A general summary of the report

Economic Impacts from Sea Level Rise and Storm Surge in Victoria, Australia over the 21st century (Kompas, T. et al (2022)).

Prepared by the Victorian Marine and Coastal Council (VMaCC), with recommendations from VMaCC and Life Saving Victoria

VICTORIAN MARINE & COASTAL COUNCIL

THE UNIVERSITY OF MELBOURNE

Life Saving Victoria

This document is a general summary of key findings from the technical report titled *Economic Impacts from Sea Level Rise and Storm Surge in Victoria, Australia over the 21st Century*[1] (the Kompas report). The summary has been prepared by the Victorian Marine and Coastal Council (VMaCC) and includes VMaCC's and Life Saving Victoria's recommendations in response to the Kompas report.

Acknowledgement of Traditional Owners

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, and their unique ability to care for Marine and Coastal Country and deep spiritual connection to it. We honour Elders past, present and emerging whose knowledge and wisdom have ensured the continuation of culture and traditional practices. We are committed to genuinely partner and meaningfully engage with Victoria's Traditional Owners and Aboriginal communities to support the protection of land and sea Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

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1 Please cite the Kompas Report as:
Tom Kompas, Karl Mallon, Michael Bojko, Tuong Nhu Che, Beth Strain, Max McKinlay, Pham Van Ha, Quentin Grafton and Natalie Stoeckl, (2022), *Economic Impacts from Sea Level Rise and Storm Surge in Victoria, Australia over the 21st Century*, Report prepared for the Victorian Marine and Coastal Council (VMACC), with support from the Department of Energy, Environment and Climate Action (DEECA) and Life Saving Victoria, Centre for Environmental and Economic Research, University of Melbourne, Melbourne and Climate Risk Pty Ltd, Sydney.

Please cite this summary report as:
Victorian Marine and Coastal Council and Life Saving Victoria (2022), *A general summary of the report Economic Impacts from Sea Level Rise and Storm Surge in Victoria, Australia over the 21st century by Kompas, T.* et al *(2022).* Victorian Marine and Coastal Council, East Melbourne.

Contents

1. Overview

The Kompas report – formally titled, *Economic Impacts from Sea Level Rise and Storm Surge in Victoria, Australia over the 21st Century* – was prepared for the Victorian Marine and Coastal Council (VMaCC) with support from Life Saving Victoria (LSV) and the Department of Energy, Environment, and Climate Action (DEECA). The Kompas report includes that:

- Using two different approaches, the University of Melbourne and Climate Risk Pty Ltd modelled the physical damages and potential economic cost of sea level rise and storm surge on Victoria's bays, and coastal and marine areas, if adequate adaptation measures are not undertaken. Each model was used to derive results for 2040, 2070 and 2100 and to indicate the 40 subregions of Victoria most affected by the impacts of sea level rise and storm surge.
- The losses in discounted present value dollars of residential and commercial assets, reserves and conservation areas, infrastructure, parks, industrial and agricultural assets due to sea level rise and storm surge were estimated to be more than $337 billion in 2100, or 2.68% of the projected gross state product (GSP) of Victoria. The modelling revealed that the costs of damage in 2070 are four times larger than 2040, and in 2100 nearly 10 times larger than in 2040.
- There was considerable variability of economic damages (market and non-market values) across the different subregions and land use classes of Victoria. In 2100, the dollar damages to reserves, arising from sea level rise and storm surge, amount to approximately 40% of the total. Reserves west of Melbourne, near Geelong, and in South Gippsland will be especially impacted. Economic losses in residential areas, including damages to land and vacant residential sites, will mostly occur around Port Phillip Bay and east of Melbourne. The bulk of commercial damages will be for land in Docklands and Southbank.
- The impacts from sea level rise and storm surge on wetlands were modelled separately, and potentially add between $46.05 billion and $104.92 billion to the losses in 2100.
- Modelling that focused solely on 3.8 million existing residential and commercial properties showed that by 2100 more than 151,000 properties are under 'high risk' of damage from sea level rise and storm surge, and more than 333,000 properties will be exposed to at least some damage. The losses are projected to force a correction to the total market value of the property portfolio in Victoria which would result in a 3.7% loss by 2100.
- There is a need for updating climate risk and hazard data continuously, raising community awareness of coastal inundation, and for a review of local planning and development guidelines, potentially extending them to ensure that future development of at-risk areas is either avoided or adapted (where possible) to accommodate bay and coastal sea level rise and storm surge.

