Article

Collaborative Design Strategies for Climate Change Adaptation

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ABSTRACT

This paper discusses the outcome of a collaborative design studio that aimed to investigate climate adaptation strategies for ten Bayside municipalities in Melbourne, Australia. The studio was part of a larger, 3-phase project titled Bay Blueprint 2070 in a partnership between the UN Global Compact Cities Programme and RMIT School of Architecture and Urban Design. The aim of the studio was to identify potential adaptation strategies for 10 municipality 'hotspots' vulnerable to increasing coastal and catchment flooding by working with local governments, the CSIRO, and key stakeholders. The studio adopted a research approach that focused on testing future scenarios for each of the hotspots. Four scenarios were identified, the first two based on representative concentration pathways (RCPs) 8.5 Extreme and Moderate RCP 4.5. The second two focused on differing approaches to adaptation. Using the 4 scenarios, students were asked to investigate potential adaptation strategies in their responses and to explain how they considered the economic, environmental and social dimensions of sustainability. These responses then were presented to key stakeholders for feedback. The final project outcomes provided a catalyst for conversations around what adaptation could look like and could be like into the future as an aid for decision making.

KEYWORDS: climate change adaptation; scenarios; design values; uncertainty; sustainability

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INTRODUCTION AND BACKGROUND

Climate change adaptation is understood in this paper as a process of reducing risk while at the same time considering the opportunities that may arise in the future as a result of a changing climate. One of the key challenges in adaptation planning is how to facilitate a shift away from the generalised language adopted at the global level towards strategies that are locally relevant or make sense at the local level [1]. Or, in other words, how can these global messages be translated to make them more locally meaningful for decision makers and communities? However, even at the local level future impacts are not necessarily 'visible' or predictable. Uncertainty around impacts and their distribution means that adaptation strategies can by no means be one off or final. As Maru and Stafford Smith [2] suggest, there are 'growing and urgent calls for research that is more relevant and useful for supporting diverse decision makers to develop, and make difficult choices between, alternative adaptation options given deep uncertainty, contested views, and scarce resources' and as a result 'there is an emerging realisation that adaptation is in fact a dynamic, long-term, transitory and transitional process that involves repeated decisions, better described as adaptation pathways'.

Use of the term adaptation pathways refers to a decision-oriented approach to unknown future possibilities and threats that aims to 'shift policy-making away from the ambition of attempting to achieve static, predefined outcomes' towards an approach that allows for change over time [3]. According to Bloemen et al. [4], 'features of the approach are that it takes into account multiple possible futures and that it foresees adjustments of plans as conditions change'. The focus is therefore on processes of decision-making that identify a sequence of possible specific actions both in the short term and the long term that can change as circumstances change [5]. The approach was first used in developing the Thames Estuary 2100 Plan [4,6–8] and in the Dutch Delta Programme on water safety and freshwater supply [9]. It since has been used elsewhere and as Bloemen et al [4] argue: Experience shows the adaptation pathways approach was effective in keeping decision processes going forward, to the final approval of a long-term plan. It helped increase awareness about uncertainties, offered visualization of multiple alternatives, provided political support for keeping long-term options open, and motivated decision-makers to modify their plans to better accommodate future conditions. By making transparent how short-term decisions can be related to long-term tasks, it motivated and facilitated policymakers, politicians, and other decision-makers to incorporate uncertainty about future conditions in their decisions and plans.

Adaptation planning is particularly pressing in a country like Australia where, as in most 'developed' countries, there is a general perception that climate change is a remote and distant future risk removed from personal experience and that even 'in areas that could be considered vulnerable to the effects of climate change, individuals have difficulties relating impacts of climate change to their local surroundings and their everyday life' [10].

This lack of awareness of the local impacts of climate change exists despite the fact that Australia's population is highly urbanised along the coastline and is highly exposed to future coastal climate impacts as well as high bushfire risk. The two largest metropoles, Melbourne and Sydney, have grown exponentially over the last decade and this growth is anticipated to accelerate over the next 25 years. As an example, Melbourne's population is currently 5.5 million and is anticipated to be 8 million by 2040. The resulting major developments in infrastructure to cater to this growing population need to be considered within the context of climate change, and how metropolitan cities evolve right now to build resilience will be critical to their liveability in coming decades.

Until recently, these things have not occurred. As noted in the Australian Government's National Climate Resilience and Adaptation Strategy 2015 [11], the Australian coastal zone has largely been developed with the expectation that the shoreline will remain stable, extreme events will occur within a range defined by historical experience, and sea levels will not change. This means that many coastal assets are vulnerable to future climate changes depending on their location and design.

The project described here aimed to identify climate adaptation strategies for the 10 cities around Port Phillip Bay in Melbourne, Australia. "Hotspots" were identified as areas already vulnerable to coastal and catchment inundation, where the physical and ecological effects of a changing climate would create increased local vulnerabilities. The challenges addressed in the studio were 3-fold:

1. To develop and to test a process of stakeholder consultation and decision-making based on future scenarios.
2. To identify adaptation strategies for 10 hotspots that captured both the existing socio-political-ecological context and each city's design visions.
3. To present these pathways and future scenarios to key local stakeholders and decision makers as part of their journey into understanding approaches to building local climate resilience.

The paper begins by introducing the case study site(s) before turning to a discussion of the process adopted and the outcomes of the project.

Climate Change Impacts: Port Phillip Bay

Port Phillip Bay is unique and possibly the largest embayment in the world. It is a relatively shallow bay covering approximately 1930 km^2 with 264 km of coastline. The Bay has a narrow 3 km-wide entrance to Bass Strait that limits tidal exchange. The ecology of the Bay has been extensively modified over the past 150+ years as a result of increasingly intensive human settlement. Significant channelisation, draining of low-lying areas, and modification to the many primary river and catchment systems that flow to the Bay has increased stormwater flows as well as nutrients and pollutants to the Bay.

These modifications, along with upstream development across Melbourne, also has made the 10 cities around the Bay (bottom of the catchment) more vulnerable to flood events, including coastal storms. Presently, these cities alone carry some 20% of Melbourne's population and have some of Melbourne's key built assets and amenities. They all have high visitor/tourist numbers and are destination precincts, with some of these cities recording annual visitors upward of 4–5 million. The Bay itself, its coastline paths, and parks are highly popular for recreational purposes.

Over the coming decades, these 10 municipalities around Port Phillip Bay will be impacted further by a range of pressures. The impacts and associated decisions will not be confined to council borders. By 2070 the Bay is projected to experience a sea level rise of 50 cm, more frequent extreme weather events, and increased erosion, reducing the availability, amenity and useability of the coast and coastal assets, as well as affecting the viability of natural ecosystems—'coastal squeeze' [12]. In addition, projections suggest that the Bay will be subject to increasing acidification and warming.

