Ocean and Coastal Management 190 (2020) 105150

Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: http://www.elsevier.com/locate/ocecoaman

Opinion Paper

The two-speed coastal climate adaptation economy in Australia

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ARTICLE INFO

Keywords:
Climate change
Coastal adaptation
Vulnerability
Coastal retreat

ABSTRACT

There is increasing global concern that climate adaptation efforts are falling behind the increasing risks associated with climate change. A number of reviews have identified this general issue in multiple nations and jurisdictions. In Australia, it is argued here that adaptation of the coastal built environment is operating at two speeds: the two-speed adaptation economy. Large civil assets and facilities in Australia now mostly have adaptation plans and strategies in place; although progress in actual on-the-ground implementation is variable in some cases. By contrast, adaptation of coastal communities and settlements continues at a very slow pace with very few specific adaptation measures being implemented that were not already being implemented as business as usual for flood or erosion management. The reasons for these differences in adaptation progress is investigated here. A key outcome of the thinking presented here is the reinforcement of the result that adaptation of coastal communities is not a challenge of relocating buildings, but rather a challenge of incentivising and supporting communities to act.

1. Introduction: The two-speed adaptation economy

For people alive today and their children, much, if not most of the infrastructure required for shelter, transport, employment, power, water supply and sanitation has already been constructed. Importantly, as a result of the long useful lives of much of the built environment, this infrastructure was designed to withstand and operate in historical environmental conditions that will be different to the conditions that these assets will have to withstand in future decades as climate change increasingly influences the natural environment (Agard et al., 2014). Particularly for major civil infrastructure such as airports, roads, railways, ports, hospitals and government buildings, but also for private dwellings, all are exposed to climate-mediated future environmental conditions over coming decades (IPCC, 2014). By definition, this implies that unless action is taken to reduce the vulnerability of the built environment, communities utilising these assets will be increasingly at risk (IPCC CZMS, 1990).

For the purposes of the thinking here it is convenient to divide the built environment into two categories: the urban built environment consisting primarily of individual dwellings and small commercial properties, and major civil assets and infrastructure such as water treatments plants, transport infrastructure, power stations and similar assets. In addition, the urban built environment can also be sub-categorised into the existing and the proposed built form as cites expand and agricultural land areas are repurposed to the built form. For the purposes of adaptation planning, in the possible new built environment, sometimes coined the 'urban sprawl', adaptation is often easier to implement (Araosa et al., 2016). For example, pre-emptive land use planning through the application of land use regulations can prevent urban development in areas deemed to be high risk from natural hazards (Gibbs, 2015a,b). By contrast, managing existing assets, especially those that are privately owned in nations that do not subscribe to command and control political economics is challenging (van Valkengoed and Steg, 2019). Hence the focus here is on adaptation of the existing built form.

Despite the now well-recognised increasing risk of hazards to the coastal built environment, it is becoming increasingly apparent that the global coastal built environment has been slow to adapt to future climactic conditions (Berrang-Ford et al., 2011; Eakin and Patt, 2011; Carmin et al., 2012; Ford et al., 2015; Araosa et al., 2016). Reviews of adaptation progress often consider adaptation progress by sector – for example agriculture, built or urban environment, finance sector, defence, education, or alternatively through a lens of organisations and individuals (Woodruff and Regan, 2019). This categorisation is logical, although the lack of specificity or granularity particularly within sectors can mask key dynamics occurring within sectors that act to retard the pace of overall sector adaptation. To this end, the core argument presented here is that adaptation to climate change of the coastal built environment in Australia is operating at two speeds: the two-speed adaptation economy. In particular, it appears that good progress is

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https://doi.org/10.1016/j.ocecoaman.2020.105150
Received 4 September 2019; Received in revised form 27 December 2019; Accepted 15 February 2020
Available online 16 March 2020

finally being made in adapting large civil assets and facilities, but poor adaptation progress is being made for the majority of the urban, especially residential environment; as explained here. The overall objective of the thinking presented here is therefore to delve deeper into the identified general issue of lack of adaptation of the coastal built environment. In particular, to help to elucidate exactly which parts of the coastal built environment have been slow to adapt to the increasing risks of coastal hazards and offer some suggestions as to why this may be the case.