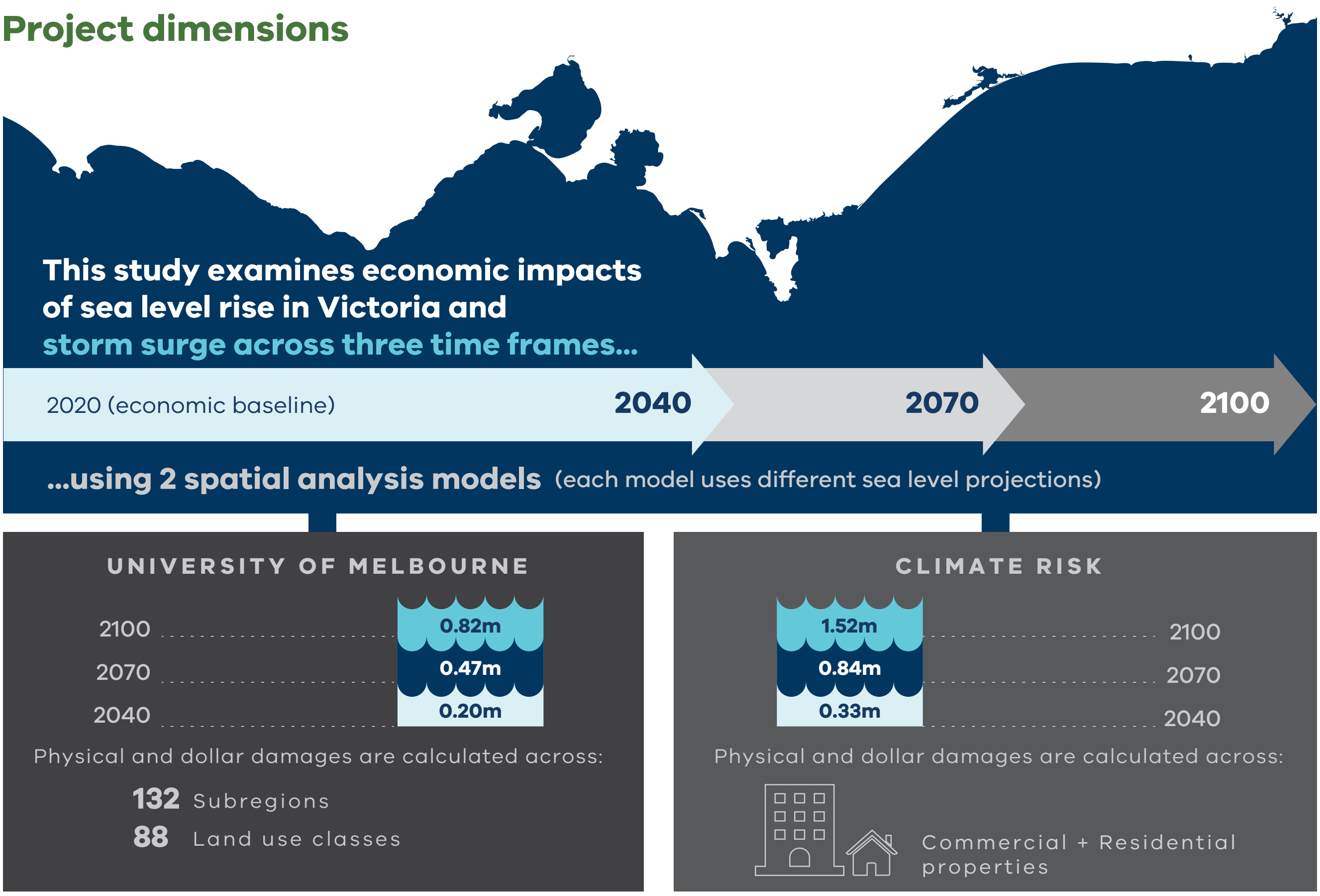
In response to the Kompas report:

VMaCC and LSV have called for the establishment of an independent taskforce to develop and promote a vision and operational blueprint to guide Victoria's response to rising sea levels and related storm surge.

The impacts of sea level rise and storm surge include exacerbation of natural coastal processes, for example, inundation and erosion, which can lead to loss of agricultural lands, parks, outdoor areas and coastal reserves. Intrusion of salt water can also harm coastal ecosystems, species and water resources, and can cause physical damage to houses, commercial buildings, factories, farms, roads, railways, bridges, electricity and communication networks, water infrastructure, public facilities, beaches and parks.

The following sets out the significant conclusions of the report titled *Economic Impacts from Sea Level Rise and Storm Surge in Victoria, Australia over the 21st Century* (the Kompas report). The Kompas report was prepared by a group of expert environmental economists from the University of Melbourne, the Australian National University, and the University of Tasmania together with Sydney environmental consultants Climate Risk Pty Ltd. The research team was led by Professor Tom Kompas of the University of Melbourne. The work involved using advanced computer models developed at the University of Melbourne (UoM) and by Climate Risk Pty Ltd (CR).

Project dimensions



Case studies further explore the nature of the damage.

By 2100, if action along Victoria's 2500 km coastline has been inadequate to adapt to inundation arising from sea level rise and accompanying storm surge, the Kompas report estimates the state could accumulate total economic damage to public infrastructure and residential and commercial assets of more than $337 billion (in present-day dollars). This amounts to about 2.7% of the estimated cumulative gross state product (GSP), that is, the total value of goods produced and services provided by Victoria. Further work shows there would be additional accumulated costs of up to $104 billion in damage to wetlands.

The Kompas report also shows that the cost to the economy will not come in one lump sum; instead, the cost of damage will accrue over time. So, the report provides estimates of how costs will increase annually, on average, until 2100 by which time the economic loss each year is estimated at more than $23 billion.

The costs of damage in 2070 are four times larger than 2040, and in 2100 nearly 10 times larger than in 2040. Further, these costs will be spread unevenly across the state. Section 5 of this Summary report, including Table 5 and Figure 3, provides further information.

The University of Melbourne and Climate Risk used different modelling approaches to examine the problem. These approaches are discussed in more detail in Section 3 of this Summary report. In brief, both modelling approaches were used to:

- project the 40 local coastal communities that will be most impacted economically (UoM) and with the greatest number of high-risk properties (CR) in 2040, 2070 and 2100.
- undertake different case studies that focused on the cost of impact and the economic benefit of adaptation measures in local representative areas.

Specifically, the UoM modelling focuses on 88 land use classes in 132 local coastal areas. The outcomes estimate that by 2100 more than 80,000 (currently) existing residential, commercial and industrial properties across more than 45,000 hectares will have been impacted by sea level rise and storm surge. There are also estimated economic damages to vacant residential and commercial land. In addition, more than 144,000 hectares of reserves (about 4.2% of the current parks) and 288,000 hectares of wetlands will also be impacted. Figures 1 and 2 below are based on the DELWP data used to inform the UoM modelling and demonstrate selected coastal area examples of the predicted extent of impact from sea level rise and storm surge in 2100.

Whilst the modelling approaches have a common focus on the years 2040, 2070 and 2100, the CR model concentrates solely on impacts on the built environment through sea level rise and storm surge across those same years. Another difference is the use, by CR, of sea level rise projections that increase to 1.52 m by 2100 (based on Haigh et al (2014) [1]) with additional associated storm surge. Whereas the UoM model takes its sea level rise projections from the Department of Environment, Land, Water and Planning data.

> Drawing on the Kompas Report, VMaCC believes that spending on adaptation over the next two decades could help mitigate future risk and save significantly on the estimates of future costs.

