Are we underestimating the sea level rise risk for property?

Georgia Warren-Myers[a]*; Gideon D.P.A. Aschwanden[b]; Franz Fuerst[c] ; and Andy Krause

[ab]Thrive, Faculty of Architecture, Building and Planning, The University of Melbourne, Australia; [c] Department of Land Economy, University of Cambridge, UK; [c] Greenfield Advisors, Seattle, WA, USA.

Provide full correspondence details here including e-mail for the *corresponding author

g.warrenmyers@unimelb.edu.au

Abstract

Sea level rise forecasts identify a potential risk and uncertainty for property owners, occupiers and stakeholders. Currently, this risk is likely underestimated, with little action being taken to address it. Recent data has suggested that previous estimates by Intergovernmental Panel on Climate Change (IPCC, 2013) of a 1 metre rise by 2100 sea level rise are severely underestimated and could reach 2.7 metres (NOAA, 2017). The uncertainty of modelling, forecasting, data availability and constant change in externalities makes this a challenging concept for property stakeholders to consider how to tackle these challenges. However, as this study demonstrates using a case study of the bayside municipality of the City of Port Phillip, even conservative measures of sea level rise and the ancillary implications of storm surge, wave heights and flooding exponentially increase the risk to property and property values. Consequently, there is increasing need for the property industry, sector, stakeholders and academics to open the discussion as to strategies for adaption and mitigation.

Keywords: Sea level rise; risk; property stakeholders; climate change

Key in the subject of the topic (selecting from the list posted under "Call for Papers" on the website of prres2018.nz)

Future directions in property

Introduction

The property sector is not immune to understanding or acknowledging the risks associated with natural disasters or extreme weather events. However, risks more closely associated with climate change such as increased extreme weather events, severe temperature durations and sea level rise, seem to be ignored by property stakeholders or put in the 'too hard basket' despite their detrimental, immediate and significant impacts on property. Within the plethora of information and research there is significant variation as to the impacts and implications of climate change and in particular sea level rise, which has perhaps led the property sector to question what the real impact is on property. Limited research has focused on identifying the challenges of risk identification for property stakeholders; and as a result action has been slow to occur through changes in the development, retrofitting to enhance urban sustainability and the resilience of property and the impact on value. This paper reports on the progress of a project examining the risk of sea level rise to properties. This project aims to firstly highlight the realities and real risks of sea level rise to property using a case study approach (reported on here). Secondly, it examines the value implications that exist for properties affected by flood and ascertain whether this stigma may have a relationship with projected sea level rise. Finally, this project aims to develop a framework to ascertain and calculate potential losses as a result of sea level rise.

Background

The impacts of Climate Change through greater extremes of heat and cold, sea level rise and an increase in extreme weather events will have a significant affect on the built environment, physically, financially and socially as well as placing a substantial burden on the economic stability of the country. Property not only provides shelter or a workplace to the inhabitants of Australia; property is major industry sector within Australia, currently employing more than the mining and resources sector (Property Council of Australia, 2015).