2. Large infrastructure in the two-speed adaptation economy

Based on feedback from adaptation practitioners, plans that the author has created, contributed to or reviewed, and presentations at multiple industry conferences, it is clear that many if not most large infrastructure and asset owners in Australia have commissioned the development of climate adaptation plans (Aldum et al., 2014). This is also evidenced by documents such as annual reports and similar corporate documents that demonstrate that every major port and airport in Australia has developed a climate adaptation strategy (see for example www.aphref.aph.gov.au_house_committee_ccwea_coastalzone_subs_sub032.pdf). See also case studies in https://coastadapt.com.au.

It is also becoming apparent that there are an increasing number of examples in Australia where on-the-ground adaptation actions have been undertaken for major civil infrastructure (Tonmoy et al., 2018) and specific and several examples of this are discussed below. This result in itself is significant as until recently, despite the large proportion of major coastal assets in Australia that have adaptation plans in place, as identified by Gibbs (2019) the initial tranche of these plans contained recommendations that had largely not been implemented. This is thought to be a result of a combination of the 'plan and forget approach', and unrealistic recommendations contained in these plans (Surminski, 2013; Gibbs, 2016). The Plan and Forget approach occurs when asset owners believe that they should develop adaptation plans, but do not see the need to actually make on-the-ground changes yet. In such cases the risk is not being actively managed but there can be a perception that the risk is being managed. The Plan and Forget approach can also occur when adaptation plans contain recommendations that are difficult, if not impossible to realistically implement (Tompkins and Eakin, 2012).

For example, in Australia many of the first sets of coastal infrastructure adaptation plans that were developed contained costly recommendations that demanded sometimes dramatic increases to the engineering robustness of structures (Gardiner et al., 2019). For example, elevating the decks and minimum floor levels of existing bridges and buildings, or the construction of major flood protections levees. In general asset owners considered that such major capital works were not often warranted based on the climate information provided; and the associated uncertainty in projections (Gasbarro and Pinkse, 2016).

Inspection of more recent adaptation plans demonstrates that this newer tranche of plans are more sophisticated and consider ways in which services delivered by these assets can be maintained during extreme weather events, or the assets can be more rapidly re-established following events (see Goldstein et al., 2019 for more information). These approaches generally require less major capital works and are consistent with resilience thinking as described in Gibbs (2009) and Hayes et al. (2019). As a result, it can be argued that the on-the-ground implementation of recommendations contained in these plans is increasing; although it is difficult to quantify exactly what specific actions have bene undertaken in some cases as most of these activities are described in documents that are either commercial in confidence and/or not presented in the scientific literature (Pinkse and Gasbarro, 2019). Additional progress has been made more recently with the introduction of the TCFD (Task Force on Climate-related Finical Disclosures). The TCFD is a voluntary, global standard for companies to provide mainstream transparency in exposure to climate change. TCFD is gaining increasing uptake globally since its introduction in 2016 (Monasterolo et al., 2017).

Two prominent examples of major adaptation actions in the form of major capital works (the Brisbane airport), and where changes have been made to assets to allow inundation to be accommodated (Queensland Urban Utilities) are presented below.