Figure 1 : Sea level rise and storm surge in example/selected coastal areas in 2100

(a) Zone 7: South Gippsland **(b) Zone 8:** Eastern Victoria

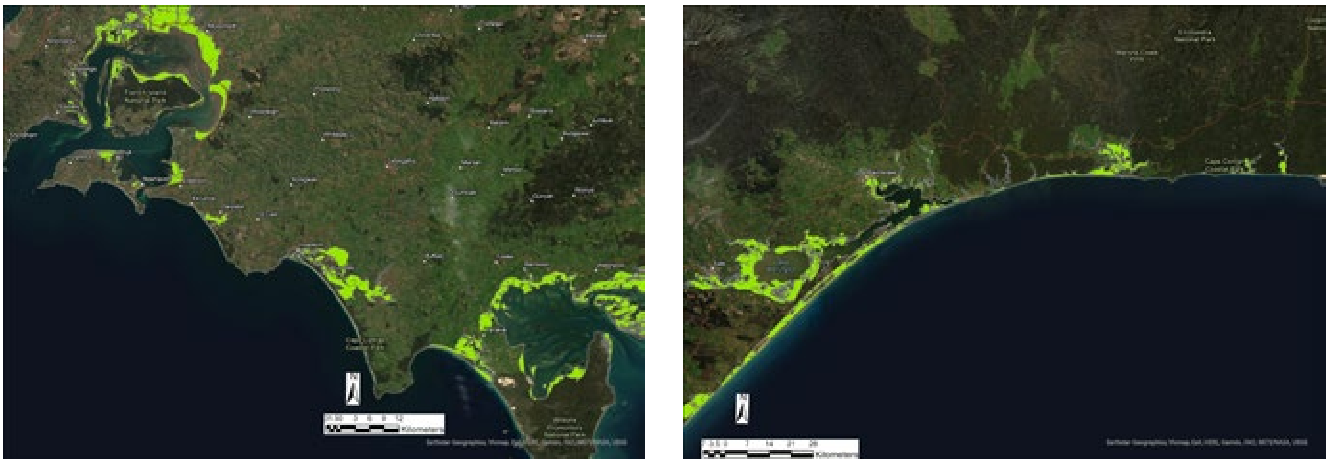


Figure 2 : Sea level rise and storm surge in example/selected coastal areas in 2100

(a) Zone 1: Western Victoria **(b) Zone 3:** West of Melbourne

Source: Department of Environment, Water, Land and Planning (2020) as cited for Figures 1 and 2 in the Kompas report.
Note: Scale varies.

The CR modelling estimates show that more than 333,000 out of 3.8 million current residential and commercial properties will be damaged by 2100; with over 151,000 of those properties having a high risk of damage. It also shows that through this time there would be a loss of about 3.7% of the value of the property portfolio for Victoria.

The researchers state that, in general, the assumptions used to reach their conclusions are conservative, meaning the Kompas report is likely to provide underestimates of the economic cost, physical damage and extent of land area affected.

Based on its findings, the Kompas report puts forward three broad recommendations:

- Update climate risk and hazard data continuously
- Raise community awareness of coastal inundation
- Amend planning and development guidelines to provide for sea level rise and storm surge in Victoria.

The Kompas report does not consider the cost of losing heritage properties or irreplaceable assets of traditional and cultural value. Nor does it allow for the costs of erosion in situations triggered by sea level rise and storm surge. A further case study on the economic impact of erosion is being considered. This would assist the understanding of future economic impacts for all of Victoria's coastal areas, including those areas (e.g., Inverloch and Skenes Creek) where existing coastal process impacts may be exacerbated.

2. Context – why was the Kompas report commissioned?

The Victorian Marine and Coastal Council (VMaCC) is the State Government's independent advisory body on marine and coastal matters; established under Victoria's *Marine and Coastal Act 2018* to provide independent advice to the Minister for Environment. Life Saving Victoria (LSV) is Victoria's peak organisation for water safety and is recognised as such by the Victorian Government.

The Victorian Government, through legislation and the work of its departments, such as the Department of Energy, Environment and Climate Action (DEECA), and statutory bodies, is already responding to the impacts of projected sea level rise and accompanying storm surge.

A particular need was identified to understand the economic impacts of sea level rise and storm surge, and the potential for savings to be made by early intervention. VMaCC, with support from LSV, engaged Professor Tom Kompas to prepare a report on these matters. The intent of the research was not necessarily to consider all future uncertainties, propose remedies or make detailed recommendations, but to provide a basis for discussion about the costs of inadequate action along with economic data to use in future business cases.

3. Modelling

To assess the economic impacts of sea level rise and storm surge, the Kompas report uses two detailed models that look at the problem from different perspectives – one was developed at the University of Melbourne in conjunction with researchers at the Australian National University and the University of Tasmania, and the other was developed in-house by Climate Risk Pty Ltd.

The modelling approaches used to assess the potential economic damages are summarised in Table 1 (see below) and the modelling approaches used for the adaptation examples are summarised in Table 2 (see below).

Table 1 : The economic damage assessment approaches

University of Melbourne model	Climate Risk Pty Ltd model
Draws upon spatial data assembled by the Department of Environment, Land, Water and Planning (DELWP) as to the extent of inundation from projected sea level rise (increasing to 0.82 m above pre-industrial levels by 2100) and storm surge (increasing to 19% above sea level by 2100). The projected sea level rises are 0.2m in 2040, 0.47m in 2070 and 0.82m in 2100 with additional storm surge increases of 6%, 13% and 19% respectively.	Uses sea level rise projections that, from a baseline of 0.00m in 1990, increase to 0.33m in 2040, 0.84m in 2070 and 1.52m by 2100.
Estimates the economic cost of the impact of sea level rise and storm surge in 132 coastal areas across 88 land use classifications, such as detached houses, schools, quarries or reserves (and including the impact on vacant land). Each coastal area – an Australian Bureau of Statistics statistical area level 2 – is deemed an economically interactive community of between 3,000 and 25,000 people. They are spread across 23 local government areas.	Concentrates solely on the economic impact to the residential and commercial built environment. It includes no estimate of the cost of inundation of vacant or agricultural land or public open space, such as recreational areas.
Assumes an average annual growth in land and asset values in line with GSP – about 2% a year – and a weighted 50% economic loss for assets and land values that are inundated.	Uses hazard data and climate change projections to identify and calculate the risk of inundation to 3.8 million existing residential and commercial properties across Victoria.
Estimates the cost of the impacts from sea level rise and storm surge (in non-market values) to the 288,000 hectares of wetlands along the coast predicted to be affected.	Estimates the potential annual costs of damage and loss of financial value of residential and commercial assets; with the estimates made based on current property values. The replacement cost of a building is based solely on a 'Simple House archetype' and fixed at $320,000 for each house of which the market value is also fixed at $740,000. The CR modelling also adjusts values to reflect a 'Climate Adjusted Value' (CAV). In comparison to the UoM modelling, however, there is no attempt to estimate changes in those values over time in line with increase in GSP.

