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Climate change resilience of Melbourne

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Climate Change Resilience of Melbourne



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Summary

Science indicates that climate change is occurring¹, and represents a global risk which demands an urgent multilateral response.² The high uncertainty in the range of possible outcomes of climate change stresses the need for immediate strategic action. Whilst international efforts in responding to climate change are strong, the role of both private enterprise and local governments in planning and implementing local enterprises is also important. Local and state government agencies in Victoria are well known for their progressive programs toward climate change resilience. Consequently it was decided to focus the review within this region where three questions were raised regarding initiatives supporting resilience to climate change.

1. What are the potential climate change risks for metropolitan Melbourne?
2. What are some of the major climate change initiatives of local councils in metropolitan Melbourne?
3. Are the identified government policies effective in light of the climate change risks identified within the scope of this study?

The greater metropolitan Melbourne area has a population figure of approximately 4.1 million.³ By 2030, Melbourne is projected to become Australia's largest city.⁴

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1. Australian Government, *The Critical Decade: Climate Change Science, Risks and Responses*, Department of Climate Change and Energy Efficiency, Canberra, 2011, p. 3.
 2. N Stern, *Stern Review: The Economics of Climate Change*, HM Treasury, Cambridge, UK, 2006.
 3. City of Melbourne, *City of Melbourne profile*, in City of Melbourne, 2012, retrieved 17 August 2012, <<http://www.melbourne.vic.gov.au/ABOUTMELBOURNE/MELBOURNEPROFILE/Pages/CityofMelbourneprofile.aspx>>.
 4. Department of Planning and Community Development, *Melbourne 2030 – Planning for sustainable growth*, Department of Planning and Community Development, Melbourne, 2010.

CLIMATE CHANGE RISKS OF MELBOURNE

Greater metropolitan Melbourne is subject to four potential climate change outcomes, including: 1) drought and reduced rainfall, 2) extreme temperature rise, 3) intense rainfall and 4) sea level rise.

Drought and rainfall:

a decline in number of annual rainy days of 6% by 2030 and 10-19% by 2070;⁵

a reduction in average stream flow of 3-11% by 2020 and 7-35% by 2050;⁶ and

up to 50% less runoff into Yarra, Maribyrnong, Werribee and Bunyip Rivers by 2070;⁷

Extreme temperature rise:

higher average annual temperature, with an increase of 0.3-1.0°C by 2020, and 0.6-2.5°C by 2050;⁸ and

an increase in annual number of days above 35°C from 9 days to 10-13 days by 2030, 15-26 days by 2070, and 16-33 days by 2100;⁹

Intense rainfall:

an increase rainfall intensity of 0.9% by 2030 and 3.0-5.9% by 2070;¹⁰

Sea level rise:

a rise in sea level of up to 1.1 metres by 2100, which puts population of approximately 937,000 at risk from inundation by 2100;¹¹ and

infrastructure and buildings in various Local Government Areas (LGAs) of metropolitan Melbourne are at highest risk from inundation and shoreline recession out of all LGAs across the state of Victoria.¹²

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5. Department of Sustainability and Environment, *Climate Change in Victoria: 2008 Summary*, Department of Sustainability and Environment, Melbourne, 2008.
 6. CSIRO, *Climate Change in Australia - Technical Report*, CSIRO, Melbourne, 2007.
 7. Department of Sustainability and Environment, *Climate Change in Port Phillip and Western Port*, Department of Sustainability and Environment, Melbourne, 2008.
 8. CSIRO & Melbourne Water, *Melbourne Water Climate Change Study: Implications of Potential Climate Change for Melbourne's Water Resources*, Melbourne Water, Melbourne, 2005.
 9. AECOM, *Adaptation of Melbourne's Metropolitan Rail Network in Response to Climate Change*, Department of Climate Change and Energy Efficiency, Melbourne, 2011.
 10. Department of Sustainability and Environment, *Climate Change in Victoria: 2008 Summary*.
 11. Geoscience Australia, *Sea level rise maps: Melbourne region*, in Information about Australia's coast, including its estuaries and coastal waterways and climate change impact, 2010, retrieved 17 August 2012, <http://www.ozcoasts.gov.au/climate/Map_images/Melbourne/mapLevel2.jsp>.
 12. Department of Climate Change and Energy Efficiency, *Climate Change Risks to Coastal Buildings and Infrastructure*, Department of Climate Change and Energy Efficiency, Canberra, 2011.

EXISTING CLIMATE CHANGE INITIATIVES FOR MELBOURNE

In response to climate change risks, local councils in the metropolitan Melbourne area have taken proactive measures in identifying and monitoring climate change impacts and planning for climate change adaptation. All councils, which have undertaken climate change adaptation planning, have implemented a risk management framework for their decision making.¹³ The framework, based on the Australian Greenhouse Office's guidance material, *Climate Change & Risk Management: A Guide for Business and Government*, is consistent with existing risk management process of councils, is highly effective in developing awareness and understanding of climate change issues and has transformed climate change from an environmental issue to a council wide policy issue.¹⁴

The City of Melbourne's *Climate Change Adaptation Strategy*¹⁵ and *Zero Net Emissions by 2020*¹⁶ strategy are exemplars of how a local council can comprehensively respond to climate change. Both strategic documents serve as models that other local councils in Australia could replicate in their climate change planning.

A number of collaborations, between councils and external stakeholders have involved a number of research and community projects for climate change planning.

Climate change planning is high on the agenda of state and federal government authorities. The Australian Government has adopted the Clean Energy Future Plan, which will attempt to mitigate climate change impacts by reducing national pollution and driving investment and innovation in renewable energy through a carbon pricing mechanism.¹⁷ Farmers and land managers are encouraged to store carbon or reduce greenhouse gas emissions on the land through the Carbon Farming Initiative.¹⁸

State and federal government agencies have commissioned a number climate change studies to determine the likely impacts of climate change on local communities and infrastructure. For example, AECOM was commissioned to undertake a series of case

13. Municipal Association of Victoria, *Stocktake of Current Victorian Local Government Climate Change Adaptation Planning*, Municipal Association of Victoria, Melbourne, 2011.

14. Municipal Association of Victoria, *Stocktake of Current Victorian Local Government Climate Change Adaptation Planning*.

15. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*, Department of Climate Change and Energy Efficiency, Melbourne, 2009.

16. City of Melbourne, *Zero Net Emissions by 2020 - Update 2008*, City of Melbourne, Melbourne, 2008.

17. Australian Government, *Clean Energy Future – our Plan*, in *Clean Energy Future*, 2012, retrieved 16 September 2012, <<http://www.cleanenergyfuture.gov.au/clean-energy-future/our-plan/>>.

18. Department of Climate Change and Energy Efficiency, *Carbon Farming Initiative*, in Department of Climate Change and Energy Efficiency, 2012, retrieved 16 September 2012, <<http://www.climatechange.gov.au/cfi/>>.

studies of infrastructure and settlements. An economic framework was developed to evaluate different climate change adaptation strategies in terms of their costs and benefits. This framework was applied to three case studies, two of which are in Melbourne, on the following topics: coastal inundation, long-term water supply security, and impacts of temperature changes on metropolitan Melbourne's rail network.¹⁹

Other climate change policies include the following initiatives of the City of Melbourne: research on cool roofs²⁰, Urban Forest Strategy²¹, and Water Sensitive Urban Design Guidelines.²² Based on the strategic policies reviewed, it is apparent that metropolitan Melbourne is advanced in their preparation for resilience to climate change due to councils' progressive and pro-active approach.

BARRIERS TO CLIMATE CHANGE RESILIENCE OF MELBOURNE

Three major challenges may represent barriers to effective climate change adaptation planning in greater Melbourne. First is the risk management framework for councils climate change planning. The most significant drawback of this approach to climate change is the potential limitation of *opportunity identification* as climate change creates not only challenges, but also opportunities for local governments and commercial enterprise.²³ Thus, the risk management process, which primarily emphasises identification and treatment of risk, should be revised to give equal consideration to opportunities.

Second, given the limited sizes and resources of local council's in metropolitan Melbourne, funding segmentation and constraint is another barrier.²⁴ To overcome this issue, state and federal government agencies should increasingly provide funding packages to councils to unify their departments for climate change planning on an ongoing basis and proactive efforts toward establishing alliances between government and private investment.