As many of the worlds' major cities are situated along coastlines and river systems, sea level rise is a major concern. Anticipated sea level changes and modelling are continually being updated and revised, and the variability of Greenhouse Gas Emissions modelling, both forecast and actual, and its relationship with sea level rise, creates uncertainty around what the height of sea levels might be in the future. Short-lived Greenhouse Gases, created at variable rates each year, can have a lingering affect for the future implications of sea level rise for hundreds of years, even after they have cleared from the atmosphere (Zickfield et al., 2017). The 2007 Intergovernmental Panel on Climate Change (IPCC, 2007) AR4 report projected a rise of 0.74 metres by 2100 with a 'high-end' rise of 1.1 metres, based on the thermal expansion of the world's oceans; yet it didn't fully incorporate implications of melting ice sheets (Gilkson, 2015) until later reiterations in IPCC AR5 (IPCC, 2013) which identified a larger sea level rise prediction. It is also pertinent to note that that IPCC reports are considered very conservative in their predictions, hence many other researchers and publications suggest modelling that demonstrates greater rises in sea level (Hansen et al. 2016; Gilkson, 2015). Sea level rise modelling takes in one of, or multiple elements in their development. Key elements incorporated are: the global expansion of the oceans; the melting of the polar icecaps and glaciers; ice lost in Greenland and West Antarctica; and loss of permafrost, to name a few. More recent research and studies in a 2017 report by the US National Oceanic and Atmospheric Association (NOAA, 2017) have suggested that current modelling now estimates a worst-case scenario at 2.7m. Dire Armageddon projections in IPCC AR5 suggest sea level rise of up to 7 metres if the Greenland ice sheet melts (Church et al., 2013), and modelling by Hansen et al. (2016) also predict that with the loss of icesheets in Antarctica and Greenland, sea level rise will be in the realm of 6 – 7 metres. Sea level rise modelling should consider "Sea level at any moment as the sum of the mean sea level, plus the state of the tides, wave set-up, responses to air pressure and near shore winds" (Department of Climate Change, 2009, pg 22). However, with an array of different models, different assumptions, sensitivities in analysis, variations and the like, unless one is an expert in the field it's difficult to understand what is or isn't incorporated in the reported sea level rise predictions.

There are various simulations, GIS maps and interactive maps that are now available to examine the potential impact of sea level rise. In the Australian context, there are variable models used by the different layers of government (Antarctic Climate and Ecosystem CRC, 2011). OzCoasts (Geoscience Australia, 2015a) provided static imagery of sea level rise at certain levels for specific areas across Australia, but this was recently superseded by CoastalRisk (NGIS, 2016) which provides an interactive map using Google maps and can have both standard sea level rise measures and also sliding scale capabilities. This tool is an excellent tool for anyone to use, yet limits the understanding on a fine grain level in terms of properties affected and impact.

The variety of sources and modelling, policies and considerations, makes it difficult for governments, industry, communities and individuals to understand the direct implications for their properties and provides a high level of uncertainty in terms of decision making. Current responses to the risk of sea level rise are insufficient across the layers of government in Australia, including the Federal, State and Local Council level. Plans, strategies and management ideas are being developed, yet there is limited communication of actions and the debate and lack of response will have significant impacts on property stakeholders, communities, economies and individuals in the future. Whilst there may be major implications for property, including: property values, legal claims and property rights; the longer-term sugar coating of the situation is likely going to be more disastrous into the future both economically and socially.

Real estate is not an isolated structure, it is integrated into and socially supports communities and individuals. Consequently, isolated approaches to enhancing urban sustainability and resilience are not productive - a broader collaborative approach to the problem is required. When property is affected by an extreme weather event or natural disaster, it is not only the building owner that bears the brunt of the direct and indirect losses in the form of costs of repairs, loss of income/rent and the like; but occupiers' businesses, employees and the broader community are also impacted socially and economically. Further, events that continue to occur and increase in magnitude also cause stigma which leads to consequential losses through increased vacancy rates, loss or demand and lower direct investment (Bienert, 2014). Thus to tackle a problem like sea level rise, solutions and mitigation strategies require engagement with property industry bodies, key institutional investors, owners, occupiers, local, state and federal government and researchers. These groups need to work together to provide a strategically aligned approach to data and information for risk assessment, which when communicated appropriately to property stakeholders, can then promote the development and implementation of risk minimisation and mitigation strategies for property in Australia.