More broadly, the Victorian Government's 2014 Coastal Strategy [13] identified the following risks associated with climate change for coastal areas across the state.

- Loss of coastal Crown land and biodiversity.
- Cliff hazards.
- Damage to public buildings and structures.
- Infrastructure damage.
- Loss of private land and damage to private property.
- Damage to heritage places and values.

In response, the strategy contains the following directive: To plan for possible sea level rise of not less than 0.8 metres by 2100, and allow for the combined effects of tides, storm surges, coastal processes and local conditions such as topography and geology, when assessing risks and coastal impacts associated with climate change [13].

Across the state of Victoria, coastal settlements located in low-lying areas are already experiencing occasional inundation. In 2009, the Report Climate Change Risks to Australia's Coast [14] suggested that between 27,600 and 44,600 residential buildings in Victoria may face risk of inundation from sea level rise. The value of the residential buildings considered to be at risk was estimated to be between $6.5 and $10.3 billion. Around 70% of residential buildings at risk in Victoria are in the Cities of Kingston, Hobsons Bay, Greater Geelong, and Port Phillip; all in Port Phillip Bay.

The aim of the urban design studio outlined in this paper was to respond to all of these existing and potential impacts. Following Evans et al. [15], the studio adopted an approach that focused on developing and then testing future scenarios for each of the hotspots as a way to explore potential futures under a range of conditions. Four scenarios were identified; the first two focused on identified climate risks based on representative concentration pathways (RCPs) 8.5 Extreme and Moderate RCP 4.5 [16]. The second two focused on scenario modelling adaptation solutions to the two climate risk pathways, identified here as 'Ideal adaptation' and 'Limited adaptation'.

The terms 'ideal' and limited 'adaptation' were used to refer to the availability of resources rather than describing 'better' or 'worse' case scenarios. 'Ideal' adaptation denotes an approach with longer-term resilience in mind, more innovative solutions that sought to work with (rather than to fight against) the climate constraints, and adequate resources for implementation. The foregrounding of resources and their implications within these two pathways was particularly pertinent given that the audience for the design proposals included local and regional decision makers with quite conventional, business-as-usual approaches to urban form and infrastructure. Enabling a collaborative, stakeholder journey of awareness of the resilience opportunities, limitations, and risks through the use of 'ideal' versus 'limited' adaptation was a way of acknowledging and working with these concerns as they were raised.

The use of scenarios as an investigative and communication tool is commonplace in the field of climate science. According to the IPCC [16], A scenario is a coherent, internally consistent, and plausible description of a possible future state of the world. Scenarios commonly are required in climate change impact, adaptation, and vulnerability assessments to provide alternative views of future conditions considered likely to influence a given system or activity. A distinction is made between climate scenarios—which describe the forcing factor of focal interest to the Intergovernmental Panel on Climate Change (IPCC)—and nonclimatic scenarios, which provide socioeconomic and environmental "context" within which climate forcing operates.

Scenarios are therefore a key input tool to inform decision-making—not a reflection of what will be but rather what could be possible under a given set of projections. In adopting this approach, we can move away from trying to make accurate predictions about a single most likely future, and instead, investigate what a desirable future might be, or what a 'worst case' might look like.

Using scenarios can also stimulate "creative ways of thinking that help stakeholders to break out of established patterns of assessing situations"

[17]. And by "Tapping community preferences, it may then be possible to try to figure out how to make a chosen 'future' feasible" to 'overcome 'predictive' mindsets, explore possibilities, and engage with potential futures' [18]. Scenarios also introduce uncertainty considerations into a reimagining of long-term planning and design conditions, 'heralding possibilities rather than fully resolved scenarios [19]. Thus, they enable both 'blue sky thinking' and the need to step outside of thinking about what currently is, towards an openness to multiple pathways and possibilities as conditions change.

METHODS

Figure 1 outlines the process adopted in the studio. Students worked either singularly or in pairs in each of the 10 Local Government Areas (LGAs) around the bay to investigate specific impacts in each of these areas. However, because LGAs are political and include administrative boundaries, students also needed to consider the impacts of their interventions on adjoining sites. At the time of this project, the key bay wide coastal hazards data sets tended to be bathymetric rather than hydraulically and hydrologically verified. As well, only four of the 10 hotspots had updated catchment flood modelling with climate change. As a result, the data sets provided for the studio by CSIRO utilised and verified the Victorian Coastal Inundation dataset [20]. These utilised LIDAR mostly at a 1 m or occasionally 10 m resolution and were patchy in some locations. CSIRO applied hydrological and hydraulic modelling to the coastal flood inputs for Port Phillip Bay for the two key risk scenarios up to 2100. This included sea level rise for the nominated RCPs and storm surge (2.4 m, 1% AEP or 1 in 100 year). Additionally, where available, there was integration with updated catchment flooding data (increased rainfall intensity and duration for the nominated RCPs). This process resulted in the provision of consistent and comparable coastal data sets across all 10 hotspots, with some including more synthesis and detail about impacts when combined with catchment flood impacts. This data was then provided to the design teams as the key climate risk scenarios from which to design the adaptation strategies.

Students then undertook initial site investigations and stakeholder consultations to identify specific qualities, threats and opportunities in the 10 hotspots. Within these hotspots, the key challenges and development/maintenance priorities were initially identified by local government officials. To assist this process as well as to facilitate consultation, students were provided with a series of design values by the project team. After the initial investigation, students identified unique attributes for each of their sites across the spectrum of socioecological and economic attributes along with some initial ideas for interventions. Based on this feedback, students developed initial concepts responding to the two climate scenarios and two adaptation scenarios. This step was followed by a series of facilitated consultations with local governments and regional and community representatives to test and to gain feedback on their initial design ideas before the students refined their concepts. The response or combination of responses were therefore dependent not only on the local context—topography, demographics, growth/development trends and identified climate risks—but also on bringing stakeholders on a collaborative resilience design journey. The key values considered to be important by local stakeholders included community aspirations, availability, and access to resources. Students were consistently encouraged to consider the value of responding to local conditions along with stakeholder considerations to ensure both the relevance of resulting design solutions as well as communication methods for implementing such solutions.

Three key responses informed the design development: retreat, accommodation, and protection. These response strategies were outlined in the 1990 IPCC Coastal Zone Management Subgroup [21] as follows:

- Retreat involves no effort to protect the land from the sea. The coastal zone is abandoned and ecosystems shift landward. This choice can be motivated by excessive economic or environmental impacts of protection. In the extreme case, an entire area may be abandoned.
- Accommodation implies that people continue to use the land at risk but do not attempt to prevent the land from being flooded. This option includes erecting emergency flood shelters, elevating buildings on piles, converting agriculture to fish farming, or growing flood- or salt tolerant crops.
- Protection involves hard structures such as sea walls and dikes, as well as soft solutions such as dunes and vegetation, to protect the land from the sea so that existing land uses can continue.