Finally, it is important to note that there is limited collaboration between local councils and the private sector in this field. Greater levels of engagement and involvement of the

19. AECOM, *Economic framework for analysis of climate change adaptation options*, Department of Climate Change and Energy Efficiency, Canberra, 2012.

20. City of Melbourne, *Cool roofs*, in City of Melbourne, 2012, retrieved 19 August 2012, <<http://www.melbourne.vic.gov.au/Sustainability/CouncilActions/Pages/Coolroofs.aspx>>.

21. City of Melbourne, *Urban Forest Strategy: Making a great city greener 2012-2032*, City of Melbourne, Melbourne, 2011.

22. City of Melbourne, *City of Melbourne WSUD Guidelines*, City of Melbourne, Melbourne, 2006.

23. City of Melbourne, *Zero Net Emissions by 2020: A roadmap to a climate neutral city*, City of Melbourne, Melbourne, 2002.

24. Municipal Association of Victoria, *Supporting Victorian Local Government Manage Climate Risks and Plan for Change*, Municipal Association of Victoria, Melbourne, 2011.

private sector is needed to plan and implement climate change policies. Collaboration with private stakeholders can be an opportunity to share resources and expertise and examples include commercial and banking sectors, tertiary sector, property and infrastructure, and community organisations.²⁵ The risks associated with climate change goes well beyond the jurisdiction of governments and will only be affectively mitigated if private enterprise and commercial interest are included in problem solving and actioning of initiatives.

25. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

Introduction

In light of scepticism about climate change impacts, the scientific reports compiled and reviewed in this body of work indicate that it is “beyond doubt” that climate change is occurring.²⁶ Climate change therefore represents global risk, and urgent global response is required.²⁷ The high uncertainty in the range of possible outcomes of climate change stresses the need for climate change action, which should focus on both adaptation and mitigation measures.²⁸ Whilst international efforts in responding to climate change are crucial, local government plays a vital role in representing the interest of its citizens in the delivery of emergency and essential services.²⁹

Local and state government agencies in Victoria are well known for their progressive programs toward climate change resilience. Consequently it was decided to focus the review within this region where three questions were raised regarding initiatives supporting resilience to climate change.

1. What are the potential climate change risks for metropolitan Melbourne?
2. What are some of the major climate change initiatives of local councils in metropolitan Melbourne?
3. Are the identified government policies effective in light of the climate change risks identified within the scope of this study?

The paper outlines potential climate change risks for the study area in a variety of timeframes. The paper will also assess the current priority of climate change actions and identify implications for the strategic actions anticipated by local governments. Lastly, the paper will review relevant policies and actions to determine Melbourne’s levels of preparedness for climate change.

The primary focus of this study is the capital city of Victoria, located on the south eastern coast of Australia. The greater Melbourne area covers 7,694 square km and has a

26. Australian Government, *The Critical Decade: Climate Change Science, Risks and Responses*, Department of Climate Change and Energy Efficiency, Canberra, 2011, p. 3.

27. N Stern, *Stern Review: The Economics of Climate Change*, HM Treasury, Cambridge, UK, 2006.

28. R Garnaut, *Garnaut Climate Change Review: Weighing the cost and benefits of climate change action*, Department of Climate Change and Energy Efficiency, Canberra, 2011.

29. Department for Communities and Local Government, *About local government*, in Department for Communities and Local Government, retrieved 24 August 2012, <<http://www.communities.gov.uk/localgovernment/about/>>.

population figure of approximately 4.1 million.³⁰ Melbourne's population figure can increase up to: 6.06 million by 2030, 13.37 million by 2070, and 24.22 million by 2100.³¹ The metropolitan area of Melbourne comprises 31 Local Government Areas (LGAs).³² Each LGA is administered by locally elected councillors representing a number of political platforms. Metropolitan Melbourne's boundary is outlined in **FIGURE 1**.³³

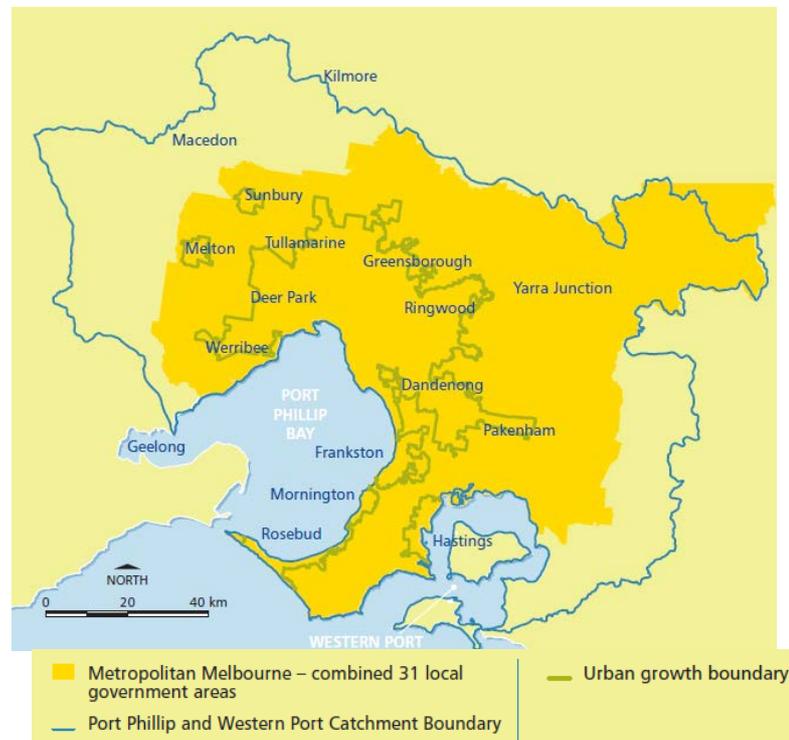


FIGURE 1: METROPOLITAN MELBOURNE BOUNDARY

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30. City of Melbourne, *City of Melbourne profile*, in City of Melbourne, 2012, retrieved 17 August 2012, <<http://www.melbourne.vic.gov.au/ABOUTMELBOURNE/MELBOURNEPROFILE/Pages/CityofMelbourneprofile.aspx>>.
31. These population figures were calculated using an annual growth rate of 2%, the average annual growth rate of the city's population from 2004 to 2009.
32. Department of Sustainability and Environment, *Melbourne metropolitan Local Government Areas*, in Department of Planning and Community Development, 2005, retrieved 17 August 2012, <http://www.dpcd.vic.gov.au/__data/assets/pdf_file/0010/31150/Melbourne_metropolitan_Local_Government_Areas.pdf>.
33. Department of Planning and Community Development, *Melbourne 2030 – Planning for sustainable growth*, Department of Planning and Community Development, Melbourne, 2010.

Climate Change Risks of Melbourne

While global climate change impacts have been closely monitored³⁴, each city offers unique implications for the impacts of change in the climate due to a variety of variables such as geography, micro climate and habitation. It is subject to different climate change impacts given its unique geographical and demographic profile, and its specific mix of local sensitivity, resilience and response capacity.³⁵ According to a *State of the Regions* report published by the Australian Local Government Association, over the last four years climate change is costing each household in Victoria over \$2500 per year. Furthermore, the average temperature has risen nearly 1°C across the state over the same period.³⁶

Four potential extreme climate change outcomes in metropolitan Melbourne have been identified based on a risk analysis conducted by the City of Melbourne.³⁷ These include: 1) drought and reduced rainfall, 2) extreme temperature rise, 3) intense rainfall, and 4) sea level rise. These impacts are discussed below.

DROUGHT AND REDUCED RAINFALL

Climate change poses a substantial risk to water utilities in the Melbourne area in terms of its water security, infrastructure and operations. Water supply in metropolitan Melbourne is traditionally captured by rural urban water authorities from rainfall runoff. However, climate change poses a threat to greater Melbourne's urban water supply with drought and reduced rainfall. Lower rainfall and drought will reduce runoff into Melbourne's water catchments, and ultimately the water supply level of water authorities will be severely affected. **Water supply in regional areas is at most risk from drought and reduced rainfall.**³⁸

In addition to a reduced water supply, a number of additional risks are associated with drought and less rainfall given that drought impacts are "multi-layered, widespread, significant, long-term and growing."³⁹ Some of the major risks include: impacts to aquatic

34. Intergovernmental Panel on Climate Change, *Reports*, in IPCC - Intergovernmental Panel on Climate Change, 2012, retrieved 18 August 2012, <http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1>.

35. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*, Department of Climate Change and Energy Efficiency, Melbourne, 2009.

36. South East Councils Climate Change Alliance, *Greenhouse Alliances – Responding to the Challenge of Climate Change*, in South East Councils Climate Change Alliance, 2012, retrieved 18 August 2012, <http://www.seccca.org.au/news_article.asp?data_id=120>.

37. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

38. AECOM, *Securing long-term water supply in a time of climatic uncertainty: Prioritising adaptation investment*, Department of Climate Change and Energy Efficiency, Melbourne, 2010.

39. South East Councils Climate Change Alliance, *Greenhouse Alliances – Responding to the Challenge of Climate Change*, p. 2.

biodiversity, increased health problems from declining water availability and quality, and social inequality and public conflict resulting from higher water restrictions.⁴⁰ AECOM recently conducted a study on water supply security of Central Highlands Water, a regional water authority servicing Ballarat and the surrounding suburbs in Central Highlands. The study revealed that water inflows from Lal Lal and White Swan reservoirs, one of the main supply sources for the water authority, could cease completely by 2075.⁴¹

Additionally, agricultural industries in Victoria are already at risk from drought, with many farming families struggling with the changing climate.⁴² As metropolitan Melbourne and its surroundings are impacted by longer periods of drought induced by climate change, not only will the agricultural industries lose their viability, but the food security of the city area will also be in jeopardy. Reduced rainfall and drought may also lead to increased risk of bushfires in water catchment areas.⁴³

Key statistical predictions of climate change impacts with respect to drought and reduced rainfall are:

- a decline in number of annual rainy days (>1mm) of 6% by 2030 and 10-19% by 2070;⁴⁴
- a reduction in average stream flow of 3-11% by 2020 and 7-35% by 2050;⁴⁵ and
- up to 50% less runoff into Yarra, Maribyrnong, Werribee and Bunyip Rivers by 2070.⁴⁶

40. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

41. AECOM, *Securing long-term water supply in a time of climatic uncertainty: Prioritising adaptation investment*.

42. Birchip Cropping Group, *'Critical Breaking Point?' The effects of drought and other pressures on farming families*, Birchip Cropping Group, Birchip, 2008.

43. CSIRO & Melbourne Water, *Melbourne Water Climate Change Study: Implications of Potential Climate Change for Melbourne's Water Resources*, Melbourne Water, Melbourne, 2005.

44. Department of Sustainability and Environment, *Climate Change in Victoria: 2008 Summary*, Department of Sustainability and Environment, Melbourne, 2008.

45. CSIRO, *Climate Change in Australia - Technical Report*, CSIRO, Melbourne, 2007.

46. Department of Sustainability and Environment, *Climate Change in Port Phillip and Western Port*, Department of Sustainability and Environment, Melbourne, 2008.

EXTREME TEMPERATURE RISE

Climate change is projected to lead to a substantial rise in metropolitan Melbourne's temperature through two phenomena, namely heatwaves and urban heat island. Heatwaves commonly occur in hot and humid days where there is little air movement.⁴⁷ These weather events result in the highest number of fatalities than any other natural hazard in Australia.⁴⁸ The greater Melbourne area is already experiencing heatwaves on a regular basis, representing a major health issue for the city's population.⁴⁹

Urban Heat Island (UHI) is a natural phenomenon in which a metropolitan area is warmer than its surrounding area, caused by two main factors. First, high concentration of buildings and other built environment features (e.g. roads and paved surfaces), which have high thermal properties and store heat during day time. The heat is then released gradually during night time. Second, combustion from industrial activity and vehicles, and heat released from domestic air conditioning contributes to the UHI effect.⁵⁰

Morris has been conducting an ongoing study on UHI effects in the wider urban area of Melbourne.⁵¹ The study uncovered that UHI is present in the central business district (CBD) and industrial suburbs of the city. The average temperature from 1985 to 1994 in these areas was 4°C higher than the average temperature in rural suburbs during summer and 3.2°C higher during winter. The temperature of the City of Melbourne's CBD can be up to 7°C higher than other suburbs in hot weather.⁵² The UHI impact is increasing in intensity due to the growing number of hard surfaces and buildings throughout the city.⁵³ **FIGURE 2** illustrates the variation in average annual temperature caused by the UHI effect.⁵⁴ Urbanised areas in the centre of the city are relatively warmer than the surrounding region which has less urban development.

47. Emergency Management Australia, *Heatwaves – Get the Facts*, in Emergency Management for Schools, 2012, retrieved 18 August 2012, <http://www.ema.gov.au/www/ema/schools.nsf/Page/Get_The_FactsHeatwaves>.

48. L Coates, 'An Overview of Fatalities from Some Natural Hazards in Australia', *Conference on Natural Disaster Reduction 1996: Conference Proceedings*, 1996, pp. 49-54.

49. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

50. J Morris, *Urban Heat Islands and Climate Change - Melbourne, Australia*, in Welcome to the School of Earth Sciences, 2012, retrieved on 19 August 2012, <<http://www.earthsci.unimelb.edu.au/~jon/WWW/uhi-melb.html>>.

51. J Morris, *Urban Heat Islands and Climate Change - Melbourne, Australia*.

52. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

53. Department of Sustainability and Environment, *Climate Change in Victoria: 2008 Summary*.

54. Department of Sustainability and Environment, *Climate Change in Port Phillip and Western Port*.

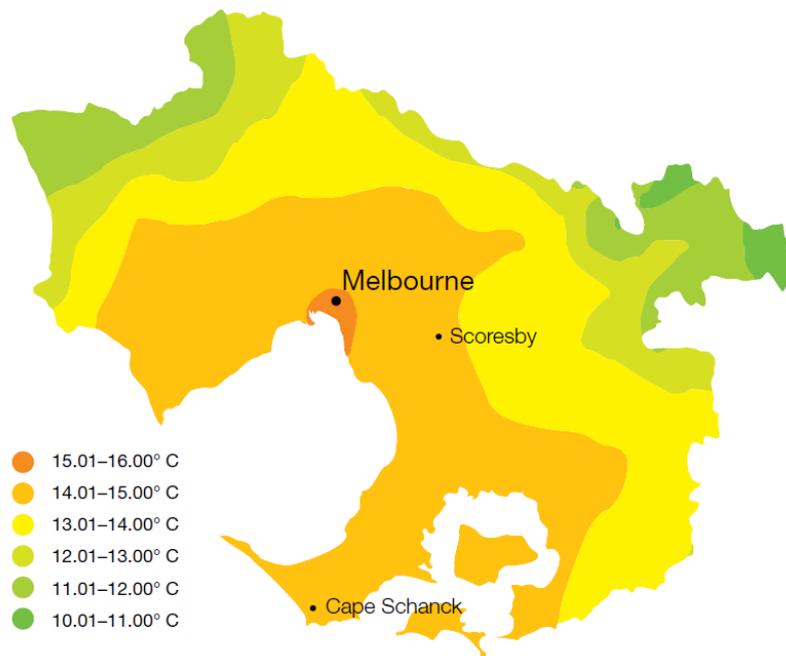


FIGURE 2: MELBOURNE’S VARIED AVERAGE ANNUAL TEMPERATURE

Consequently climate change is expected to take affect by warmer temperatures, higher frequency and intensity of heatwaves.⁵⁵ **The city’s urbanised suburbs and CBD areas are most at risk** as they are likely to experience even higher temperature increases due to the UHI effect. Higher city temperature is associated with a number of risks. The most significant is increased levels of heat stress and deaths.⁵⁶ In addition to these direct impacts on the population, extremely hot temperature may also reduce the performance of urban infrastructure such as train service, signal and power failures, failure of network operations, malfunctioning of trains’ air conditioning units, and buckled rail tracks made of wooden sleepers.⁵⁷ Higher temperature, in combination with drought, will also lead to a higher probability of bushfires.⁵⁸

Key statistical predictions of climate change impacts with respect to extreme temperature increases are:

- higher average annual temperature, with an increase of 0.3-1.0°C by 2020, and 0.6-2.5°C by 2050;⁵⁹ and

55. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

56. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

57. Parliament of Victoria, *Select Committee of the Legislative Council on Train Services*, Parliament of Victoria, Melbourne, 2010.

