients, the value of
coefficients is comparatively small after the cyclone (2011 and 2012).
This then adds to the evidence that Cyclone Yasi did exert an influence
on residential property values. To be noted is that the magnitude of
Cyclone Yasi, which was the second major cyclone in five years to hit
Northern Queensland after Cyclone Larry (in 2006), was significantly
larger than the latter.

5. Conclusions

Public’s concern about climate change is relatively low although
having an experience of an extreme weather event such as a flood
elevates their concern about the effects of climate change and produces
a greater willingness to undertake adaptive measures (Spence et al.,
2011). This study examined public’s response to beach erosion and extreme
weather events in terms of property market behaviours, par-

cularly when governments intervene to mitigate climate change im-

pacts. Property buying is a long-term investment decision and here we
explored individuals’ long-term decision making in response to climate
change and extreme weather events. In line with existing research, this
study confirms that property prices decrease considerably (approxi-

mately 20%) after a severe cyclone, while the impact of beach erosion
on property values is less.

This is in spite of the fact that the selected suburbs in the survey are
those highly vulnerable to beach erosion. Beaches lying between
Kawana and Alexandra Headland are shown to have already been af-
fected, with up to 10 m of sand being swept out to sea. In an effort to
mitigate beach erosion, the Sunshine Coast Council has been mon-
itoring several locations and is also incurring expenditure to pump sand
onto the beaches between Alexandra Headland and Maroochydore.
One possible reason for the low level of responsiveness in property prices
to beach erosion is this sort of intervention. However, it is quite possible in
the long-run that the detrimental effects of beach erosion will event-
ually adversely affect residential property values. Furthermore, the
method we adopted in this analysis is not perfect in distinguishing
amenities and disamenities of being close to a beach. Future research in
this area, therefore, needs to address some of the shortcomings of this
analysis.

The Sunshine Coast Council has adopted both adaptation and mi-
tigation approaches in its climate change action plan. This includes
strategies such as environmental protection, beach nourishment, and
building community resilience to natural hazards (Zeppel, 2011). In
addition, the Sunshine Coast Council has announced that future infra-
structure projects, including housing development plans, need to in-
corporate adaptation to minimise natural hazard impacts (Sunshine
Coast Council, 2011; Zeppel, 2011). These positive measures indeed
help to stabilise property market values.

As extreme weather events are difficult to forecast under certain
circumstances, residents living in cyclone prone areas need to prepare
for cyclones by having safety precautionary measures ready at all times.
These measures can include checking with local council and/or the
building control authority to see if residential properties in cyclone
prone areas have been built to cyclone standards, knowing the nearest
safe high ground and safest access route to it and ensuring the walls,
roofs and eaves of residential properties are secure (Bureau of
Meteorology, 2013). The use of a natural experimental approach can be
used for precise estimation of disaster impacts. In this research we could
not capture the public’s adaptation strategies (if any) to climate change
and extreme weather events.

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