2.1. Adaptation through major capital works

Brisbane is a large coastal city on the east coast of Australia. The major Brisbane airport facility, owned and operated by Brisbane Airport Corporation (BAC), is undertaking a facility expansion that involves the construction of a second runway. One end of this runway extends to the low-lying coastline. The airport has already been identified as an inundation risk in previous coastal flooding modelling studies; hence coastal inundation will be a major hazard for this new runway. In anticipation of future vulnerability to inundation, the runway, which is being constructed by dredging submarine sands from nearby Moreton Bay, has been constructed substantially higher than the existing runways. Following a set of updated inundation modelling that accounted for potential increased sea levels over the expected usable life of the runway, a decision was made to add extra sand to the runway so that the pavement is laid at an elevation at least 1.5 m above the modelled one in one hundred year storm event, accounting for an increased sea level rise. Therefore, an explicit decision was made to incorporate projected sea level elevations in the construction of this major facility despite the substantial additional costs. This is a clear case where climate projections have been incorporated into the design of major new infrastructure in Australia (see http://ipweaq.intersearch.com.au/ipweaqjspui/bitstream/1/3087/1/Brisbanes%20New%20Parallel%20Runway%20Sept%202016.pdf).

2.2. Adaptation through accommodation

In 2011 large parts of the coastal city of Brisbane were inundated by flooding from an extreme catchment rainfall event (Espada et al., 2015). Queensland Urban Utilities (QUU) is the water supply and sewage utility for the city and during this event large parts of the water and wastewater network were out of service. Multiple treatment plants and pumping stations were partly or fully inundated leading to the discharge of untreated wastewater into the environment and loss of service of water supply to some communities (Espada et al., 2015). QUU realised the increasing risk of such events in future decades and as a result, QUU commissioned an extensive resilience planning program and associated capital works program that increased the resilience of the water supply and wastewater treatment asset network to future, climate induced inundation. Careful consideration was given to cost-effective ways of reducing the impacts of future events; for example through relocating essential services to higher elevations within existing facilities rather than attempting to protect entire facilities through bunds and levees. Careful consideration was also given to seeking ways of allowing some services to become disrupted during extreme events, but with ways if bringing services levels back up rapidly following major events (Gibbs, 2019).

3. The coastal residential built environment in the two-speed adaptation economy

These two examples demonstrate the increasing rate of progress evidenced in the management of large coastal infrastructure and assets in Australia. Interestingly, the adaptation of large coastal infrastructure in Australia preferentially follows the accommodate or manage adaptation approach, followed by the protect approach (Klein et al., 2001). However, by contrast to the increasing pace of real adaptation being undertaken for civil assets and infrastructure, examples of real adaptation for residential communities in the coastal built environment remain

more elusive.

Climate adaptation responses are commonly classified into the typology of protect, retreat or accommodate (IPCC CZMS, 1990). Although contested at times, this typology remains in widespread use (Klein et al., 2001; Le, 2019; Oulahen et al., 2019; Zhu et al., 2010). In the coastal zone the protect approach generally involves engineered structures such as seawalls but can also include green infrastructure options such as beach nourishment (Rulleau and Rey-Valette, 2017). The retreat approach is generally regarded as relocating the built environment either further inland or onto higher ground (IPCC CZMS, 1990). The accommodate approach mostly involves finding ways of accommodating episodic inundation events within the existing built environment (IPCC CZMS, 1990).

There are limited examples of all of these adaptation approaches emerging in Australia. For example, following a large coastal storm event in the city of Sydney in 2016 (Harley et al., 2017) that resulted in substantial storm damage of private property, the local government has commenced a private property buyback scheme (https://www.smh.com.au/national/council-offer-of-3m-for-at-risk-house-declined-20070624-gdqgmb.html) as a strategic retreat initiative. However, these foreshore properties have traditionally been valued at many millions of dollars and hence the local authority is barely able to purchase a single property per year. This may be effective over a time scale of many decades, but this approach also introduces a moral hazard in that it removes the incentive for individual home-owners to adapt, as the local government becomes the insurer of last resort.