58. Australian Government, *The Critical Decade: Climate Change Science, Risks and Responses*.

59. CSIRO & Melbourne Water, *Melbourne Water Climate Change Study: Implications of Potential Climate Change for Melbourne’s Water Resources*.

- an increase in annual number of days above 35°C from 9 days to 10-13 days by 2030, 15-26 days by 2070, and 16-33 days by 2100.⁶⁰

CSIRO's record and projection of annual number of days above 37°C under low emissions (A1FI) and high emissions (A1B) scenarios from 1970 to 2100 is displayed in **FIGURE 3** below.⁶¹

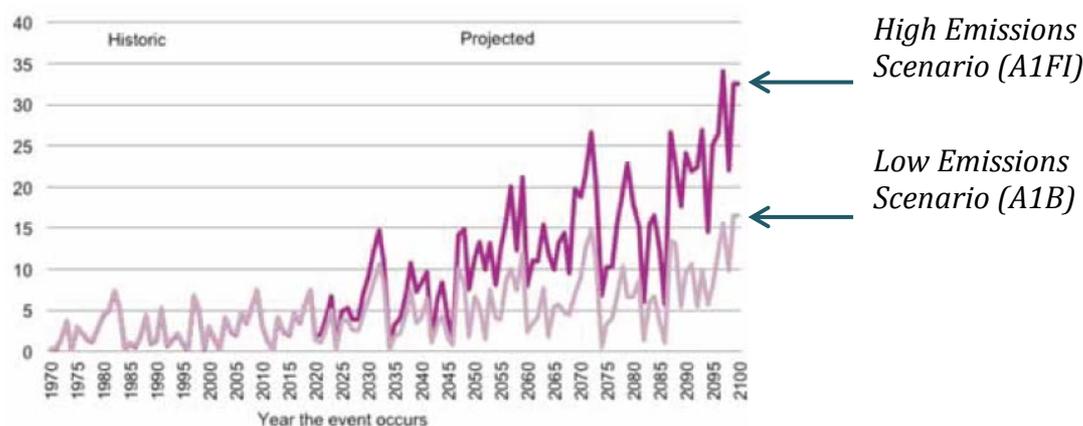


FIGURE 3: ANNUAL NUMBER OF DAYS ABOVE 37°C UNDER LOW AND HIGH EMISSIONS SCENARIOS

INTENSE RAINFALL

Metropolitan Melbourne will experience an increase in heavy rainfall intensity, particularly in the summer and autumn months.⁶² Intense rainfall events may lead to heavy down pours and flash flooding, which can cause injuries, fatalities, power outages and disruptions to the public transport system.⁶³ Higher frequency of flood can potentially diminish water quality through inducing stormwater pollution and erosion. These risks may also affect insurance risk as well as design standards of the city's infrastructure (such as bridges, roads, dams and stormwater).⁶⁴ An increase rainfall intensity of 0.9% by 2030 and 3.0-5.9% by 2070 has been predicted for the greater Melbourne area.⁶⁵ Examples of such impacts were witnessed in Queensland's Toowoomba central business district during the flash flood in January 2011.⁶⁶

60. AECOM, *Adaptation of Melbourne's Metropolitan Rail Network in Response to Climate Change*, Department of Climate Change and Energy Efficiency, Melbourne, 2011.

61. AECOM, *Adaptation of Melbourne's Metropolitan Rail Network in Response to Climate Change*.

62. CSIRO, *Climate Change in Australia - Technical Report*.

63. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

64. CSIRO, *Climate Change in Australia - Technical Report*.

65. Department of Sustainability and Environment, *Climate Change in Victoria: 2008 Summary*.

66. The Australian, *Toowoomba torrent no one knew was coming*, in The Australian, 2011, retrieved 24 August 2012, < <http://www.theaustralian.com.au/national-affairs/toowoomba-torrent-no-one-knew-was-coming/story-fn59niix-1225985261999>>.

SEA LEVEL RISE

CSIRO currently predicts an increase in sea levels of 1.1 metres by the end of the 21st century.⁶⁷ OzCoasts, an online database, has published maps of selected regions where sea levels may rise.⁶⁸ This mapping indicates a number of suburbs in Melbourne are potentially at risk from inundation as a result of the 1.1 metre sea level rise. A list of these vulnerable suburbs can be found in Appendix A.

According to the data, the suburbs identified to be vulnerable have a cumulative population of approximately 158,000⁶⁹, which represents 3.87% of Melbourne's present population figure of 4.1-million. Using the projected population figures for the anticipated growth in this area, the level of impact on humans from sea level rise will increase to: 234,000 by 2030, 517,000 by 2070, and 937,000 by 2100. These figures are shown diagrammatically in **FIGURE 4** below.

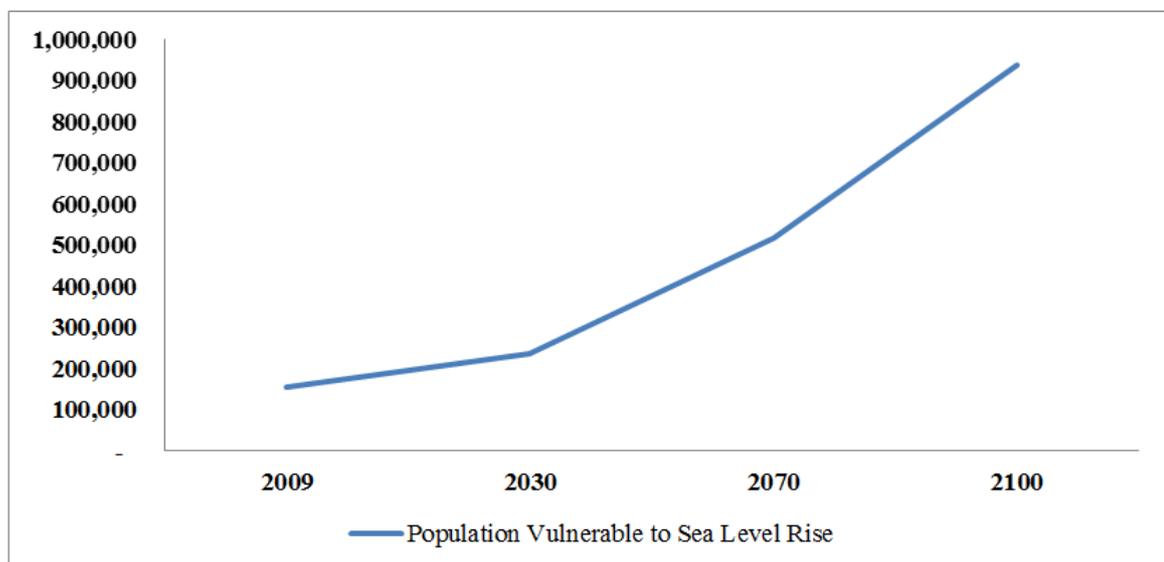


FIGURE 4: MELBOURNE'S PRESENT AND FUTURE POPULATION VULNERABLE TO SEA LEVEL RISE

In general, urban communities located adjacent to metropolitan Melbourne's coastline and creeks are at high risk from sea level rise. The sea level rise is projected to have the most significant impact on the south eastern urban communities of Cannons Creek, Dalmore, Tooradin, Caldermeade and Queensferry. Point Lonsdale, Queenscliff and Ocean Grove, which are located on the south western coast will also potentially be severely inundated.

67. City of Melbourne, *Urban Forest Strategy: Making a great city greener 2012-2032*, City of Melbourne, Melbourne, 2011.

68. Geoscience Australia, *Sea level rise maps: Melbourne region*, in Information about Australia's coast, including its estuaries and coastal waterways and climate change impact, 2010, retrieved 17 August 2012, <http://www.ozcoasts.gov.au/climate/Map_images/Melbourne/mapLevel2.jsp>.