While these three responses are not mutually exclusive, they provided a lens through which stakeholders and students could consider the implications of the proposed design interventions on adjacent sites. As an example, the use of coastal and storm surge protection measures such as sea walls or offshore reefs needed to be considered in relation to the impacts such a measure would have on other sites around Port Phillip Bay. Using these three lenses also allowed stakeholders and students to think through some of the complexities of adaptation and how adaptation strategies need to demonstrate flexibility in the face of uncertainty.

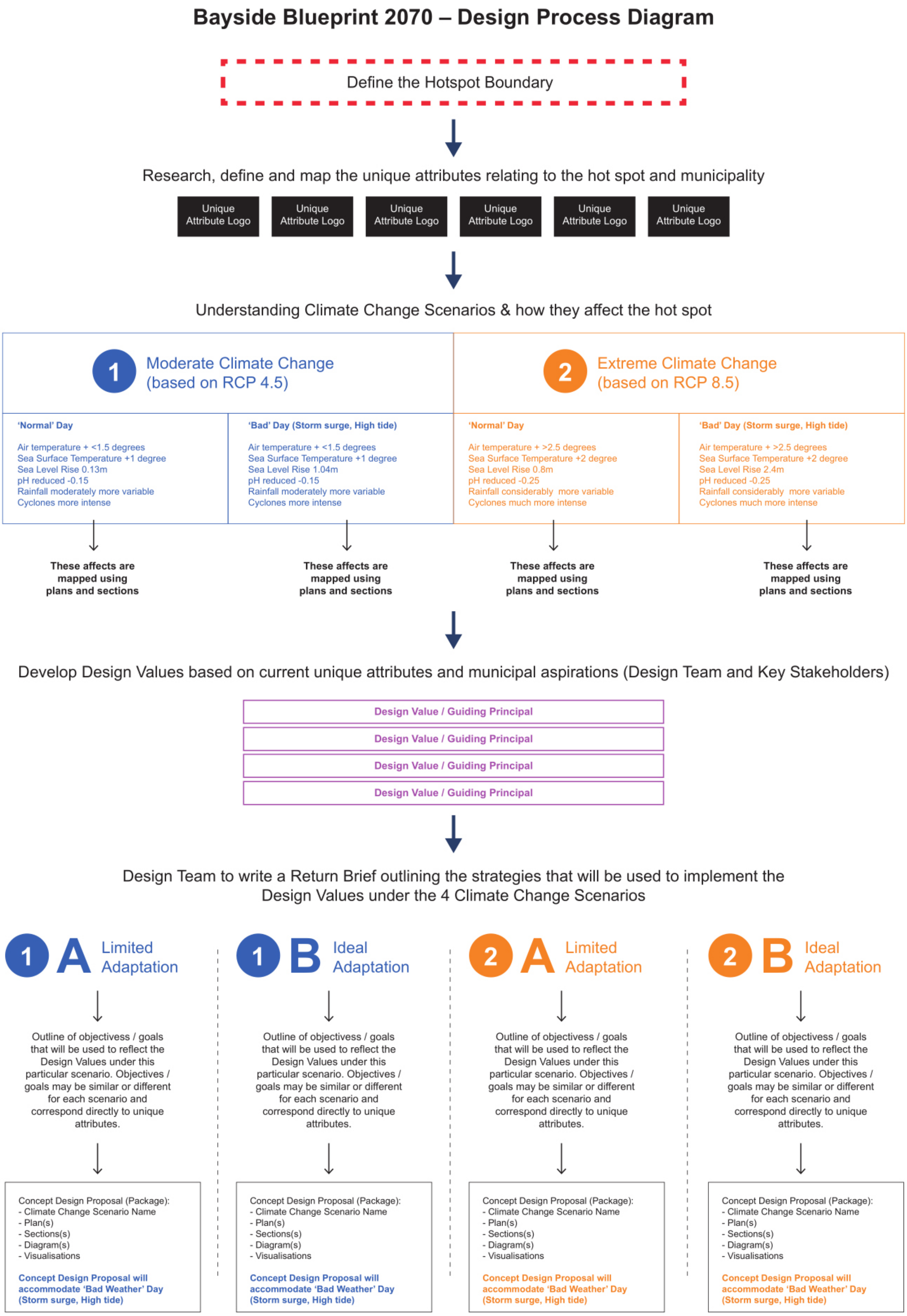

Figure 1. The design process.

RESULTS

The following provides an overview of two sets of proposals that respond to the four climate change scenarios. The first set of project proposals respond to conditions in the Borough of Queenscliff, a small town on the Bellarine Peninsula in south-western Victoria, at the entrance to Port Phillip. It is approximately 103 km from Melbourne Central Business District (CBD) and has a population of 1315 [22]. The second set of project proposals is for the suburb of Seaford, 36 km in the south-east of the Melbourne CBD. Seaford is part of the City of Frankston and has a population of 16,463 [23]. See Figure 2 for project locations around Port Philip Bay.

Figure 2. Project locations around Port Phillip Bay.

The student project proposals outlined here shared the design values of 'Living Better with More Water' and 'Vegetation, Biodiversity and Habitat Enhancement'. These design values were nominated based on the existing impacts of climate change on the landscape conditions and surrounding infrastructure as well as future ambitions of both municipalities. The following sections outline each of the project proposal series and their ability to transition and to adapt to the four climate change scenarios along with a discussion comparing the overall potential impacts of each.

Project Proposals Series 1—Location: Queenscliff

Queenscliff is a small town located at the western head of Port Phillip Bay. Its population is expected to increase by 15.7% between 2011 and 2026, resulting in increased use of public spaces, infrastructure, and required resources. Queenscliff has a strong sense of community and is laced with a rich and biodiverse natural coastal ecology. Tourism plays a major role because this destination town is surrounded by water on three sides. The Laker's Cutting area at Murray Road and adjacent residential area were nominated as the 'hotspot' due to their unique landscape character and high exposure to wind and water. These conditions present heightened climate risk because the area is vulnerable to storm surge and sea level rise. Laker's Cutting is bounded by low rise residential dwellings on the south boundary with open landscape and agriculture to the north and west boundaries. On the east boundary, Laker's Cutting meets the Port Phillip Heads Marine National Park.

Moderate climate change with limited adaptation

The project proposal "A Framework" (Figure 3) identified a series of potential specific actions in both the short term and the longer term that respond to changing circumstances for both existing dwellings and new homes, as well as roads and public space. They provided stakeholders and policy makers with potential design interventions that could be implemented over time in response to the above scenario and also focussed on the need for more reliable data collection and awareness raising.