Similarly, many local coastal government authorities in Australia have implemented planning provisions whereby buildings that are new, or being refurbished, must abide by higher minimum floor level elevations. In this approach over long periods of time the vulnerability of the coastal built environment can be increased (the accommodate approach). However once again the rate of progress in increasing the overall vulnerability of the existing built environment is frustratingly slow as the pace of adaptation of explicitly linked to the rate of major refurbishment of private homes.

Australia, like all coastal nations has small sections of the built environment that are located in coastal erosion prone areas. The most common remedial action in such cases is to construct engineered structures such as seawalls; leading to the commonly-used expression "I'm not sure what the problem actually is, but the solution is a seawall (R. Tomlinson – pers. Comm.). With sea level rise, the number of the erosion areas is expected to increase. This approach is commonly regarded as business as usual coastal management in Australia rather than an explicit climate adaptation response.

There are several prominent examples of managed or reactive retreat of residential areas in Australia. Perhaps the single best example is the small settlement of Grantham. Grantham was also inundated during the major 2011 flood event in South-east Queensland and rather than reconstruct the local built environment in the same location, the local government council was able to secure funds to relocate the settlement a short distance away at a higher elevation. However, although this was a reactive or managed retreat approach, it was not the strategic retreat commonly advocated in climate adaptation plans that recommend pre-emptive retreat where settlements are relocated in advance of a major event occurring (Siders et al., 2019). By contrast, this was a reactive retreat exercise that followed the destruction of the settlement in a major inundation event.

These are explicit examples of deliberate climate adaptation actions being undertaken at a community level. However, in the greater context that most Australian live in the coastal zone (LGASQ, 2015; Gibbs et al., 2013), these examples are a minority. Consistent with this result, Gibbs (2019) reviewed a number of coastal climate adaptation plans from around Australia and concluded that there was a lack of consistency in adaptation responses for coastal settlements, suggesting an immaturity in the science and planning of community-level coastal climate adaptation in Australia.

Similarly, Pearce et al. (2018) undertook a systematic review of adaptation responses in Australia. The key conclusion of this study was that whilst adaptation actions are underway across a number of sectors, they are best described as preliminary or groundwork. This study did not consider non-peer reviewed documents and hence the large volume of adaptation plans generated by private sector consultants was not captured. However, it can be argued that the general conclusions remain the same. Pearce et al. (2018) also observed that some of the best adaptation progress was being made by the agricultural sector. This is not surprising in light of the fact that in many cases this sector can be more responsive as a result of the relative lack of fixed and inflexible infrastructure used in this sector by comparison the urban built environment.

In summary, it can be argued that in the coastal built environment in Australia, real adaptation progress is now being made for fixed large civil assets and infrastructure but adaptation efforts for the existing residential built environment remains in the preliminary or groundwork stage (using the terminology of Pearce et al., 2018) with a lack of real progress in on-the-ground adaptation. This is described here as the two-speed coastal adaptation economy.

4. Reasons for the two-speed adaptation economy

It is suggested that the reasons why the two-speed adaptation economy in Australia exists can be clustered into the following categories:

a) **Scope and complexity** and variety of actors involved in decision-making
b) **Risk perceptions** and lack of incentives
c) **Confusing typology** of adaptation options.

These categories are based on previous thinking and logic presented in Gibbs (2016, 2019) and are discussed in more detail below. This categorisation was developed in an Australian, context, but is probably equally valid in a general developed or industrialised nation context; especially where strong private property rights regimes are in place.

Scope and complexity. Planning, financing and undertaking adaptation measures of large civil assets can seem a daunting task. However, compared to gaining agreement from a whole community; many of whom own private assets such as houses, the internal organisational process of developing and implementing large asset adaptation solutions can be relatively straightforward. Most owners and operators of large civil infrastructure are familiar the with the engineering planning, design and construction processes and hence even large adaptation projects involving substantial capital expenditure can be business as usual; once the key decision-makers have been convinced of the merit of implementing adaptation measures (Ng et al., 2019).