69. This figure was attained from the Australian Bureau of Statistics' (ABS) 2011 Census data.

In addition to the population at risk mentioned above, a 1.1 metre sea level rise may also impact buildings and infrastructure along the coastal areas with a combined hazard of inundation and shoreline recession. In 2011, the Department of Climate Change and Energy Efficiency (DCCEE) conducted an inquiry into climate change risks to coastal buildings and infrastructure throughout all LGAs in Australia. Four major categories of infrastructure / buildings were the focus of the study. These include commercial buildings, light industrial buildings, roads and rails.⁷⁰

According to the inquiry findings, commercial buildings are at highest levels of vulnerability in the following LGAs in Southern Victoria: Surf Coast (347-417 buildings) Maribyrnong (242-347 buildings), and Kingston (230-250 buildings). Light industrial buildings are particularly exposed to the hazard in Greater Geelong (290-374 buildings) and Frankston (152-280 buildings). Meanwhile, the City of Melbourne has the greatest length of rail exposed to the hazard, with 27-39 km of rail track vulnerable to the impacts of a changing climate. Cardinia, Hobsons Bay and Casey are also susceptible, with 10-17 km of rail track in each municipality vulnerable to sea level rise. Wellington's roads (640-775 km at risk) are areas of concern out of all LGAs in Melbourne. According to the study other places of high susceptibility are local roads in Greater Geelong (382-457 km).

It should be noted that the infrastructure and buildings in the LGAs discussed above are at highest risk out of all LGAs **across Victoria**.

The data presented in this report is a compilation of information available on the internet and within the public realm. This information indicates the high level of vulnerability that major urban areas of Melbourne are exposed to based on sea level rise and climate change predictions.

70. Department of Climate Change and Energy Efficiency, *Climate Change Risks to Coastal Buildings and Infrastructure*, Department of Climate Change and Energy Efficiency, Canberra, 2011.

Climate Change Initiatives for Melbourne

Across Australia many local governments are actively engaging climate change policies, frameworks and actions that are aimed at mitigating the impacts while nurturing economic prosperity. The City of Melbourne and the greater conurbation of this region have activated public policy initiatives from a variety of agencies and non-government organisations (NGO's). Although the full array of actions and policy initiatives is not represented in this report there has been an attempt to identify the most apparent engagement progressed and undertaken.

POLICIES AND FRAMEWORKS FOR CLIMATE CHANGE

According to Municipal Association of Victoria's (MAV) report on local government climate change adaptation planning in Victoria, all councils in Victoria, which have undertaken adaptation planning, have implemented a risk management framework for their decision making.⁷¹ The framework is based on the Australian Greenhouse Office's (AGO) guidance material, *Climate Change & Risk Management: A Guide for Business and Government*, which states that:

The manifestations of climate change includes higher temperature, altered rainfall patterns and more frequent or intense extreme events such as heatwaves, drought and storms. The document is a guide to integrating climate change impacts into risk management and other strategic planning activities in Australia public and private sector organisations. The purpose of this Guide is to assist Australian business and organisations to adapt to climate change.⁷²

The Guide then goes on to say it is directed at elected representatives and directors, general management and specialist risk managers or external risk experts. These directives offer guidance to leaders and policy authors to take into consideration. Such guidelines offered from the highest level of government ensure a clear standard of directives that can be implemented across the nation.

71. Municipal Association of Victoria, *Stocktake of Current Victorian Local Government Climate Change Adaptation Planning*, Municipal Association of Victoria, Melbourne, 2011.

72. Broadleaf Capital International & Marsden Jacob Associates, *Climate Change Impacts & Risk Assessment: A Guide for Business and Government*, Australian Greenhouse Office, Canberra, 2006, p. 8.

CLIMATE CHANGE ADAPTATION STRATEGY

A number of climate change adaptation strategies across the world have been engaged. *The Climate Change Adaptation Strategies for local Impact, Key Messages for UNFCCC Negotiators*, was published in May 2009. This document was aimed at providing an international protocol to considerations for how local communities across the planet can develop mitigations strategies for the impacts of climate change.⁷³ Later that same year in Australia, *Climate Change Adaptation Strategy* was prepared by The City of Melbourne. The City of Melbourne document outlines an assessment of major climate change risks that the city is anticipating and proposes adaptation measures for the City. This document informs the strategic planning process, which will guide the council's development to ensure that the city is resilient to climate change impacts. Moreover, the document is a communication platform for informing all stakeholders and the local community about implications of climate change for Melbourne. By being informed of the issues, stakeholders gain awareness of the issues and may develop more informed leadership response.⁷⁴

The City of Melbourne invested approximately \$30 million in its climate change initiatives in 2010-11 and \$11.2 million in 2011-2012.⁷⁵ The council aims to increase Melbourne's resilience to climate change by mitigating the extent of identified climate change risks through the following categories of actions:

- **loss prevention** (reducing the city's vulnerability to climate change);
- **loss sharing** (spreading any incurred losses among a wider population body (such as insurance));
- **behaviour modification** (eliminating human activity which causes environmental hazards); and
- **relocation** (moving vulnerable population or systems away from areas highly subject to climate change impacts).⁷⁶

Based on the risks identified under each major climate change impact, the strategy proposes a number of short-term and long-term adaptation actions. The strategy

73. International Federation of Red Cross and Red Crescent Societies, Red Cross / Red Crescent Climate Centre & ProVention Consortium, *Climate Change Adaptation Strategies for Local Impact: Key Messages for UNFCCC Negotiators*, The United Nations, Bonn, 2009.

74. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

75. City of Melbourne, *Adapting to climate change*, in City of Melbourne, 2012, retrieved 20 August 2012, <<http://www.melbourne.vic.gov.au/SUSTAINABILITY/COUNCILACTIONS/Pages/AdaptingClimateChange.aspx>>.

76. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

articulates two key adaptation measures which are ‘high value’ given that they can potentially address many risks.⁷⁷ The first measure, with the highest value and priority, is stormwater harvesting and re-use, which can: reduce potable water usage, water public parks and street trees, prevent floods, and improve local water system resilience. The second measure involves improving the city’s passive cooling efficiency to alleviate the UHI effect within the built environment.

ZERO NET EMISSIONS BY 2020

In 2009 the City of Melbourne established an ambitious target of zero net Green House Gas (GHG) emissions by 2020 for its municipality in its *Zero Net Emissions by 2020 publication*. The strategies and associated actions provide opportunities for emissions reduction across various aspects of the local economy and community. The following four sectors are the main focus of the strategy: commercial sector; residential sector; passenger transport (road and rail); and greening of power supply.⁷⁸ A number of actions articulated in the *Zero Net Emissions* strategy have been implemented by the local government authority. Some of the major initiatives are listed according to their respective sector in **TABLE 1**, which also lists the council’s emissions reduction objective for each sector⁷⁹

77. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

78. City of Melbourne, *Zero Net Emissions by 2020 - Update 2008*, City of Melbourne, Melbourne, 2008.

79. City of Melbourne, *Zero Net Emissions by 2020 - Update 2008*.

TABLE 1: MAJOR INITIATIVES ZERO NET EMISSIONS BY 2020

OBJECTIVE	ACTIONS
COMMERCIAL	
25% lower emissions by 2020	Implement a large-scale program to retrofit 70% (or 1200) of the existing office buildings Increase greenhouse performance standards to at least Australian Building Greenhouse Rating Scheme (ABGR) 5 stars Encourage owners of education, health and community buildings to retrofit their buildings Encourage the accommodation sector and the retail and wholesale sector to retrofit their buildings Establish new standards for retail, wholesale and hotel developments
RESIDENTIAL	
20% lower emissions by 2020	Facilitate a house-to-house audit program, which targets water heating, insulation and space Enable retrofits on common areas in 75% of high-rise residential developments Implement a behavioural change program to encourage local residents to be involved in the audit program, and provide energy efficiency advice to local residents
PASSENGER TRANSPORT	
20% lower emissions from public transport 15% lower emissions from cars, and 100% increase in bicycle use by 2020	Introduce low-carbon or green energy to reduce emissions generated by public transport Coordinate with the Department of Transport in improving public transport service and encourage a shift in transport mode from private cars Introduce a Cycle Melbourne scheme, an integrated program which will improve bicycle hire, end of trip facilities and cycling infrastructure
GREEN POWER SUPPLY	

OBJECTIVE	ACTIONS
18% lower emissions from conventional energy sources by 2020	<p>Encourage locally sourced and / or sited renewable energy generation (such as photovoltaic cells and wind turbines) in the following locations:</p> <ul style="list-style-type: none"> high density city blocks where heating and cooling demands are 24 hours any business or activity with a high electricity demand low-density manufacturing sites or offshore locations (for wind turbines)

COOL ROOFS

In 2011, the City of Melbourne commissioned the University of Melbourne to research different cool roof products and their relative performance in Melbourne’s climate.⁸⁰ This initiative is a response to the climate change’s extreme temperature rise impact as well as the UHI effect within the city. Cool roofs reduce the amount of heat transferred to their buildings below, which can keep buildings cooler and at a constant temperature.⁸¹ The study has been completed and the council aims to encourage building owners, managers and facility managers to apply cool roof technology to their building.