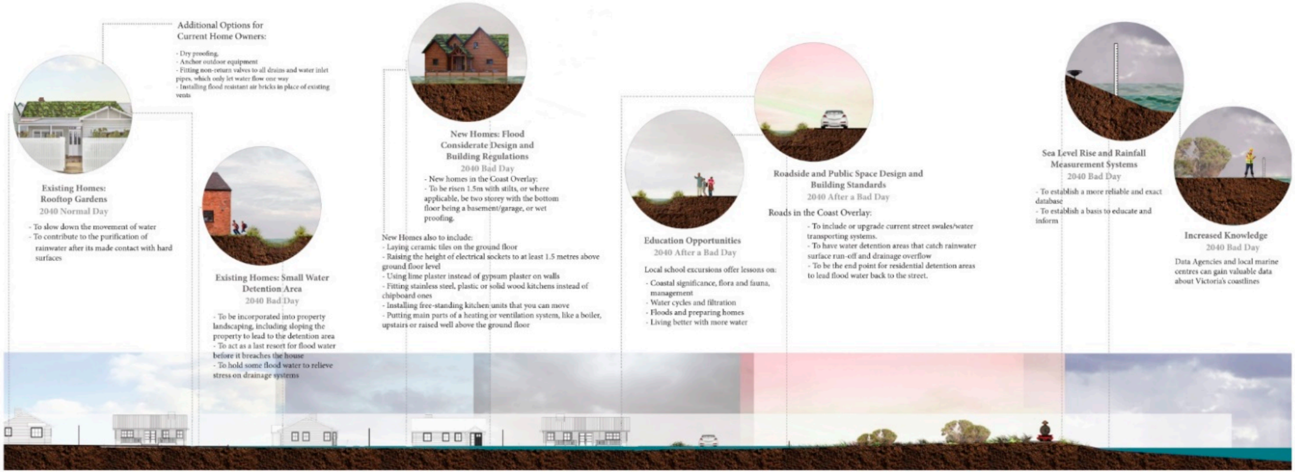

Figure 3. Potential design strategies based on 'the framework'.

Moderate climate change with ideal adaptation

Within the 'Ideal' adaptation scenario, design ideas are bold yet feasible, shifting away from individual, residential scale interventions to focus on community infrastructure that further promotes the overall resilience of Queenscliff.

The project proposal "A Garden" is a water catchment area and middle ground between residents and water. The planting scheme includes seven major planting areas that stretch across the entire garden and create moments of submergence into each micro-garden type. These types include water-loving Australian natives in the form of: -Trees, -Grasses, -

Reeds and Rushes, -Saltmarsh, -Yellow and Red Flowers, -and Blue and White Flowers.

The shape of the gardens responds to the existing crown land space between Murray Road and Laker's Cutting and seamlessly blends into the existing streetscape. Utilising the existing railway embankment dictates an edge height of 1.5 m to Laker's Cutting. This height accommodates a sea level rise of 1.4 m. The garden is a space for recreation, a destination for local drainage, and an element of infrastructure that showcases water movement within a natural environment, filtering it before re-entrance into the ocean (Figures 4 and 5). The project draws inspiration for the Cranbourne Botanical Gardens by TCL, Melbourne Australia.

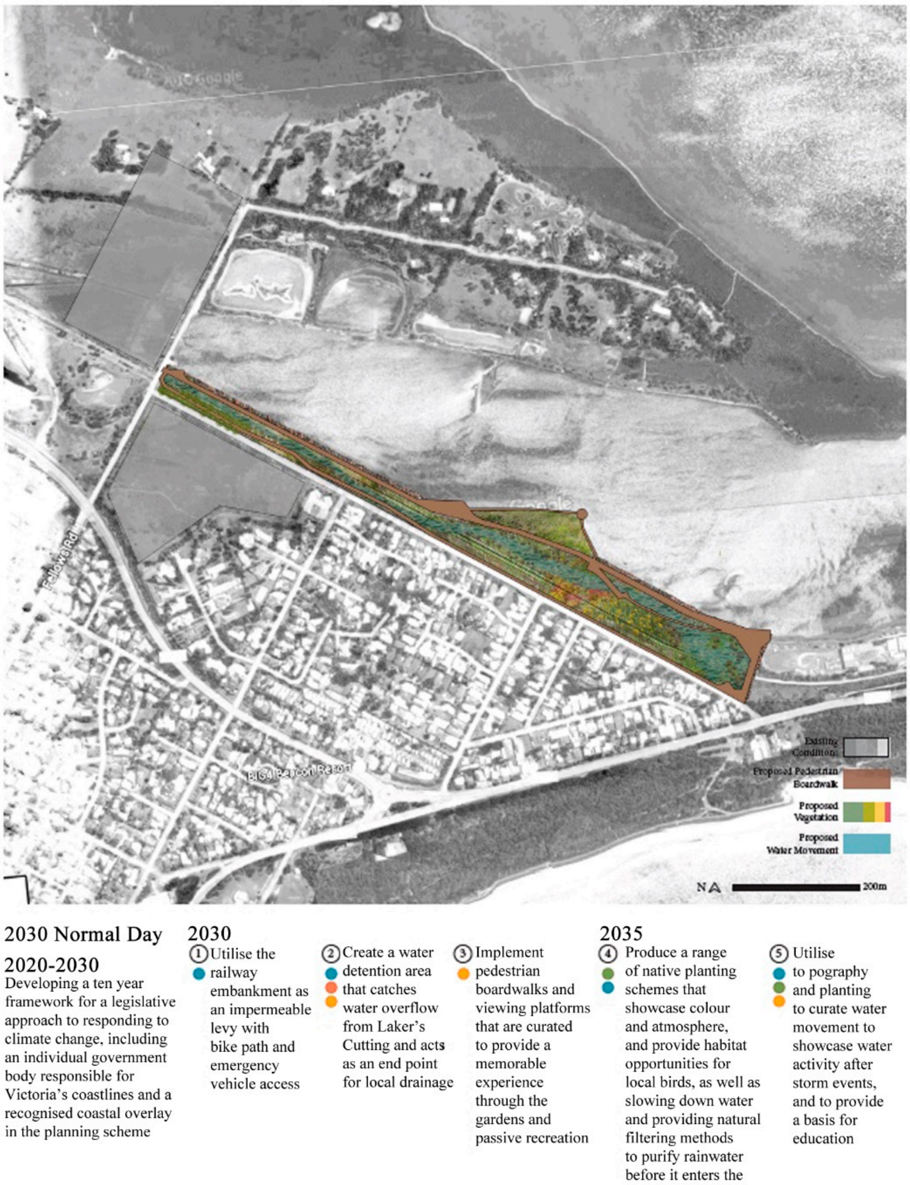

Figure 4. A garden project proposal plan, Queenscliff Victoria, moderate climate change with ideal adaptation strategies scenario.