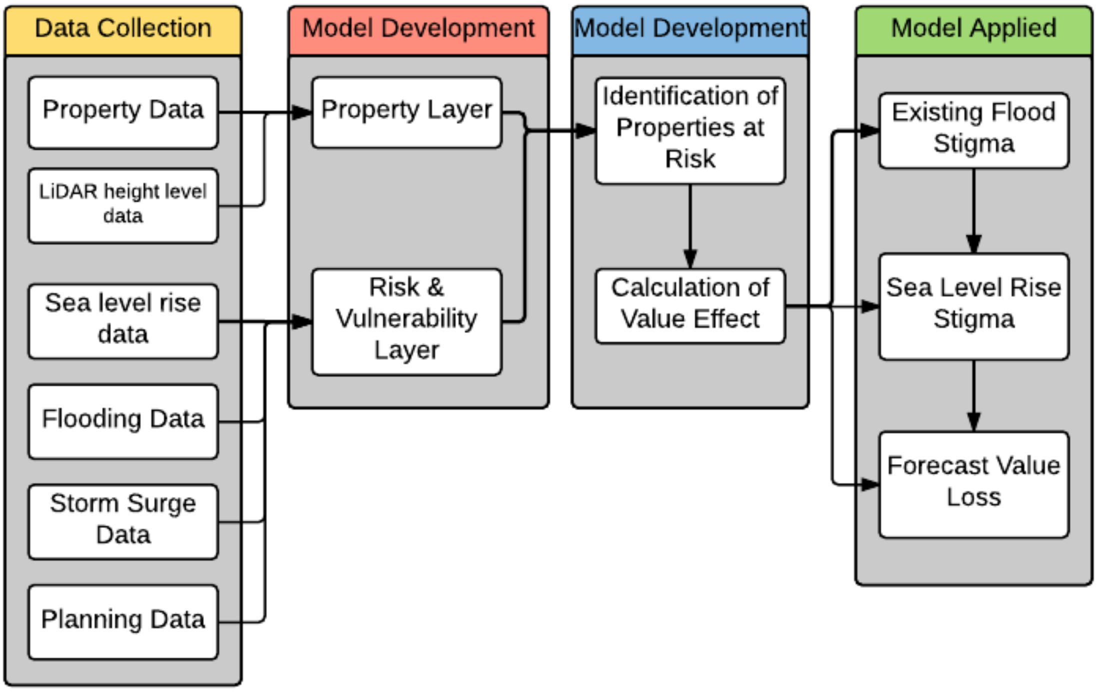
An opportunity and key driver for change in the property sector will be through identifying and quantifying the implications for property values from sea level rise and subsequent events that might affect properties' operational capacities. This will propel the need for more investigation and structures to assess risk and create risk minimisation strategies and adaption to minimise the future impact of these events. In time, understanding of risk, risk mitigation strategies and adoption approaches or lack thereof, will influence investment and occupation decisions within the sector leading to future implications for market value and insurable values.

Research Approach

This research project is made up of several stages which are required in order to investigate the implication of sea level rise for properties. Figure 1 depicts the staged processes of the project; data collection and model development are major elements of the study, whilst the application of the model once set up allows for more streamlined regression analysis of the data sets. This project uses a case study municipality of the City of Port Phillip (COPP), which is located in the inner suburbs of Melbourne and spans 11km of the coastline of Port Phillip Bay. COPP has a range of management plans and information documents relating to sea level rise plus expected future flood levels at 2100, in the *Flood Management Plan* (City of Port Phillip and Melbourne Water, 2012); and more recently in *Planning for Sea Level Rise Guidelines in February 2017* (Melbourne Water, 2017). There are also local investigations, studies and policies in the City of Port Phillip including: *Climate Change in the City of Port Phillip – An Initial Perspective* (City of Port Phillip, 2007); *Planning for Climate Change: A Case Study* (NATCLIM, 2007), *Climate Adaption Plan: Climate Adept City* (City of Port Phillip, 2010) and *Towards a Water Sensitive Elwood* (Rogers and Gunn, 2015). More recently, action by the Council has included an Amendment C111 (2016) to the planning scheme, which revised the use of the Special Building Overlay (SBO) to incorporate sea level rise as a consideration in the use of the SBO. However clarity is still sought as to how this will be implemented, whether the sea level rise risk elements will be clearly communicated with current and future stakeholders, and finally how this will limit or affect properties. Presently, the SBO is generally referred to in relation to types of flooding including riverine flooding, overland flows, coastal tidal and storm surge flooding, and sea level rise. The actual overlay SBO1 refers to overland flows from Melbourne's water drainage system; SBO2 refers to overland flows resulting from Council's drainage system and SBO3 is a more general overlay similar to SBO1 but with less restriction in relation to planning permits. This research aims to provide more information to not only local government about implications and the range of impacts of sea level rise to the municipality, but also to press the need for clear communication with property stakeholders and attempt to raise awareness by property stakeholders.