Table 2 : The different adaptation case study approaches

University of Melbourne model	Climate Risk Pty Ltd model
Uses a preliminary study to estimate the potential role of mangroves in alleviating impacts in the areas of Barwon Heads, Williamstown, Hastings, Phillip Island, and Stony Point.	Studies the economic impact on the built environment and infrastructure in the areas of the Bellarine Peninsula, Williamstown, Hastings, Phillip Island and Wyndham.
Based on work by Strain et al. [2], comparisons were made between the cost effectiveness of mangroves and artificial barriers such as rock groynes and seawalls.	Two approaches: **1.** Critical infrastructure assets (as defined by Climate Risk Pty Ltd[2]: for example, schools, telecommunications facilities, police stations) analysed for coastal inundation risk and 'Maximum-to-Date Valuation-at-Risk %'. **2.** The approximate economic cost of adaptation was compared with that of no adaptation for high-risk properties. Hypothetical actions of adaptation to 1, 2, 3 and 4 metres were used, noting that each elevation is a proxy for different measures.
The model assumed that mangroves and rock revetments provided full protection in these specific areas.	The model does not identify how adaptation can be achieved.

The Kompas report explains that the two approaches were designed differently; however, focusing on the economic costs, the modelling allows for comparisons when the 2100 figures for the UoM model (0.82m rise) and the CR model figures for 2070 (0.84 m rise) are considered. Comparisons can also be considered when restricting the coverage of the UoM model to land uses involving residential and commercial properties and infrastructure.

A significant difference between the two models, however, is in the estimates they use for sea level rise. The 0.82m by 2100 figure used by UoM, and based on DELWP data, is based on projections published in 2014 by the UN's Intergovernmental Panel on Climate Change (IPCC). More recent projections published in the past few years, including in the IPCC's Special Report on the Ocean and the Cryosphere in a Changing Climate (2019) [3], give values of more than 1m of sea level rise, which means the levels of inundation predicted by the UoM model are conservative. Whilst the CR model is based on sea level projections of up to 1.52m by 2100 from Haigh et al (2014) [1], similar projections for Victoria, of at least 1.5m by 2100, are discussed by Kirezci et al. (2020) [4], and Tebaldi et al. (2021) [5]. These sea level rises are based on the RCP 8.5 projections [4].

The results from the UoM modelling are reported for 2040, 2070 and 2100 in present-day dollar values using a discount rate of 5% and also in future dollars without a discount rate (see Tables 3 and 4 below).

2 The term "critical infrastructure", as used in the Kompas Report (p.51), covers power infrastructure such as electricity substations and telecommunications towers; emergency infrastructure such as police, fire and ambulance stations as well as hospitals; and includes education facilities (primary, secondary and tertiary).

Discount rate

A discount rate is a device routinely employed by economists projecting into the future to put comparisons onto a common footing. The rate compensates for the fact that for many human activities, such as investing in buildings or infrastructure, money paid today will be worth more than in the future, because of inflation and the fact that assets tend to appreciate. In this report, however, the discount rate approach is somewhat contentious because of environmental considerations. For instance, the worth of mangroves or wetlands, which supply economic and environmental services such as carbon sequestration, flood control, wave attenuation and prevention of erosion, is difficult to value. Hence, the reporting of results with both a relatively low discount rate and with no discount rate. The Kompas report authors have consistently applied a 5% discount rate as it is the more conservative approach and enables comparison.

Table 3 : A comparative summary of cumulative economic damages for sea-level rise and storm surge (SLR/S) in Victoria with a 5% discount rate and assumed growth in gross state product (GSP) and land/asset values for 2040, 2070 and 2100. (The average % loss is the ratio of the cumulative (or total) Present Value (PV) of SLR/S costs to cumulative GSP in Victoria).

Year	Total PV or SLR/S Costs $billion	Total GSP VIC $billion	Loss from SLR/S as % of GSP
2040	122.78	7,082.47	1.73
2070	237.40	11,524.27	2.06
2100	337.82	12,597.70	2.68

Source: Table 10, Kompas report

Table 4 : Estimated damages from sea-level rise and storm surge (% of gross state product (GSP)) in 2040, 2070 and 2100 in Victoria as average per year losses (from 2020), with average GSP for current (non-discounted) dollar values and assumed growth in land/asset values and GSP.

Year	SLR/S Costs (avg/yr) $billion	GSP VIC (avg/yr) $billion	Loss from SLR/S as % of GSP
2040	9.44	547.69	1.73
2070	14.77	718.06	2.06
2100	23.66	883.24	2.68

Source: Table 11, Kompas report

The results from the CR modelling include application of a 'Climate Adjusted Value' (CAV). The CAV is applied to reflect an adjusted market value for the 'representative property; specifically due to the increased costs of insurance associated with climate change. Climate Risk states that the increased insurance costs will negatively affect the capacity for mortgage repayments and that the CAV is used to calculate the resulting reduced loan values for residential and commercial properties.

Both the UoM and CR models allow researchers to demonstrate different aspects of the consequences of sea level rise, such as which areas, or what land classes, will be most severely impacted over time.

For each of the models, the Kompas report provides a list in order of the 40 most impacted suburbs and local regions for 2040, 2070 and 2100. In the UoM ranking, the report suggests that these regions account for roughly 78% of the projected economic losses for the State.