Figure 5. A garden project proposal visualisation, Queenscliff Victoria, moderate climate change with ideal adaptation strategies scenario.

Extreme climate change with limited adaptation

The ambition of the project proposal ‘A Wall’ was to create a physical barrier between the ocean and the community and to provide security for homes that are located in an inundation zone. ‘A Wall’ is situated along the water’s edge and responded to the potential for inundation through utilization of a gap between the water and an existing railway embankment. Although most of the land around Laker’s Cutting is subject to flooding, the wall has been designed to create a physical barrier on the south side only to protect the adjacent residential development. This goal was considered to be the highest priority in an adaptation scenario where funding is limited. ‘A Wall’ was designed to be four metres wide to allow emergency vehicle access, increasing safety of the area during storm events. The wall also provides bike access from Bellarine Highway along Murray Road to meet the existing bike path at the Marine Eco-centre. The intervention also promotes a series of programs such as observation of wildlife, physical exercise, revegetation of native flora and relaxation on the adjacent grass fields and benches provided along the wall path (Figures 6 and 7). The design of ‘A Wall’ was informed by projects such as the Artificial Wildlife Intertidal Mudflats in Japan and ARO’s work in Manhattan.

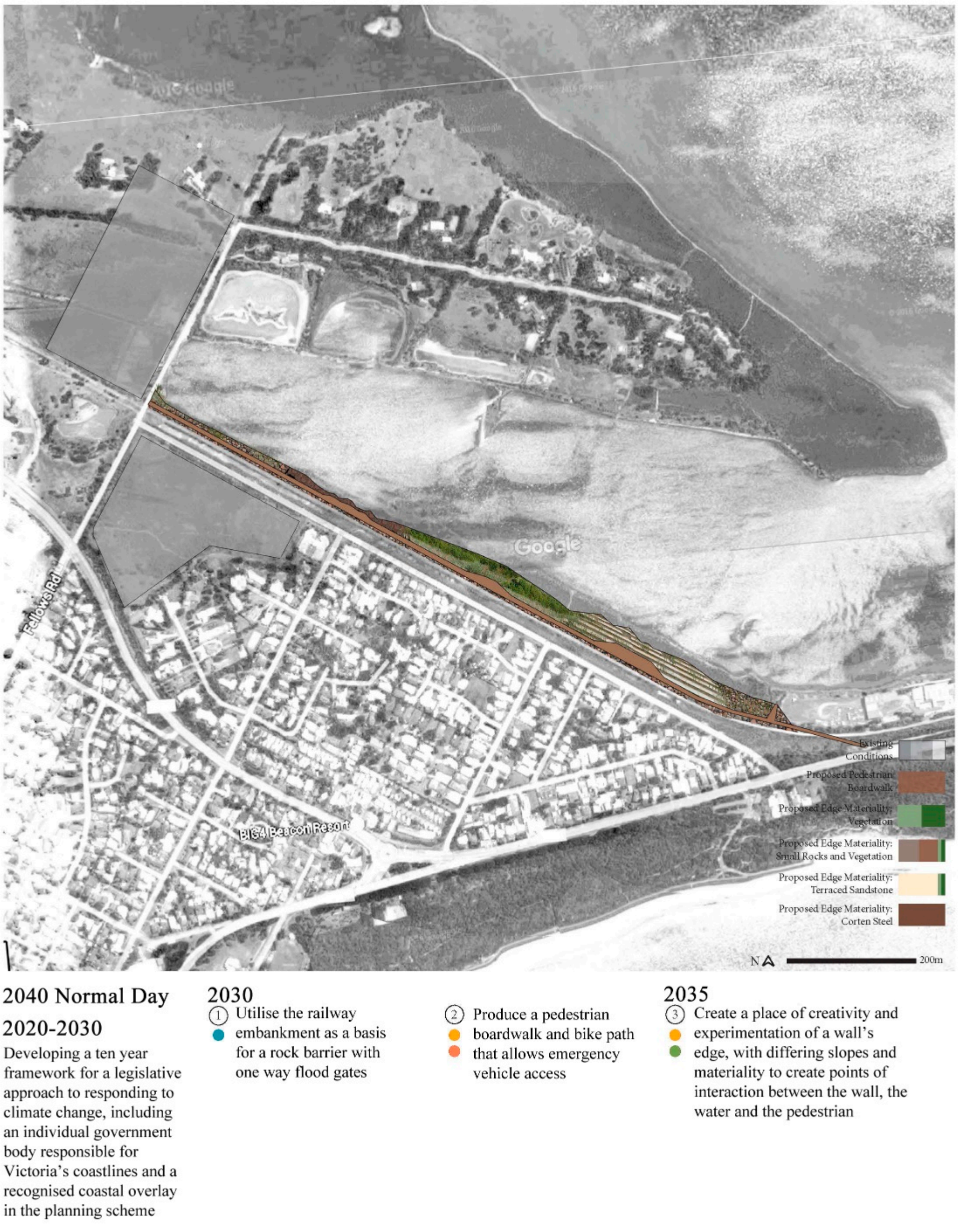

Figure 6. A wall project proposal plan, Queenscliff Victoria, extreme climate change with limited adaptation strategies scenario.

Figure 7. A wall project proposal visualisation, Queenscliff Victoria, extreme climate change with limited adaptation strategies scenario.

Extreme climate change with ideal adaptation

"An Ecosystem" responded to the projected higher levels of inundation that could occur as part of the extreme climate change scenario. The project consists of a mudflat and saltmarsh ecosystem and middle ground between residents and water. The use of intertidal mudflats provides the site with infrastructure that welcomes rain events and enables opportunities to cycle water nutrients.

By developing this infrastructure, the entire ecosystem has the opportunity to perform and to thrive during the extreme climate change scenario. The project provides habitat enhancement, revegetation on a large scale, nature connection for residents, and educational opportunities for the locals and visitors to learn about water management, flood zones, and endangered flora and fauna and their natural processes. Similar to the "A Garden" project, the mudflat design has the capacity to receive local drainage from any rainfall event, relieving pressure on existing drainage infrastructure (Figures 8 and 9).