This paper presents the research to date, which comprises up to the second model development phase part 2, 'Identification of Properties at Risk'.

Figure 1. Project Research Approach



Data Collection and Model Development

The data collection comprises two main components, the collection of property related data and then information pertaining to sea level rise and its additional implications. The property data comprised of the information held on all properties within the City of Port Phillip, obtained by the Valuer General. This data provides individual details of the properties, a geolocation code, size of the land, age and condition of dwelling, zoning and any key features. In addition, property transaction data for residential properties has also been collected from Australian Property Monitor (APM) from January 2011 to December 2016. The APM data and Valuer General data were then matched in GIS along with LiDAR height level data so all properties were calculated to have a height above sea level. The matching process comprised three steps: Direct matching, which achieved a 52% match; Inverse Address, that matched the valuation data to address points by their full address (46%); and the remainder were matched using fuzzy matching techniques. Once this was complete and all properties had height level information, different scenarios relating to sea level heights could be run using R and QGIS to identify which properties were affected.

The sea level rise scenarios developed in this research required extensive investigation of the various methods commonly used to easily model sea level rise. This research uses a similar approach adopted by OzCoasts (Geoscience Australia, 2015a), McInnes et al. (2015) and Hauer et al. (2016) in using the ‘bucket fill’ or ‘bathtub’ method to calculate properties to be inundated. This method is noted as a passive approach and is a simplified representation of reality. This research creates a digital elevation model using Australian Height Datum (AHD) information applies and using the ‘bathtub’ approach, a cut of topography which makes the assumption that any properties under a particular AHD will be submerged. This assumes that the modelled scenario is a still water estimation, as thisis not a dynamic model that could anticipate wave run up or wave set up. The purpose of recreating this for this research is not to provide detailed and accurate information but more to highlight the underestimation by property stakeholders of the broader implications of sea level rise. The limitations of this approach and its adoption here is important, as the authors are not experts in the modelling of sea level rise or oceans. This approach has been modelled with a purpose to demonstrate the implications, consequently this modelling is not as accurate, nor does it hold itself to the accuracy of resources like Coastal Risk or more precise modelling should be used. In addition, there are certain factors that are not taken into account in this model (similar to other studies that have used this modelling approach), like existing sea walls, soil and geological condition of the coastlines, erosion, existing flood plains, hydrodynamics, wave driven run up, hydrological models or other local factors. Further, it does not take into account losses in infrastructure or restricted access, e.g. isolated parcels surrounding by water. The model creation allows for any height to be tested. For the writing of this paper and to demonstrate the variations between sea level rise alone and the other contributory factors, Table 1 shows the range of assumptions and levels used within the model to project the inundation level. On analysis this allowed for properties to be identified as being inundated at different levels.

Table 1. Values used for modelling purposes

Element	Values	Reference
Sea level rise	0.2 metres, 0.5 metres, 0.8 metres, 1 metres, 1.1 metres	OzCoasts (Geoscience Australia, 2015a); Department of Climate Change, 2009; Melbourne Water, 2009; Church et al. 2013; IPCC, 2014
Flood levels	1.6 metres (no waves action) 1.6 metres (some allowance for wave action	Melbourne Water (2009) Melbourne Water (2017)
Highest Astronomical Tide for Port Phillip Bay	0.5 meters	OzCoasts (Geoscience Australia, 2015b)
Storm Surge	0.5 metres and 1.0 metres 0.9 metres	McInnes et al.(2009, 2011) Tonkin and Taylor (2014); Ministry for the Environment (2008)

This paper reports on the properties inundated and surmises why property stakeholders aren't more concerned with a 1.0 metre sea level rise. Further, as demonstrated in the results, this paper shows that the implications of new flood levels, tides and storm surge have a greater impact on properties, their potential future values and operational capacities.