4. Limitations of the work

The most obvious limitation of the modelling in the Kompas report is the use of the 2014 IPCC estimates of sea level rise in the UoM model. In 2019, the IPCC increased its prediction of sea level rise in 2100 from 0.82m to more than 1m [3]. Together with an additional 19% storm surge level, this will add significantly to the level of inundation the coast will experience.

Another limitation is the difficulty of estimating with any certainty the future values of residential, commercial, industrial and agricultural land and property, and particularly how the risk of, and exposure to, coastal inundation will impact those values. Future property values and losses will vary greatly in different regions. They may also vary according to whether land is likely to suffer permanent inundation or is simply subject to occasional storm surge.

The Kompas report concludes that further work needs to be undertaken to improve the accuracy of estimating the cost of damage to parks and reserves, and the value of wetlands, and other 'undeveloped' land. Such work should help to answer the question of whether 5% is an appropriate discount rate or if this should be a lower value.

There are many other inherent uncertainties in predicting future costs of the impacts of sea level rise and storm surge. These include factors associated with planning policy, building regulation requirements, engineering requirements, the management of environmental impacts, and decision-making around land use and development at all levels of government.

Importantly, as acknowledged earlier, the Kompas report does not include any analysis of the economic cost of impacts to heritage, Traditional Owner values or cultural properties, sites or infrastructure. This gap in accounting for these important assets offers an opportunity for further work.

5. Discussion

Global warming causes an increase in the level of oceans in two distinct ways, freshwater runoff from the melting of land-based glaciers and ice caps, and thermal expansion of water as it heats. The latest CSIRO measurements, as reported in the Bureau of Meteorology's State of the Climate 2020 [6], put the average rate of sea level increase globally at about 3.5 mm a year. The BoM report shows that along the Victorian coast, the figure varies from below that rate in the west to well above in the east. A higher sea level, combined with potential changes to the frequency and intensity of storms, may lead to increased inundation by storm-driven surges.

The Kompas report estimates that the consolidated state-wide cost of the impact of sea level rise and associated storm surge in 2100, if nothing is done in terms of adaptation, could total more than $337 billion in present (discounted) dollars or about 2.7% of the projected GSP (see Table 5 and Figure 3 below). The report puts the average annual cost of sea level rise and storm surge in 2100 at more than $23 billion, and the 2.7% fall in projected GSP is nearly half of the cost to Victoria of the COVID pandemic in 2020 [7]. Further, the modelling estimates an accumulated cost of up to $104 billion in damage to wetlands, with consequent losses to ecosystem services. When economic costs such as these discussed in the Kompas report are considered, the potential constraints on expenditure in other economic areas should also be considered.

The potential economic cost, the Kompas report says,

> '...is more than enough to trigger severe financial instability for many coastal communities and the State of Victoria itself....'

Table 5 : Present (discounted) values due to sea-level rise and storm surge damages in 2100 by land use class and region of Victoria (in $ million). Modelled with a 5% discount rate with growth in asset values ($ million). Note the total values of all damages.

		Land Use Category										
		LU1	LU2	LU3	LU4	LU5	LU6	LU7	LU8	LU9	LU10	
		Residential	Commercial	Industrial	Quarry	Farming	Utility	Social	Parks	Reserves	Other	
Region		2100										Sum
1	Western Victoria	5,490	158	242		5,274	798	92	1,123	10,208	216	**23,601**
2	Geelong	5,353	445	1,604	1,032	3,296	6,179	454	144	6,795	342	**25,645***
3	West of Melbourne	2,310	165	5,288		193	4,000	1,167	135	71,475	746	**85,481**
4	Melbourne	830	46,678	4,237			1,407	1,242	19	1,299	6,814	**62,526**
5	Port Phillip	36,815	1,025	301			59	235	4	59	460	**38,957**
6	East of Melbourne	31,490	408	944		4,816	1,940	689	272	2,119	470	**43,147**
7	South Gippsland	3,465	105	215		4,354	279	37	4	29,585	352	**38,395***
8	Eastern Victoria	9,107	102	9		1,301	733	93	53	8,541	127	**20,066**
	Total	**94,859***	**49,085**	**12,841**	**1032**	**19,234**	**15,395**	**4,009**	**1,754**	**130,081**	**9,527**	**337,819**

Source: Table 6, Kompas report.

Notes to Table 5 above:

The above information is extracted from Table 6 of the Kompas report with figures rounded to reflect the Table 6 Totals – see Table 6 for the complete set of 2040, 2070 and 2100 figures. See Table 2 in the Kompas report for the multiple land use classification definitions (note that 'Reserves' does not include wetlands).

* Figure/s adjusted to account for any rounding errors and ensure 'Sum' and 'Total' figures are consistent with the precise figures in Table 6 of the Kompas report.