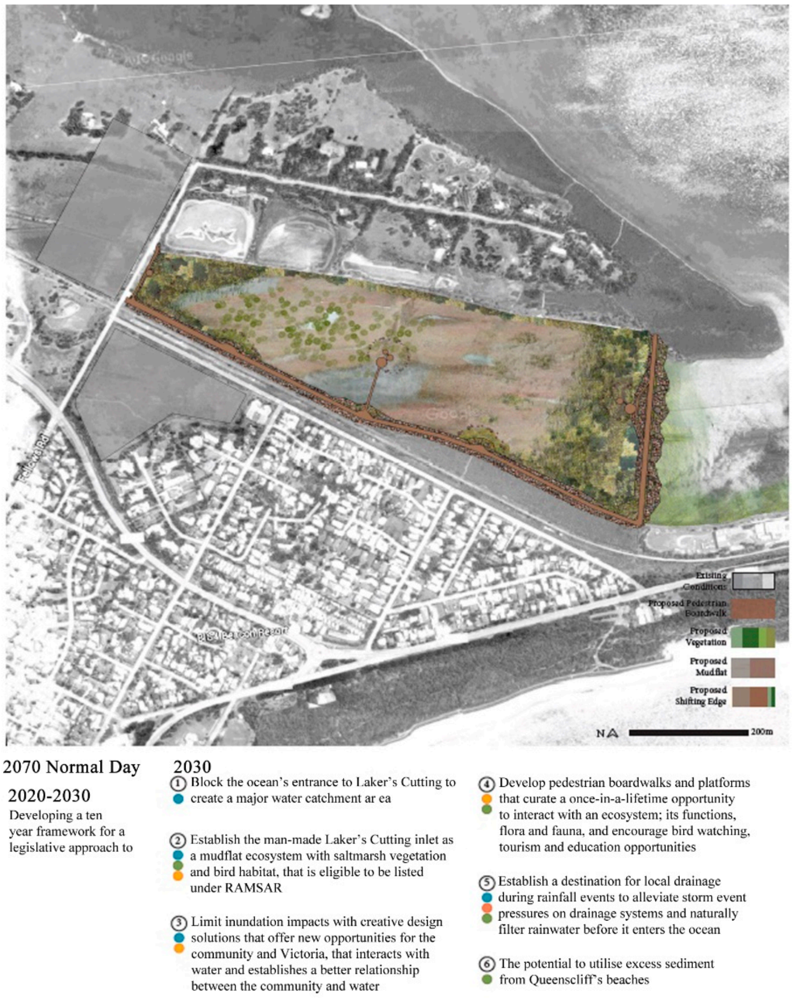

Figure 8. An ecosystem project proposal plan, Queenscliff Victoria, extreme climate change with ideal adaptation strategies scenario.

Figure 9. An ecosystem project proposal visualisation, Queenscliff Victoria, extreme climate change with ideal adaptation strategies scenario.

Project Proposals Series 2—Location: Seaford

Seaford is a suburb within the City of Frankston. The Seaford pier and broader foreshore area was identified as a 'hotspot' in the municipality because there is currently evidence of coastal sand dune erosion and storm-battered fencing. It is projected that this damage to the foreshore will escalate and that the dunes will struggle to recover. The hotspot boundary width spans approximately 300 metres from the Frankston Railway Line through Seaford's central business district and into Port Phillip Bay.

The site is a busy area with many unique attributes and a diverse range of functions and uses that include commercial and community facilities, the Kananook Creek, the Frankston Rail line and Seaford Station, the Nepean Highway, residential properties, the Life Saving Club, and a pedestrian mobility network.

Moderate climate change with limited adaptation

The project proposal 'KNEE-JERK' is an intervention that employs defensive responses to mitigate the potential effects of climate change on the Seaford hotspot. Because resources are limited, the propositions are an attempt to keep the projected effects of climate change away from the site. Although these responses are not designed to fail, they are not ideal, and there is no guarantee that they will succeed. They are simply 'knee-jerk' reactions to particular conditions that require a fast response.

The proposal includes breakwaters to reduce dune erosion and to allow continued access to and use of the foreshore, an erosion rock-wall to protect the Life Saving Club and beach accessibility, fencing to control foreshore dune erosion and an inundation wall to protect residential and commercial properties from Kananook Creek inundation (Figure 10). The project proposal draws inspiration from the Presque Isle Shoreline Erosion Control project, Breakwaters at Lake Erie in Pennsylvania, and Mobile Flood-Wall in Austria.