Value Calculation and Analysis

The next stage of the project is to calculate value effects, and this is done in several ways. Firstly, by understanding the current perception and stigma related to flood within the case study area of City of Port Phillip. Secondly, by examining whether there is any current sentiment affecting values in relation to sea level rise. Finally, by utilising building information and data, the calculation of total losses and partial losses as a result of sea level rise and flooding will be undertaken. The difficulty in the final stage is the calculation of value lost; whilst direct losses can be readily calculated, indirect and consequential losses are a lot more difficult to ascertain and likely pose a substantial risk to property stakeholders. The details of the approaches used will be outlined in future papers.

Results and Discussion

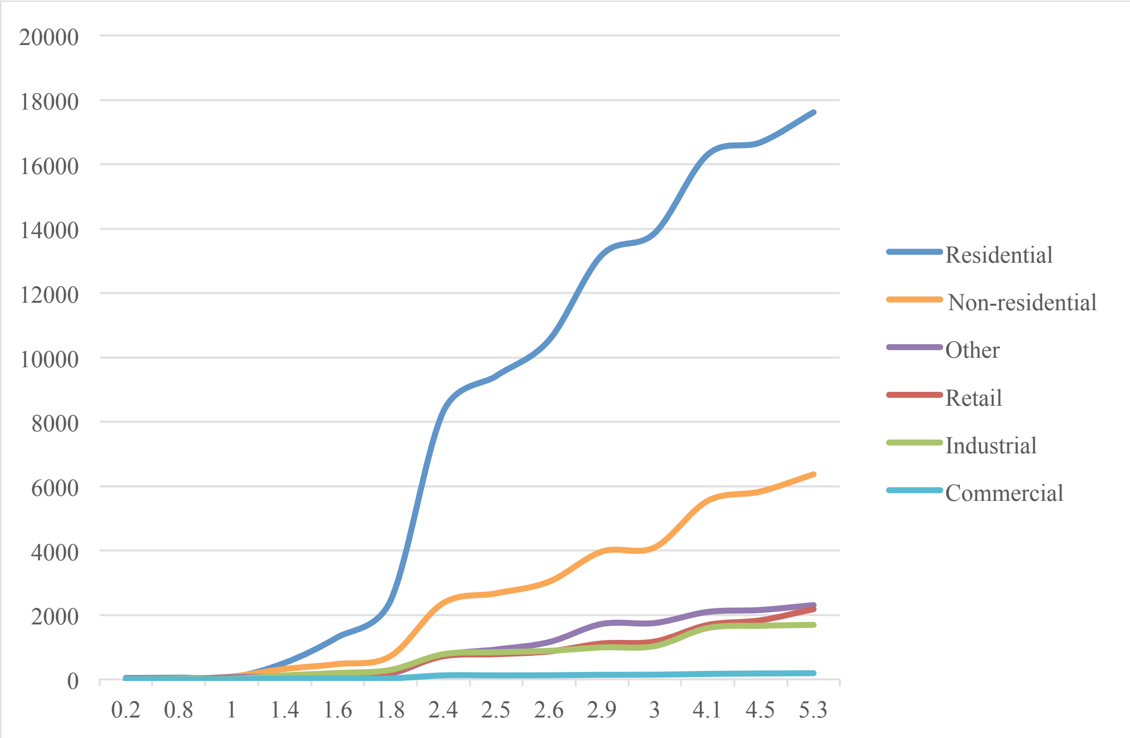
The analysis of the data and the modelling of a range of heights found that up to a one metre sea level rise, only a small proportion of properties will be affected - only 0.27% of properties in the City of Port Phillip (COPP). However the recent worst-case scenario reported by US national Oceanic and Atmospheric Association (NOAA, 2017) suggests that 2.7 metres is a more reasonable estimate, and this height would affect 30% of the properties in COPP. This then escalates substantially when new flood levels are incorporated, which is then further exacerbated by an estimation of the astronomical high tide and storm surge of 0.5 metres, taking the number of propertied affected to 45% and then 50% with a storm surge of 1.0 metre (at a sea level rise of 1 metre). Table 2 provides an overview of modelled heights and properties affected within the COPP. Should the melting of the Greenland ice sheet with the expected sea level rise of 7 metres (IPCC, 2014)), this would decimate the COPP, with 76% underwater in the still modelled assessment and 80% taking into account flood, high tide and storm surge to 1 metre.