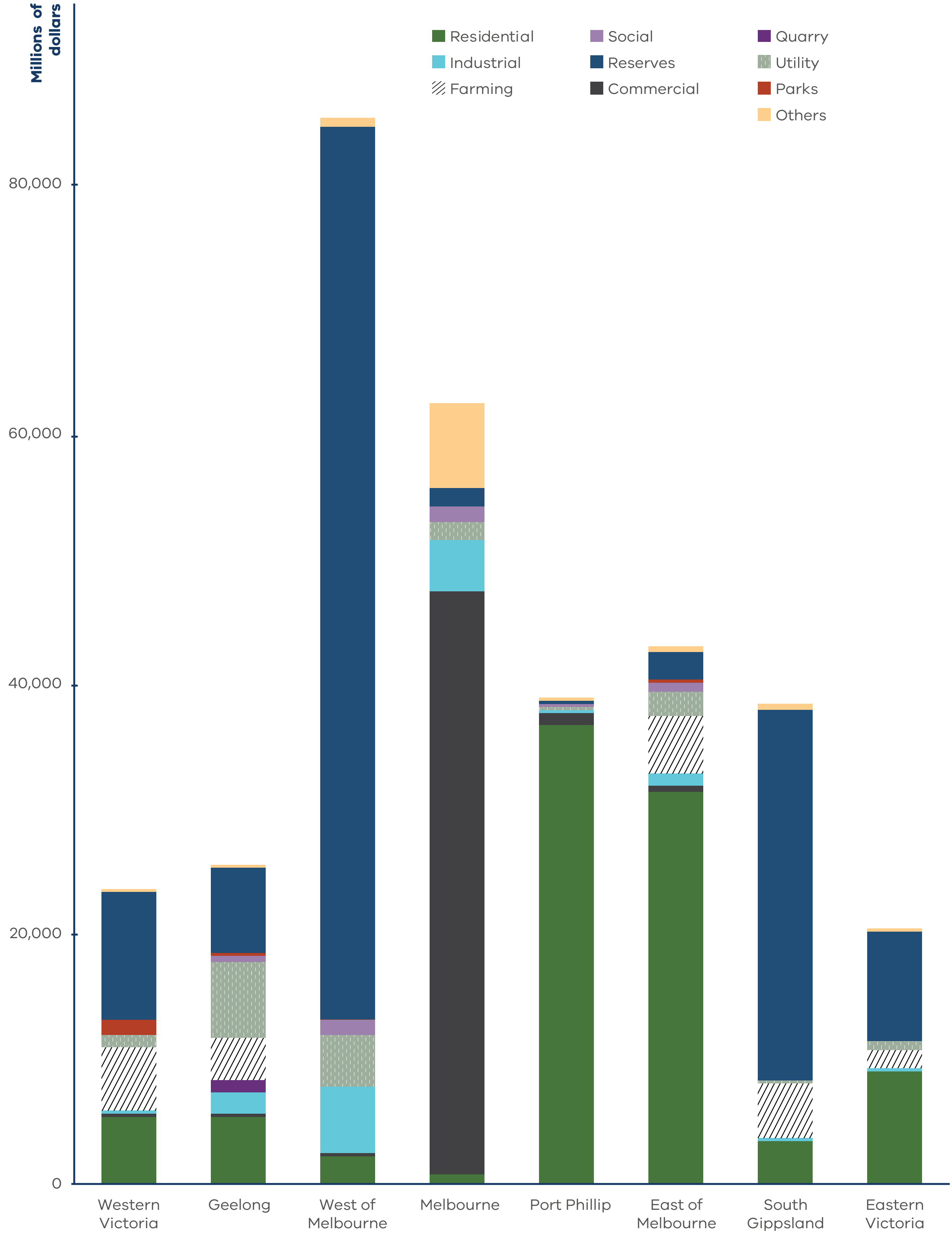


Figure 3: Extent of damage among different land use classes in different regions of the Victorian coast in 2100 due to sea-level rise and storm surge in 2100 (in $ millions). Modelled with a 5% discount rate with growth in assets.

Source: information based on Table 6, Kompas Report.

The consequences of sea level rise and storm surge will affect the majority of Victorians – be it through saltwater intrusion into farmland, building foundations or water supplies; physical damage to property; or detrimental changes to a favourite recreational area. According to the Australian Bureau of Statistics (ABS) more than 80% of Victorians live within 50 km of the coast. The *Wave 5 Marine and Coastal Community Attitudes & Behaviour Report* [8] found that more than three-quarters of Victorians visit the coast to walk or swim at least once a year, and about half of these people visit more than five times a year. Their experiences of the coast will change.

Areas all along Victoria's more than 2500 km of coastline will be affected, though the level and type of impact will vary. To provide an idea of what this means in practical terms, the UoM analysis shows that damage to reserves and conservation areas (for example, foreshores and national parks) will be significant to the west of Melbourne, around Geelong and in South Gippsland, whereas the residential land will be most affected around Port Phillip Bay, and there will be significant commercial area damages in Docklands and Southbank.

By 2100, the UoM model (see Table 1 earlier in this Summary report) estimates more than 80,000 (currently) existing residential, commercial and industrial properties on more than 45,000 hectares across the state will be impacted by inundation. Damages to vacant residential and commercial land are also estimated. In addition, more than 144,000 hectares of reserves or 4.2% of current parks, as well as 288,000 hectares of wetlands will be affected.

The cumulative cost estimate in the Kompas report is more than $337 billion by 2100 (see Table 5 and Figure 3 above). This includes not only private buildings and land, but also beaches, coastal reserves, public open space and the assets, such as life saving clubs and boat ramps, that support the activities for which this public land is used.

The UoM model also provides a cumulative estimate of $104 billion by 2100 as the cost of impact on the natural environment, particularly wetlands. Wetlands provide significant ecosystem services including retention of nutrients, prevention of erosion, maintenance of biodiversity and recreational opportunities. [9]

The CR model (see Table 1 earlier in this Summary report) considers only the built environment and uses a state-wide average market value for all residential properties of $740,000 and an average replacement value of $320,000. With the 'Climate Adjusted Value' applied, the Kompas report suggests that the economic loss due to inundation of a Victorian property portfolio worth $2.9 trillion in 2021 will be about $104 billion by 2100 (assuming no increase in asset values over time). This loss is about 3.7% of the value of the property portfolio for Victoria.

The CR model estimates that by 2100 without action on adaptation 333,470 of the existing 3.8 million properties on the coast would be impacted by inundation in some way, with more than 151,000 (about one in 25) of these properties at a high risk of damage.

The Kompas report provides at least three reasons for the differences in the dollar value of losses between the two models, including:

1. The CR model uses average property values across the state; whereas the UoM model draws on local valuations, which vary dramatically and assumes an increase in asset value and land prices of about 2% annually, in line with the growth in GSP.
2. The UoM model does not focus solely on replacing existing buildings but also estimates losses across a much broader set of 88 land use categories, including vacant land. The CR model does not consider vacant land at all.
3. The CR model assumes no increase in asset values or land prices over time.

As discussed above, the Kompas report explains that the modelling outcomes can be compared for specific approaches, for example, by matching the 2100 figures for the UoM model (0.82m rise) with the CR model 2070 figures (0.84m rise). Restricting the coverage of the UoM model to land uses involving residential and commercial properties and infrastructure also allows for comparison. When the comparisons are made, the two models come up with roughly equivalent figures.