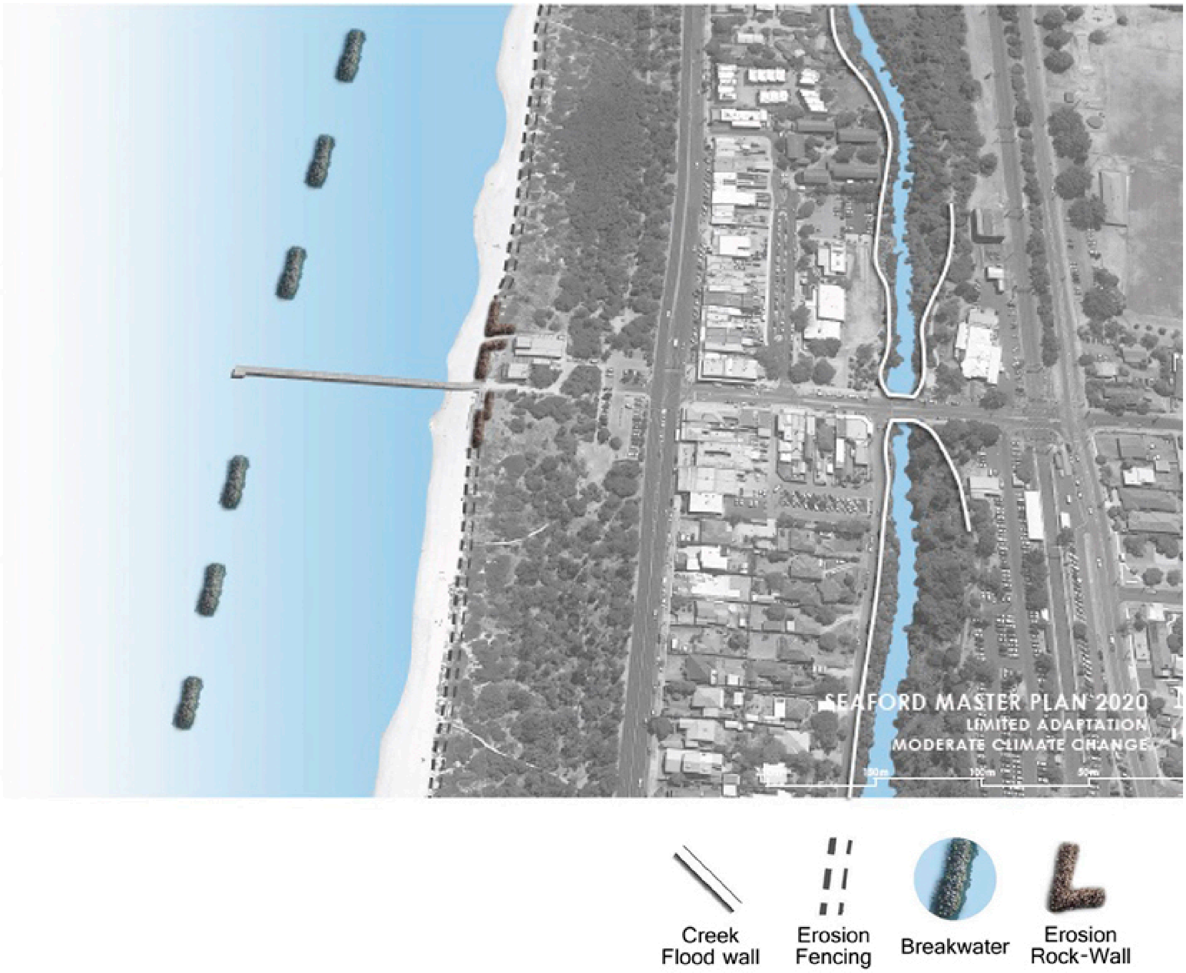

Figure 10. Knee-jerk project proposal plan, Seaford Victoria, moderate climate change with limited adaptation strategies scenario.

Moderate climate change with ideal adaptation

The project proposal 'ARCHIPELAGO' employs a flexible strategy to prepare the Seaford hotspot for the possible effects of climate change. With unlimited resources available, the interventions adapt to the changing conditions. This proposal is not short-term. It is expected to have lasting effects that will optimise the social, environmental and economical outcomes of the site, creating an iconic, enjoyable and prosperous place in which to live, to work and to visit.

The project consists of living breakwaters to allow continued access to and use of the foreshore as well as to provide recreational and economic opportunities, foreshore steps to control foreshore dune erosion and to improve public accessibility, vegetated dune mesh to further control foreshore dune erosion and to enhance biodiversity, and creek inundation steps and levees to protect residential and commercial properties from Kananook Creek inundation and to allow and to enhance continued public access to the creek (Figures 11 and 12). The project draws inspiration from Richmond City's industrial waterfront along the Fraser River in Canada and the Borth sea defence project, where ARCHIPELAGO utilises multi-purpose reefs as a result of recreational fishing.

Figure 11. Archipelago project proposal plan, Seaford Victoria, moderate climate change with ideal adaptation strategies scenario.

Figure 12. Archipelago project proposal visualisation, Seaford Victoria, moderate climate change with ideal adaptation strategies scenario.

Extreme climate change with limited adaptation

The ambition of the project proposal ‘FORTITUDE’ is to employ defensive strategies to mitigate the adverse effects of climate change on the Seaford hotspot. The interventions include double breakwaters to reduce dune erosion and to allow continued access to and use of the foreshore, the implementation of a sea wall to protect the Life Saving Club and beach accessibility, the implementation of fencing along the foreshore to control dune erosion and the implementation of a creek wall to protect residential and commercial properties from Kananook Creek inundation (Figures 13 and 14). The design of ‘FORTITUDE’ was informed by the tombolo breakwaters that extend the foreshore as seen in East Beach, East Ocean View Norfolk in the USA, the glass flood wall implemented at Wells-Next-The-Sea in England, and the Blackpool seawall designed to strengthen coastal resilience through biomimicry.

Figure 13. Fortitude project proposal plan, Seaford Victoria, extreme climate change with limited adaptation strategies scenario.

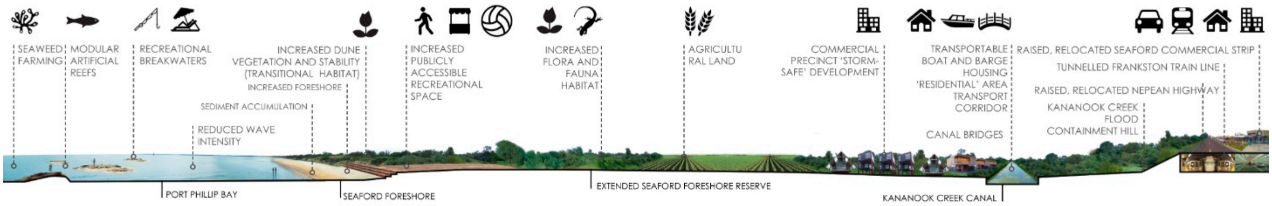

Figure 14. Fortitude project proposal sectional-elevation, Seaford Victoria, extreme climate change with limited adaptation strategies scenario.

Extreme climate change with ideal adaptation

The project proposal 'AFLOAT' aims to adapt the community lifestyle to respond to the impacts projected in the extreme climate change scenario. The proposal aimed to deliver a response that is socially attractive and sustainable whilst homes, businesses and infrastructure are protected during inundation events.

The proposal includes the implementation of double breakwaters to reduce dune erosion as seen in project 'Fortitude', the implementation of fencing along the foreshore to further control dune erosion, and introduction of aquaculture and seaweed farming as well as modular artificial reefs to slow down wave movement. The proposal also increases the size of the existing foreshore through the implementation of a programmable foreshore wall, relocates the Nepean Highway to be situated on top of the new Frankston line tunnel and Seaford Station and to match the newly raised commercial strip at grade level, and replaces the current Nepean Highway arterial road with agriculture opportunities. The project sets out to transform the existing commercial precinct to include 'storm-safe' developments and transforms the existing Kananook Creek Canal to become a transportable boat and barge housing residential area and transport corridor with canal pedestrian bridges (Figures 15 and 16). The project draws upon sustainable built homes such as the F9 Flood-Proof House that has been designed to withstand flooding and to provide a safe haven when natural disaster strikes. In addition, the project employs a series of barge housing units modelled on those found in Regents Canal in England.