Table 2. Modelled heights and number of properties affected in COPP

Sea Level Rise (SLR) (metres)	SLR No. of properties affected	SLR and Flood Levels (+1.6 m)	SLRF No. affected	SLRF + Highest Astronomical Tide (HAT) (+0.5m)	SLRF + HAT No. affected	Plus Storm Surge (+0.5m)	Plus Storm surge No. affected
0.5	0.23%	2.1	6%	2.6	18%	3.1	33%
0.8	0.24%	2.4	12%	2.9	27%	3.4	40%
1	0.27%	2.6	22%	3.1	35%	3.6	44%
1.6	3.4%	3.2	41%	3.7	47%	4.2	50%
2	10%	3.6	45%	4.1	50%	4.6	52%
2.4	22%	4	49%	4.5	51%	5	55%
2.7	30%	4.3	50%	4.8	53%	5.3	58%
7	76%	8.6	76%	9.1	78%	9.6	80%

Further analysis was also done over a range of heights to examine the effect on the different property types. Figure 1 demonstrates that residential properties, as expected in this municipality (predominately residential), are, by number the worst affected. The chart also shows that overall not many properties are affected at 1 metre sea level rise. So direct and complete loss of property value is contained to approximately 0.27% of properties in COPP. However, the number of properties that are affected by potential future flooding is substantial, accounting for 44% of the municipality. Residential properties by numbers are by far the worst affected properties, and consequently first perception would be that residential properties will bear the full brunt of direct and indirect losses. This was expected, as this municipality is mostly residential with pockets of industrial land to the western side in Port Melbourne, commercial situated in South Melbourne, and retail comprising small shopping areas within each of the suburbs. With much of the industrial land identified as areas for future urban growth and substantial increases in density, the exposure of this land to potential sea level rise and flooding should be of concern to the local government. This research should highlight to authorities the need to engage with households within the municipality to raise awarenss and develop ways in which to communicate the potential risk inherent in the property based on various scenarios. Recently COPP incorporated sea level rise into their Special Building Overlay through Amendment C111 (2016), which identifies properties that are affected by flooding associated with riverine flooding, overland flows, coastal, tidal and storm surge flooding and sea level rise. So this does not provide clarity in regard to whether the property is affected by sea level rise, or whether there is increasing future risk of the property from sea level rise related implications like further flooding. This lack of clear representation does not assist owners and occupiers in understanding the level of risk their property is exposed to and the possible timeframes.

Figure 1. Properties affected: sorted by property type



Conclusion

This research presents a new perspective on how vulnerable property actually is to sea level rise. As demonstrated, the risk directly related to the sea level rise of up to one metre is not substantial within this case study, but this may not be the case in many other areas. Many of the sea level rise models and projects assume a flat-water scenario, which doesn't really represent what reality might occur given the variability in tides, wind, precipitation, storms and the like. What this study aims to do is incorporate some of these considerations, using existing information and research combined together with property information through GIS to highlight the increased flood risk that properties will be subjected to in the event of sea level rise. The effect on properties exponentially increases when elements of high tide, existing flood levels and storm surge are taken into account.

Action in relation to sea level rise is predominately focused on by governments, local, state and federal, and much related to planning and policies. However, there is not a consensus on action to examine sea level risk in Australia, and at present various local governments and authorities are developing different plans and analyses, which is often resulting in variations across areas. However in many areas the awareness of the public to proposed and future planning changes is variable. There is a lack of disclosure of the issue and extent of risk property is exposed to in relation to sea level rise and future flooding; this has substantial implications for ownership, investment, management and occupation. Further the implications for current and future values of properties in relation to the risk profile of the property from various losses requires further research and disclosure. There has been little consideration, interaction or action by private property stakeholders. The implications to value are of utmost concern to property stakeholders, so the lack of discussion, mitigation and action coming from the property sector in relation to sea level rise is surprising. This may have to do with the plethora of information, inconsistent modelling and reporting which creates uncertainty; but also perhaps that the real impacts may not be clearly evident. This research will hopefully draw to the attention of a broad range of stakeholders involved with property, the broader implications of sea level rise and the increased risks associated with properties near coastal areas.

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