The models allow the demonstration of several aspects of the impact of inundation from sea level rise, such as which areas will be most impacted over time. For each model, the Kompas report provides a list of the top 40 suburbs and local regions in order of economic impact for 2040, 2070 and 2100.

Under the UoM model the top 40 are ranked with respect to cost to the local economy. This model estimates that in 2100 the top 40 local regions will account for about 78% of the total bill. There is great variability in the contribution of various categories of land use to the cost. At the top of the list is the Werribee – Point Cook subregion where a major cost is due to inundation of parks and reserves. Next comes Docklands where the major contributor is damage to commercial interests and then Foster in South Gippsland where reserves also figure, along with farming and residential areas.

In general, economic damage ($ values) to reserves will be considerable; amounting to approximately 40% of the economic cost in 2100. The areas where reserves will be most impacted are Geelong, South Gippsland and West of Melbourne. In terms of residential properties, the most economic damage is sustained around Port Phillip Bay and east of Melbourne. The greatest economic losses for commercial and industrial land will be experienced west of Melbourne and in Melbourne itself. There will be agricultural losses across all coastal areas of the state outside of the Melbourne metropolitan area.

In the CR model, the focus is solely on property loss. The modelling showed that, in general, the proportion of properties at risk of inundation state-wide increases over time, but that in local areas the economic cost of that risk is driven by a small subset of properties at high risk of greatest impact by inundation. The top 10 areas of the CR top 40 in 2100, containing the greatest number of these high-risk properties, are all grouped around Port Phillip Bay. And the top three areas are the inner Melbourne suburbs of Southbank, Docklands and Port Melbourne. They make a large contribution to the economic cost because of the high density of development in low-lying areas.

The Kompas report also includes use of the CR model on the impacts of sea level rise and storm surge and the use of adaptation in response. For one of the CR case study approaches, the economic risk to an area's critical infrastructure was analysed (see Table 2 earlier in this Summary report). As an example, the CR analysis found that by 2100 in Williamstown, if no adaption action is taken to manage the consequences of inundation, nearly 2500 properties, a primary school, two police stations and two telecommunications towers are likely to be impacted. In contrast, no critical infrastructure, and only about 700 properties, would be affected in Hastings.

The Kompas report also shows that there could be significant opportunities for a better economic outcome by employing the appropriate measures of adaptation. The CR case study analysis provides further examples of how economic costs resulting from coastal inundation can be reduced when hypothetical adaptation actions are applied (for example, 1,2,3 and 4m elevations (as proxy), see Table 2 above). In these case study examples, the report suggests that the risk of damage and economic impact could be reduced by means of adaptation measures, with the 3m and 4m elevations resulting in the most significant reductions. Importantly, the report notes the need for further consideration to be given to any appropriate adaptation pathways, particularly in the context of regulatory requirements for the use and development of coastal land.

The UoM discusses the use of mangroves as another example of a potential adaptation measure (see Table 2 above). Mangroves can form natural barriers which can provide wave attenuation to protect against the impacts of inundation. The Kompas report, in discussing the work by Strain *et al* (2022) [2], found that, on average, for the same or better efficiency of wave attenuation, the cost of planting mangroves was significantly cheaper than building artificial rock barriers. But it also cautioned that further work into the details of how best to plant or restore mangroves is warranted. This study suggested that natural habitats, such as mangroves, although demanding greater time and land area to set in place, could provide less expensive and more effective protection against storm surge than artificial groynes or sea walls.

The Kompas report argues that while natural barriers can be a possible solution, some circumstances, however, may demand artificial barriers. It suggests that any decision support frameworks deciding such coastal management issues need to consider natural barriers as part of any adaptation response.

The considerable impact and potentially significant economic losses due to coastal erosion as a result sea level rise, and particularly storm surge, were not considered. A further case study on the economic impact of erosion is being considered.

The Kompas report made three broad recommendations based on the analysis:

1. Update climate risk and hazard data continuously
2. Raise community awareness of coastal inundation, especially in at-risk regions
3. Amend planning and development guidelines to avoid, design for or accommodate the increasing risk of inundation as result of sea level rise and storm surge.

Image Credit: *Andrew Bray*

6. Victorian Government activity

The Victorian Government has a range of adaptation initiatives either in place or in preparation to respond to sea level rise and storm surge.

Both the *Marine and Coastal Act 2018* and the Marine and Coastal Policy (DELWP, 2020) include a focus on working with natural processes to build the resilience of the coast to the impacts of climate change. This includes managing the risks of climate change for buildings, infrastructure, public spaces and the natural environment.

The *Marine and Coastal Act 2018* also aligns with other Victorian legislation and tools developed for planning and managing the risks of climate change in marine and coastal areas. These include the *Climate Change Act 2017* and the *Planning and Environment Act 1987*, and their respective tools – the Climate Change Adaptation Action Plans and the Victoria Planning Provisions.

Under Victoria's *Marine and Coastal Act 2018*, DELWP recently released *Victoria's Marine and Coastal Strategy* (DELWP, May 2022) which will:

- enable Traditional Owners to fully integrate cultural values, uses and practices in the healing and ongoing management of Country
- build the foundations for long-term climate adaptation and environmental protection in Victoria's marine and coastal environment
- improve integration and coordination across governments, industries, and communities when planning and managing marine and coastal areas
- build the skills and capability of Traditional Owners, communities, managers, and governments to effectively plan and manage for a healthy and resilient marine and coastal environment.

The Strategy says it will do so through six actions:

Action 1: Supporting Traditional Owners to embed their rights and obligations into planning and management of the marine and coastal environment.

Action 2: Improving the condition and ecological connectivity of habitats and respecting and caring for marine and coastal areas.

Action 3: Adapting to impacts of climate change.

Action 4: Supporting sustainable use and development of the marine and coastal environment.

Action 5: Implementing the Marine Spatial Planning Framework to integrate long-term planning for different uses in the marine environment.

Action 6: Identifying the resource needs and funding for sustainable marine and coastal management.