URBAN FOREST STRATEGY

Urban forest is the accumulation of all vegetation, soil and water which provides an ecosystem that enhances a city’s liveability. The City of Melbourne has adopted an Urban Forest Strategy, which will increase the Greater Melbourne’s canopy cover from 22% to 40% by 2040 and improve the biodiversity of Melbourne’s urban forest.⁸² This strategy, in addition to creating and maintaining Melbourne’s urban landscape integrity, also aims to mitigate the predicted rise in city’s temperature from climate change as well as the expected intensification of the UHI effect in the city. The urban forest will provide shade and cooling to improve thermal comfort at street level for city dwellers.

WATER SENSITIVE URBAN DESIGN GUIDELINES

The City of Melbourne published a Water Sensitive Urban Design (WSUD) Guidelines document in 2006 to inform council staff, residents and developers about how to apply

80. City of Melbourne, *Cool roofs*, in City of Melbourne, 2012, retrieved 19 August 2012, <<http://www.melbourne.vic.gov.au/Sustainability/CouncilActions/Pages/Coolroofs.aspx>>.

81. The University of Melbourne, *Cool Roofs: City of Melbourne Research Report*, City of Melbourne, Melbourne, 2011.

82. City of Melbourne, *Urban Forest Strategy: Making a great city greener 2012-2032*.

WSUD to their urban developments or water reuse and treatment projects.⁸³ WSUD principles are intended to minimise both urban pollution on natural water bodies and urban demand for water. Therefore, the guidelines are invaluable in order for an adequate response to the potential drought caused by climate change and limiting the city's demand for water.

JOINT ORGANISATIONS

A number of joint organisations have been established in response to climate change challenges. These organisations and their primary activities are outlined in **TABLE 2** below.

TABLE 2: JOINT CLIMATE CHANGE ORGANISATIONS IN MELBOURNE

ORGANISATION	PRIMARY ACTIVITY
South East Councils Climate Change Alliance	A network of 8 councils ⁸⁴ in South East Victoria, the South East Councils Climate Change Alliance, formerly Western Port Greenhouse Alliance, aims to plan and implement a collaborative regional response to climate change. The organisation has been carrying out projects in three main areas: greenhouse gas (GHG) abatement, carbon sequestration and climate change adaptation through research and responses. ⁸⁵
Greenhouse and Climate Change Alliances	Funded by the Victorian Government, Greenhouse and Climate Change Alliances are partnerships of over 70 councils in Victoria. The Alliances were established to respond to climate change through working closely with members, local communities and private organisations in mitigation, adaptation and sequestration activity. ⁸⁶
Central Victorian Greenhouse Alliance	The Central Victorian Greenhouse Alliance represents 14 local councils in Central Victoria, businesses and community organisations. ⁸⁷ The organisation's key activities include: raising awareness of climate change; initiating sustainability projects; and providing a forum for discussion of opportunities and challenges. ⁸⁸

83. City of Melbourne, *City of Melbourne WSUD Guidelines*, City of Melbourne, Melbourne, 2006.

84. A list of the council members of SECCCA can be found in Appendix B.

85. South East Councils Climate Change Alliance, *SECCCA: local governments in the south - east responding to climate change*, in South East Councils Climate Change Alliance, 2012, retrieved 19 August 2012, <http://www.seccca.org.au/docs/SECCCA_Flier.pdf>.

86. Greenhouse and Climate Change Alliances, *Greenhouse Alliances - Responding to the Challenge of Climate Change*, Greenhouse and Climate Change Alliances, Melbourne, 2012.

87. A list of all members of the Central Victorian Greenhouse Alliance can be found in Appendix C.

88. Central Victorian Greenhouse Alliance, *Welcome to the CVGA*, in Central Victorian Greenhouse Alliance, 2012, retrieved 21 August 2012, <<http://www.cvga.org.au/main/>>.

WESTERN PORT'S CLIMATE CHANGE IMPACTS AND ADAPTATION

The Climate Change Impacts and Adaptation Western Port scoping study, funded by the Department of Sustainability and Environment (DSE), was launched in 2005 by the South East Councils Climate Change Alliance (SECCCA). The study aimed to increase awareness of climate change impacts across the Western Port region, assess the region's vulnerabilities to climate change, and explore potential adaptation measures for the region. The study comprises three stages: 1) Needs Analysis, 2) Climate Change Impacts in Western Port, and 3) Stakeholder Engagement. As a result of these studies, a project on the impacts of climate change within human settlements in the region was undertaken.⁸⁹

NEEDS ANALYSIS

The first stage of this work involved identification of key stakeholders' information requirements. Interviews were conducted with 25 stakeholders (15 local councils and 10 private organisations) to determine the types of climate change information required by different sectors, who would use the information, and how new information could be integrated into the decision making processes of the stakeholders' organisation. The study findings indicated a need for local governments to play a leadership and coordination role in instigating regional response to climate change.⁹⁰

CLIMATE CHANGE IMPACTS IN WESTERN PORT

The second stage of the scoping study investigated Western Port's regional profile and climate change impacts on the region's natural environment, economy and society. The study concluded that effective adaptation to climate change requires government, business and communities in the region to understand the new challenges presented by climate change, and take action to reduce or manage the likely impacts of climate change.⁹¹

STAKEHOLDER ENGAGEMENT

In the third stage, a series of workshops were organised to identify and prioritise climate change risks within three major domains including environment and natural resources, social and community, and economy and infrastructure. Over 100 representatives from the following groups participated in the workshops: state government, local government,

89. South East Councils Climate Change Alliance, *Adapting to the Impacts of Climate Change in the Western Port Region 2005-2006 Projects*, in South East Councils Climate Change Alliance, 2009, retrieved 18 August 2012, <http://www.seccca.org.au/project_summary.asp?data_id=11>.

90. The Regional Development Company, *Climate Change Impacts and Adaptation in Western Port Region: Needs Analysis Report*, South East Councils Climate Change Alliance, Melbourne, 2005.

91. C Brooke & P Kinrade, *Climate Change Impacts in Western Port*, South East Councils Climate Change Alliance, Melbourne, 2006.

training institutions and community organisations.⁹² The study determined key issues such as stormwater, housing and accommodation, infrastructure siting and planning⁹³ and prioritized them.

IMPACTS OF CLIMATE CHANGE ON HUMAN SETTLEMENTS IN WESTERN PORT

This project aimed to enhance the capacity and knowledge of local councils, state government and other relevant stakeholders in Western Port to prepare climate change adaptation strategies. The project involved an integrated assessment which combined environmental, social and economic knowledge on climate change. The study identified key climate change impacts as well as implications on housing, land and infrastructure in the region. Adaptation measures that decision makers could implement were also explored.⁹⁴ As a result of the study, local councils in Western Port now have a comprehensive understanding of exposure to climate change risks.

DECIDING FOR THE COAST

The Australian Government's Department of Climate Change and Energy Efficiency *Coastal Centre for Climate Change Adaptation Program* provided a grant through the *Coastal Adaptation Decision Pathways* for the South East Coast Councils Climate Change Alliance to launch the *Deciding for the Coast* program in 2011. The project will develop decision support instruments for coastal planners in Western Port in relation to the threat of sea level rise. *Deciding for the Coast* will provide a series of options, assessment criteria and decision checklists for comparison of alternative coastal adaptation and decision making pathways. The planning tools to be considered include land use zoning capacities, the establishment of land use constraint overlays, setting thresholds and trigger points for actions. The objective of the work is to provide effective decision-making process for use by local government councils in their adaptation actions.⁹⁵

STATE AND FEDERAL GOVERNMENT INITIATIVES

Climate change planning is high on the agenda of state and federal government authorities. The Australian Government has adopted the Clean Energy Future Plan, which

92. South East Councils Climate Change Alliance, *Adapting to the Impacts of Climate Change in the Western Port Region 2005-2006 Projects*.