By contrast, gaining consensus from entire residential communities on a common adaptation pathway is a substantially larger and more difficult task (O'Donnell, 2019). Individual residents have their own drivers and expectations around the advantages and disadvantages of different adaptation approaches, and therefore resolving these differing drivers and incentives can be challenging (Measham et al., 2011). This is especially the case when adaptation planning is done well in advance of the threat of inundation being realised (strategic retreat). In addition, in locations where high economic density or concentration of the built environment occurs in the coastal zone, whether it be high value private properties or commercial centres, the asset anchoring phenomena can restrict many forms of adaptation response. Asset anchoring occurs when these high value assets logically choose coastal protection as the primary adaptation response (as relocation becomes very expensive), but this action effectively locks the lower economic vale assets in locations at-risk – "why should we move when they haven't" is a common response to asset anchoring (Gibbs, 2013).

Risk perceptions. Surveys of residents at risk repeatedly reveal the

same results: individual owners of residences repeatedly and chronically underestimate the risk of natural hazards (Shao et al., 2017) – "it won't happen to me". The same surveys also repeatedly reveal a lack of understanding of private and government insurance. Private insurers manage liabilities and exposure of residential assets through annualising policies. Therefore, residents need to effectively re-insure their assets every year whilst insurers have an annual opportunity to re-assess the risk, and adjust premiums accordingly. Meanwhile home-owners are left with the residual or uninsured risk after this occurs. Surveys in Australia have also revealed chronic underinsurance of the private housing stock (Booth and Tranter, 2017); indicating significant vulnerability of many householders.

Surveys have also demonstrated a lack of understanding about the role of government in Australia as the insurer of last resort (Booth and Tranter, 2017). This in itself is surprising given the stated policy of the Australian government, and many State government of not to be the insurer of last resort of private assets (Carter, 2012). Whilst government continue to provide very small post-disaster relief grants, these fall well short of full reimbursement of direct or indirect damage costs.

As home-owners systematically underestimate the risk, and future availability and affordability of insurance cover (from both private insurers and government), there is little incentive to take adaptation actions that may decrease the vulnerability, or increase the resilience of their assets. Private asset owners who voluntarily undertake resilience measures are also often unrewarded by private insurers, thus creating a perverse incentive that acts to maintain the vulnerability of the housing stock in the face of increasing risks from climate-induced natural hazards.

There is a clear role here for the provision of climate services, especially the provision of climate-informed coastal flooding or inundation maps. However simply presenting maps to communities can also be problematic unless the delivery comes with clear information about how to interpret inundation maps.

As owners observe a lack of action of their neighbours, this reinforces their belief that adaptation actions are not necessary, embedding a social proof of their own lack of adaptive progress. The typical return period for major climate-mediated natural hazard events such as major floods, storm surges and the like have historically been greater than the typical length of time that owners own specific assets such as houses. The average length of home-ownership in Australia is around a decade (ABS, 2016), and typical return periods for natural hazards have been a few decades. This reinforces the 'it won't happen to us' view.

Confusing typology. The third postulated reason for the lack of adaptation progress in the existing residential built environment in coastal Australia is that when community's relevant local governments in locations increasingly at risk are presented with adaptation options during adaptation planning exercises, the typology of the options is confusing and unhelpful (see Palutikof et al., 2019 for details of adaptation typologies). In Australia, it is common to the use adaptation typology identified above; namely: protect, retreat or accommodate. However, as identified in Gibbs (2019), attempting to try and force policy-makers and regulators into one of these three functional adaptation approaches can be problematic. There are likely to be a number of specific reasons for this, as described below.

Firstly, the strategic retreat option which is commonly advocated and involves relocating communities at risk in advance of inundation risks becoming too high has increasingly been found to be difficult to implement from a political perspective. In Australia few elected local government leaders have been willing to ask communities increasingly at risk to voluntarily relocate landwards. By contrast, the reactive retreat approach whereby communities are incentivised not to rebuild in vulnerable locations immediately following major storm events is a much more politically favourable approach. However, stating this intention in a formal adaptation planning document is also seen to be politically challenging for local elected officials. This is the likely reason why retreat policies have largely failed to gain traction in Australia.