The Strategy also supports community consultation, communication and discussion about the significance of the ongoing changes along the coast, the increased impacts of storm surge as sea levels rise, and the challenges and opportunities that climate change will bring. The aim is to help people understand the risks and feel confident in making decisions about where they can live, work, play and invest.

The Strategy is part of an ongoing process that will assist Victoria's response to the latest scientific projections and modelling of climate change and sea level rise. This includes understanding global sea level rise projections at a Victorian scale.

Further, to help local government and communities to adapt to climate change along the coast, DEECA has developed a framework, guidelines and support mechanisms to coordinate adaptation planning state-wide. This program is entitled Victoria's Resilient Coast – Adapting for 2100+.

The *Climate Change Act 2017* also supports marine and coastal programs through the development of Adaptation Action Plans to target the specific needs of the built environment, the natural environment, education, health, agriculture, transport and water. The first set of these action plans was launched on 10 February 2022.

There are many other state-wide and regional projects and strategies which target or include specific aspects of adaptation to sea level rise and storm surge. One project example, the Victorian Coastal Monitoring Program, monitors current shoreline changes; another updates the science on erosion, inundation and saline intrusion around Port Phillip Bay. As another strategy example, flood management strategies are also prepared by catchment management authorities for the Victorian coast. These are periodically updated to reflect changing inundation predictions.

7. VMaCC and LSV recommendations

In considering a response to the Kompas report, the Victorian Marine and Coastal Council (VMaCC) and Life Saving Victoria (LSV) support its general recommendations and propose some important next steps. These additional recommendations recognise:

- the actions commenced by the Victorian Government to respond to sea level rise and storm surge (including inundation) through, for example, funding to implement Victoria's *Marine and Coastal Strategy 2022*, and the ongoing development of sector-based climate change adaptation action plans
- that extensive infrastructure (roads, water treatment plants, ports) supporting the economic viability of Greater Melbourne, Greater Geelong, Portland and the Gippsland Lakes region is located on the coast
- the majority of Victoria's most expensive real estate (per hectare) is on the coast; and that
- the Victorian coast is the preferred tourism destination for most Victorians and visitors.

While the newly released *Marine and Coastal Strategy 2022* has received important initial funding, VMaCC and LSV note that a realistic and appropriate level of ongoing funding needs to be provided to implement the actions proposed in the Strategy. We also note that future strategies can use the funding outcomes of the taskforce proposed in Recommendation 1 as an input.

Recommendation 1.

An independent taskforce or commission with investigative and determinative powers be established to develop and promote a vision for, and operational blueprint to guide, Victoria's response to the economy-wide consequences of rising sea levels and related storm surge.

VMaCC and LSV have given thought to the potential scope of such a taskforce, and how it could complement the actions of Victoria's *Marine and Coastal Strategy* (2022) (Strategy). We offer the following reflections but understand that it is for government to define the scope and operations of such a taskforce. We have highlighted areas of alignment with the actions outlined in the Strategy. The purpose of an independent taskforce would be to produce a multi-decadal blueprint for Victoria's response to sea level rise and storm surge that considers the potentially conflicting needs of stakeholders and rights-holders.

This blueprint could do the following:

a. Review the current planning approaches and instruments used by government agencies (national, state and local) and by non-government entities with a view to the integration and co-ordination of responses to sea level rise and storm surge, including a focus on economic efficiencies (complements Strategy Actions 4 and 6).

b. Seek world's best practice for adaptation to rising sea levels and storm surge with a view to the improvement and implementation of these practices in Victoria (complements Strategy Action 3). This would include interventions consistent with the adaptation hierarchy outlined in Victoria's *Marine and Coastal Policy*.

c. Identify and disseminate information on the adaptation measures required to address the potential loss of cultural values and heritage, public spaces (including parks and reserves), public infrastructure (including roads, provision of potable water, and management of sewage and stormwater), emergency services (including lifesaving clubs) and recreational services (including yacht clubs, boat ramps, moorings, and berths), and marine and coastal species and habitats (complements Strategy Actions 1 and 3).

d. Identify and disseminate innovative, adaptive and resilient coastal design for buildings and private infrastructure (complements Strategy Actions 3 and 4).

e. Support the establishment of a process to be determined and driven by Traditional Owners, which allows them to address the loss of cultural values and Country within Victoria's marine and coastal environment, and to develop ways to adapt (complements Strategy Action 1).

f. Assess the effect that sea level rise and storm surge will have on coastal stakeholders (building on the Kompas report and the initial outcomes of the Victorian Government Department of Energy, Environment and Climate Action's project on coastal hazard risk management and adaptation titled Victoria's Resilient Coast – Adapting for 2100+), informed by studies on the environmental, tourism, commercial, recreational, social and cultural value of all these places to humans and wildlife (complements Strategy Actions 3 and 4).

g. Create a framework for the investment fund proposed in Recommendation 2 for the replacement of public land and amenity lost to rising sea level and storm surge.

It is recommended that:

- Members of the taskforce should include eminent Victorians and independent experts.
- The taskforce should operate with appropriate administrative support for a short, targeted period (for example, 18 to 24 months).

Recommendation 2.
A Victorian Coastal Adaptation Future Investment Fund be established to enable investment in future adaptation actions to sea level rise, storm surge and associated impacts on coastal environments and processes.

VMaCC and LSV recognise that a key action (Action 6) of Victoria's *Marine and Coastal Strategy 2022* is to assess the financing of coastal adaptation programs. The outcomes of that project (and taskforce findings) should be used as an input to shaping the fund.

VMaCC and LSV have given thought to the fund and understand that it is for government to define its scope and operations. Modelled on the Australian Futures Fund, or similar investment driven vehicles, the fund would require early investment of a substantial amount of capital, building up to a large base by 2030. While noting that the final quantum is a decision for government, the size of the initial investments should consider the projected cost detailed in this report of the impact without adequate adaptation, as detailed in the Kompas Report.

Recommendation 3.
Raise community awareness of the implications of sea level rise and storm surge associated with climate change and normalise the community's understanding of the need for ongoing adaptation.

To support this recommendation, it is recommended that the findings of the Kompas Report be broadly communicated.

8. References

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