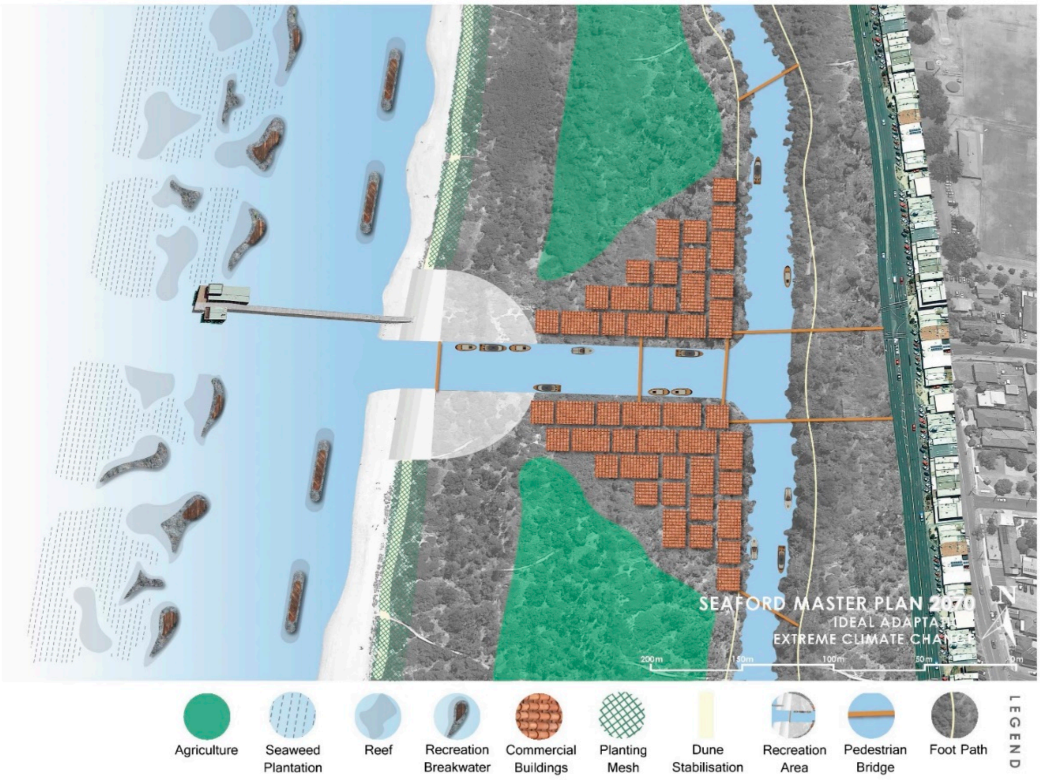

Figure 15. Afloat project proposal plan, Seaford Victoria, extreme climate change with ideal adaptation strategies scenario.

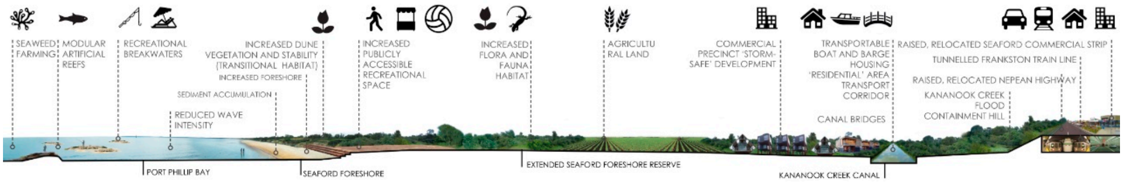

Figure 16. Afloat project proposal sectional-elevation, Seaford Victoria, extreme climate change with ideal adaptation strategies scenario.

DISCUSSION

An adaptation pathways approach requires consideration of multiple possible futures that leads to a variety of potential 'solutions' that are flexible and open to change as conditions change [4]. Pathways thinking also frames adaptation as evolving over time. So rather than 'pathways' being understood as a sequence of decisions, the concept allows for an understanding of adaptation in terms of changing systems, values and knowledge [5]. And so, "Integral to the adaptation pathways approach is recognising 'one possible' future is not adequate, [sic] multiple futures need to be identified and analysed" [24]. The student projects discussed above work not only with the uncertainty associated with climate change but also with the potential for institutional and resource constraints. The proposals also illustrate the similarities of and differences between design strategies and techniques when addressing stakeholder and municipal aspirations, along with site specific geomorphological and socio-economic conditions. Both sets of project proposals suggest multiple possible futures that enable flexibility and adjustment of plans as conditions change. The Queenscliff and Seaford municipalities have similar characteristics, including low lying areas with low density single detached housing, streetscape and rail infrastructure. The Seaford 'hotspot' includes community infrastructure such as the local RSL and commercial and retail centres. Queenscliff is a tourist destination, whereas Seaford is predominately a residential coastal suburb. Both the Queenscliff and Seaford 'hotspots' show evidence of the impacts of climate change, including eroding coastlines. A key difference between both hotspots is the landscape conditions: while Queenscliff includes endangered mudflats, Seaford has endangered sand dunes.

The projects, along with other student projects, were developed in partnership with key stakeholders and decision makers as part of stage 2 of a larger project where stage 3, or the stage to follow, will focus on training and capacity building, while stage 1 identified key challenges to climate adaptation and resilience, including data gaps [24]. Stage 1 identified that 'with worsening physical and climatic impacts, the current localised and inconsistent approach to Bay management will not be viable into future' [24]. The ambition of stage 2 was to identify a suite of adaptation approaches for coastal typologies found around Port Phillip Bay and to 'allow the project team and stakeholders to imagine the Bay well beyond the influences of current political and business operating cycles' [24]. The visualisations produced by the students created 'a powerful catalyst for conversation and were intended to be thought provoking' [4,24].

The four climate change scenarios that were addressed in the student projects present varying projections for average air temperature and sea surface temperature as well as days with no rain events ('normal' day) vs extreme rain events ('bad' day) that result in high levels of storm surge (see Figure 1). Although these scenarios are simply projections, they allowed the students and stakeholders to consider the implications of different levels of inundation and accommodate for the 'bad' day events. Within the limited adaptation scenario, the design proposals consisted of simple innovations that may or may not work and may also reflect on how limited adaptation may not contribute to any successful adaptation at all. Meanwhile, ideal adaptation scenarios present big and bold design propositions that reflected unlimited resources, time and funding.

Educationally, unlike many design studios where students are presented with a ‘problem’ and are then required to present a ‘solution’, in this studio the students needed to acknowledge the uncertainty associated with climate change and to propose multiple solutions based on 4 potential future scenarios. Because this was a final studio for the students as future decision makers, this outcome was an important one, as was working collaboratively with multiple stakeholders to understand and to work with local conditions and aspirations.

CONCLUSION

The studio outcomes discussed in this paper focussed on developing and then exploring future scenarios for 10 hotspots located around Port Phillip Bay, Victoria, Australia. Four scenarios were employed, the first two based on representative concentration pathways (RCPs) 8.5 Extreme and Moderate RCP 4.5 (IPCC 2014). The second two were identified as ‘Ideal adaptation’ and ‘Limited adaptation’. Using the 4 scenarios, students were asked to consider what extreme climate change/limited adaptation or moderate climate change/ideal adaptation would look like in 2070. The strength of the approach was that stakeholders were presented with alternative scenarios that focussed discussions around ‘what if’ or what could be rather than ‘what is’ or ‘what will be’ and provided a powerful first step for pathways planning. Developing proposals that worked with alternative adaptation pathways provided a powerful and useful contrast for stakeholders and decision makers to think beyond singular and fixed solutions in the face of uncertainty and to consider alternative potentials and possibilities. Working with stakeholders in each of the 10 municipalities around Port Phillip Bay also meant that the design proposals reflected local values and geomorphological conditions, while also providing propositions that served as a catalyst for conversations about what adaptation could look like into the future.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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