Similarly, in a review of adaptation plans in Australia, Gibbs (2019) observed that the accommodate adaptation approach was not readily understood by communities. Accommodating the increased frequency of coastal inundation in particular can occur at a community scale, through for example increasing the capacity of drainage systems. It can also occur at an individual asset or building scale, for example through lifting essential building services, or by slowly repurposing the built environment at risk. This lack of clear explanation about the accommodate adaptation option is speculated here to be a reason why communities and local governments are struggling with the implementation of coastal adaptation plans. Once again, there is an explicit role for climate services here to provide real examples to communities and local governments in locations increasingly at risk of where adaptation approaches have been applied and been successful.

5. Summary and concluding remarks

Observations of climate adaptation practices in the coastal built environment in Australia suggest that a two-speed adaptation economy is underway. This is characterised by increasing progress being made in on-the-ground adaptation efforts to large civil assets and infrastructure, but slow progress being made in real adaptation of the residential built environment.

The reasons for the lack of progress in adaptation of the coastal residential built environment are suggested to be: the complexity and number of actors (including within government itself) in coastal residential climate vulnerability issues (Patterson and Huiteme, 2019; Göpfert et al., 2019), the lack of incentives and understanding of risk in the general community, and issues associated with the way adaptation options are presented to local authorities and community at risk. In summary, the challenge of adapting large civil infrastructure and private buildings in communities is quite different (Gibbs, 2015a,b). The former is more technical in nature, the latter more of a social challenge.

There is a clear role for climate services (Dilling and Carmen Lemos, 2011) to assist in breaking down these barriers, and these include:

- The increased provision of not only updated flood and inundation maps, but information and education pieces that can help asset owners better understand the risks to their assets,
- Knowledge and information on the benefits of increasing the resilience of the built environment so that asset owners become incentivised by insurers to reduce the vulnerability of their assets,
- Knowledge and examples of how a more refined set of adaptation options can be implemented by communities and local government authorities.

In Australia is it now wide-spread that local and state government agencies provide coastal flood and inundation maps. However, it is recognised that there is also widespread lack of understanding among the community on how to interpret these maps. By contrast, owners and operators of large infrastructure are able to fund expertise to correctly interpret this information.

Examples and knowledge of ways to increase resilience and increasingly available (for example see Palutikof et al., 2019) and over time it is reasonable to expect that this information will be further disseminated.

By contrast, it is becoming increasingly recognised that there are substantial barriers in the way of the owners of private houses and residences to increase the resilience of adaptive capacity of private dwellings. This is a result of a combination of minimum regulatory building standards, and a lack of recognition by insurers for efforts to upgrade assets (as described in https://greencrossaustralia.org/media/9997813/0001grc_hypothetical%20report%20p6_final.pdf).

Therefore, individual building owners and occupants, whilst have access to climate projections and other technical information, may not be using this information for decision-making. In Australia, local

Governments more often than not provide flood or inundation maps for communities. However as highlighted above the general community understanding of this information remains poor and critical parts of the real estate community, especially relators can be particularly unhelpful in the application of such information (Box et al., 2016). As a result, a strong social norm develops where residents in areas not recently impacted by inundation events feel immune from impacts of future inundation or storm damage either as result of lack of appreciation of the real risk, or because they are under the impression that private insurance or government will provide insurance coverage (Nguyen, 2016). Therefore, a challenge of climate services and information is to change these social norms so that individual residents are in a better position to manage their climate risk.

Declaration of competing interest

No conflicts of interest.

Acknowledgements

The author wishes to thank Susan Rutledge and Tiki Taane for their invaluable support and assistance in the preparation of this manuscript.

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