93. Marsden Jacob Associates, The Regional Development Company & CSIRO, *Adapting to the Impacts of Climate Change in the Western Port Region: Part 3 - Strategic Directions*, South East Councils Climate Change Alliance, Melbourne, 2006.

94. SECCCA, *Impacts of Climate Change on Human Settlements in the Western Port Region: an Integrated Assessment - Briefing Paper*, South East Councils Climate Change Alliance, Melbourne, 2006.

95. SECCCA. *Deciding for the coast*, in South East Councils Climate Change Alliance, 2012, retrieved 20 August 2012, <http://www.seccca.org.au/project_summary.asp?data_id=17>.

will attempt to mitigate climate change impacts by reducing national pollution and driving investment and innovation in renewable energy through a carbon pricing mechanism.⁹⁶ Farmers and land managers are encouraged to store carbon or reduce greenhouse gas emissions on the land through the Carbon Farming Initiative.⁹⁷

State and federal government agencies have commissioned a number climate change studies to determine the likely impacts of climate change on local communities and infrastructure. For example, AECOM was commissioned to undertake a series of case studies of infrastructure and settlements. An economic framework was developed to evaluate different climate change adaptation strategies in terms of their costs and benefits. This framework was applied to three case studies, two of which are in Melbourne, on the following topics: coastal inundation, long-term water supply security, and impacts of temperature changes on metropolitan Melbourne's rail network.⁹⁸

96. Australian Government, *Clean Energy Future – our Plan*.

97. Department of Climate Change and Energy Efficiency, *Carbon Farming Initiative*.

98. AECOM, *Economic framework for analysis of climate change adaptation options*.

Analysis of Climate Change Initiatives

An analysis of the discussed climate change initiatives suggests that climate change is a high priority issue for local councils in Victoria as a whole and metropolitan Melbourne in particular. Local government councils are collaborating with local community members and the private sectors to develop greater awareness and secure participation in their climate change adaptation measures. Climate change impacts are also being closely monitored by local, state and federal governments. Four major points, discussed below, arise from the analysis: 1) risk management's benefits and drawbacks, 2) funding segmentation and constraint, 3) effective collaborative efforts, and 4) comprehensive planning for climate change.

RISK MANAGEMENT'S BENEFITS AND DRAWBACKS

The Australian Government's Department of Environment and Heritage Australian Greenhouse Office (AGO) publication, *Climate Change Impacts & Risk Management Guide* has been broadly recognised and in this case study, utilised by councils in the greater Melbourne metropolitan area. There are two sides to this level of strategic planning that detail both advantages and disadvantages. **TABLE 3** below attempts to articulate the difference more clearly.⁹⁹

99. Municipal Association of Victoria, *Stocktake of Current Victorian Local Government Climate Change Adaptation Planning*.

TABLE 3: BENEFITS AND DRAWBACKS OF AGO’S RISK MANAGEMENT FRAMEWORK

ADVANTAGES	DISADVANTAGES
CONSISTENCY WITH EXISTING FRAMEWORK	LIMITATION OF OPPORTUNITY IDENTIFICATION
The framework is highly consistent with existing council risk management frameworks. Thus, council staff participating in planning processes for climate change were familiar with the framework.	The focus of risk management is primarily on identification and treatment of risk, which may limit opportunities presented by climate change to be missed during the planning processes.
AWARENESS CREATION	EXTENSIVE WORKSHOPS
The risk assessment process allowed all participating staff to develop awareness and understanding of climate change issues. As a result, climate change was moved from “an environmental issues to a council issue”, and many staff immediately considered implications of climate change for their responsible area. ¹⁰⁰	Risk assessment workshops can be “tedious and intense” as too many stakeholders are involved in an attempt to cover too many issues. ¹⁰¹

Climate change represents not only challenges but also opportunities.¹⁰² Thus, the risk management framework’s limitation of opportunity identification may significantly impede the ability of local government agencies throughout Australia to pursue opportunities found in their climate change adaptive planning. Opportunities that may be missed as a result of the risk management procedure can include, but are not limited to:

- extensive involvement and collaboration with the private sector and local communities in climate change adaptation planning;
- emphasis on technology utilising alternative, renewable sources of energy (for example 100 per cent of Victoria’s energy needs could be supplied using a combination of wind, bioelectricity, solar and geothermal power);¹⁰³ and
- opportunity to implement behavioural change programs to promote energy efficiency across businesses and households.¹⁰⁴

100. Municipal Association of Victoria, *Stocktake of Current Victorian Local Government Climate Change Adaptation Planning*, p. 22.

101. Municipal Association of Victoria, *Stocktake of Current Victorian Local Government Climate Change Adaptation Planning*, p. 23.

102. City of Melbourne, *Zero Net Emissions by 2020: A roadmap to a climate neutral city*, City of Melbourne, Melbourne, 2002.

103. Central Victorian Greenhouse Alliance, *Welcome to the CVGA*.

FUNDING SEGMENTATION AND CONSTRAINT

Funding in councils is traditionally provided for adaptation planning for one specific issue (such as health or water). Such funding segmentation has resulted in a disjointed consideration of climate change implications for local councils, which are highly interdisciplinary and cut across a number of business units. In addition, rather than ongoing, funding is often once-off, which leads to inadequate funding for implementation of strategies. Furthermore many councils, particularly those with limited resources, frequently lack sufficient funding to commission climate change planning work.¹⁰⁵

To overcome this, state and federal government departments should provide funding packages for councils to plan and implement a holistic climate change strategy for their communities. These funding packages should also require climate change adaptation planning to consider various issues and involve several council departments. Funding from higher levels of governments is already occurring for some council initiatives (such as Victorian Government's funding for Greenhouse Alliances and DSE's funding for SECCCA's Climate Change Impacts and Adaptation Western Port scoping study).

EFFECTIVE COLLABORATIVE EFFORTS AMONG COUNCILS

Councils within Melbourne and its regional area have been collaborating together on a number of initiatives as joint organisations. Such collaboration is an effective method of accumulating and sharing resources and insights of each individual council, which is small in size and commonly lacks adequate staff and budget for undertaking climate change planning individually.¹⁰⁶ The joint collaborations have resulted in implementation of a number of climate change studies and community projects.

LIMITED COLLABORATION WITH THE PRIVATE SECTOR

Across the initiatives reviewed by this study, there is limited collaboration between local councils and the private sector. Eight private stakeholders are partners in the Central Victorian Greenhouse Alliance whereas businesses are engaged by Greenhouse and Climate Change Alliances. Given funding and resource constraints of many councils, there is a need for greater involvement of the private sector in planning for adaptation to climate change. By collaborating together, resources (including personnel, expertise and

104. Department of Climate Change and Energy Efficiency. *New energy efficiency programs provide opportunity*, 2012, retrieved 25 August 2012, < <http://www.climatechange.gov.au/media/whats-new/energy-efficiency-programs.aspx>>.

105. Municipal Association of Victoria, *Supporting Victorian Local Government Manage Climate Risks and Plan for Change*, Municipal Association of Victoria, Melbourne, 2011.

106. Municipal Association of Victoria, *Supporting Victorian Local Government Manage Climate Risks and Plan for Change*.

funds) can be shared between the private sector and the public sector in order to effectively plan and implement climate change initiatives. Furthermore, climate change will impact all stakeholders and not just local communities. Thus, adaptive planning is a shared responsibility of all levels of government and the private sector.

As climate change impacts are complex and multi-faceted, private sectors, which should be involved in climate change planning, could include: commercial and banking sectors (to ensure insurances are in place to spread financial impacts of climate change); tertiary sector (to conduct cutting-edge research on climate change impacts and best practices of climate change adaptation); property and infrastructure (to ensure new and existing buildings and infrastructure are resilient to climate change impacts and minimise their GHG emissions); and community organisations (to create and sustain community awareness of climate change impacts and implications for local community members). Private sector input is also important for many adaptation measures proposed by the City of Melbourne¹⁰⁷, some of which are outlined in

TABLE 4.

107. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*.

TABLE 4: POTENTIAL CONTRIBUTION OF PRIVATE SECTOR TO CITY OF MELBOURNE’S PROPOSED CLIMATE CHANGE ADAPTATION MEASURES

MEASURE	POTENTIAL PRIVATE SECTOR’S CONTRIBUTION
“Saving water ... at source [with] demand management strategies which engage, communicate and educate to bring about behavioural change.” ¹⁰⁸	Local community organisations, particularly those representing the interest of specific demographic groups, can liaise with the council and organise educational forums for their members to reduce their water usage.
“Saving water and preventing stormwater pollution at source by using structural techniques to treat and/or harvest alternative water supplies.” ¹⁰⁹	Research institutions and tertiary education institutions can be engaged to conduct research on best practices of water harvesting and treatment which could potentially be implemented throughout Melbourne.
“Engage with sporting grounds managers and sporting groups to convey risks of hardening grounds and likely adaptation measures.” ¹¹⁰	Sporting clubs and groups should partner up with local councils to plan and implement climate change adaptation measures for their sporting facilities.
“Review transport upgrade recommendations for Melbourne with relevant stakeholders to consider potential for inclusion of additional climate resilience measures” ¹¹¹	Transport planning consultants can be engaged to develop and evaluate options for improving resilience of transport infrastructure to climate change impacts in Melbourne.
“Liaise with relevant stakeholders regarding potential revision of engineering guidelines relevant to the City of Melbourne [in response to the potential impacts of heatwave].” ¹¹²	Ongoing engagement with and input from engineering and infrastructure consultants is necessary for the revision of these guidelines.
“Revised planning guidelines for habitable floor levels to better protect future development.”	Property developers should communicate with local councils to ensure that their interests and opinions are taken into consideration during the revision of the planning guidelines.

108. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*, p. 93.

109. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*, p. 93.

110. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*, p. 94.

111. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*, p. 97.

112. City of Melbourne, *City of Melbourne Climate Change Adaptation Strategy*, p. 100.

COMPREHENSIVE PLANNING FOR CLIMATE CHANGE

The City of Melbourne's *Climate Change Adaptation Strategy* and *Zero Net Emissions by 2020* strategy are exemplars of how a local council can comprehensively respond to climate change through adapting to potential climate impacts and mitigating the city's GHG emissions. The council has established clear goals and actions for the municipality's emissions reduction within each sector in the *Zero Net Emissions* strategy. Meanwhile, the *Climate Change Adaptation Strategy* has integrated a risk management methodology systematically whereby each risk identified is given a weighting over short (now), medium (2030) and long (2070) terms in order to prioritise adaptive responses of the strategy. Each adaptive measure is also assessed in terms of its value by identifying the risks it influences or controls. Adaptive measures with the highest value are then given high priority. Additionally, the council identifies stakeholders to share and mitigate each of the identified risks. Thus, the local government, with its engagement with local communities is well-prepared to address many of the areas of its municipality's vulnerability to climate change.

Both strategic documents serve as models that may be modified for other local councils in Australia to replicate in their climate change planning.

Conclusion

According to a number of studies by public and private organisations, climate change is occurring and its impacts are already evident. Many cities are now at risk from climate change. Each city is subject to different climate change impacts given its unique geographical and demographic profile and its specific mix of local sensitivity, resilience and response capacity. Melbourne, the capital city of Victoria and predicted to be Australia's largest city by 2030, is potentially subject to four particular climate change impacts, including: drought and reduced rainfall, extreme temperature rise, intense rainfall, and sea level rise.

These climate change impacts represent high risks not only the population of metropolitan Melbourne, but also the city's built and natural environments. Impacts of climate change are multi-faceted, widespread, significant and growing. This review has discussed climate change impacts which have been projected by a number of organisations. There is a high degree of uncertainty in future climate change outcomes, which implies that ongoing monitoring of climate change will be vital for organisations to plan and respond through adaptation strategies.

Local councils, given their close link to local communities, have a major role of ensuring their communities are resilient to climate change in the short, medium and long terms. The City of Melbourne has noted that "*Cities which plan and act early will better withstand the impacts of climate change and maintain a platform for future health and prosperity.*"¹¹³ This paper has explored some major climate change adaptation measures in place for local authorities in Victoria, and revealed that climate change is a topic of significant priority for local councils. Many local governments have incorporated climate change planning into their strategic planning instruments. Furthermore, a number of councils have formed networks to collaborate and combine their resources and knowledge in climate change planning and actions. Based on the policies reviewed, the review revealed that metropolitan Melbourne is actively developing resilience to climate change.

However, three major challenges may represent barriers to effective climate change adaptation planning in the future. First, whilst councils have implemented the Commonwealth Governments risk management framework for their climate change planning, the methodology has both benefits and drawbacks. The most significant drawback of this approach is the potential limitation of opportunity identification, as climate change creates not only challenges but also opportunities. Therefore, the risk management process, which primarily emphasises identification and treatment of risk, should be revised to give equal consideration to opportunities which councils can potentially pursue in light of climate change.

113. City of Melbourne, *Adapting to climate change*.

Second, given the limited size and resource availability of many local governments there are constraints in strategic preparedness. Allowances that can alleviate this constraint in order to achieve higher level readiness of climate change impact and future planning are recommended. To overcome this issue, state and federal government agencies should increasingly provide policy guidance, funding and support in this important area of risks management.

Finally, it is important to note that there is limited collaboration between local councils and the private sector in this field. Greater levels of engagement and involvement of the private sector is needed to plan and implement climate change policies. Collaboration with private stakeholders can be an opportunity to share resources and expertise and examples include commercial and banking sector, tertiary sector, property and infrastructure, and community organisations.

The risk associated with climate change goes well beyond the jurisdiction of governments and will only be affectively mitigated if private enterprise and commercial interest are included in problem solving and actioning of initiatives.

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Appendices

APPENDIX A: SUBURBS AT RISK FROM SEA LEVEL RISE

The following suburbs in Melbourne were identified to be vulnerable to inundation as a result of a 1.1 metre sea level rise:

- Queenscliff;
- Point Lonsdale and its surrounding suburbs of Ocean Grove, Barwon Heads, Connewarre and Wallington;
- Swan Bay, particularly at Swan Bay Holiday Park;
- St Leonards, particularly the community surrounding Salt Lake and the community adjacent to Edwards Point State Faunal Reserve;
- Portarlington and Indented Head, particularly the community situated along the coast
- Breamlea, particularly the community adjacent to Thompson Creek;
- Elwood;
- Aspendale Gardens and Chelsea Heights;
- Patterson Lakes;
- Seaford, particularly the community adjacent to Seaford Wetlands;
- Frankston, particularly the community along Kananook Creek;
- Hastings, particularly the community adjacent to Jacks Beach Reserve and Western Port;
- Somerville;
- Cannons Creek, Warneet and Blind Bight;
- Tooradin, Dalmore and Koo Wee Rup, the majority of which will be fully inundated;
- Caldermeade;
- Jam Jerrup;
- Pioneer Bay, Grantville and Queensferry;
- Corinella and Coronet Bay, particularly the community located adjacent to the coast; and
- San Remo, particularly the community along the coast.

These suburbs were identified through an appraisal of all sea level rise maps (under the 1.1 metre sea level rise scenario) published on OzCoasts.¹¹⁴

114. Geoscience Australia, *Sea level rise maps: Melbourne region*.

APPENDIX B: SOUTH EAST COUNCILS CLIMATE CHANGE ALLIANCE'S COUNCIL MEMBERS

SECCCA is a network of the following eight local councils in South East Victoria:

- Bass Coast Shire Council;
- Shire of Baw Baw;
- City of Bayside;
- Cardinia Shire Council;
- City of Casey;
- Frankston City Council;
- Kingston City Council; and
- Mornington Peninsula Shire Council.¹¹⁵

APPENDIX C: CENTRAL VICTORIAN GREENHOUSE ALLIANCE'S MEMBERS

As of March 2011, the Central Victorian Greenhouse Alliance represents a number of council, corporate, business, NGO and community members, listed below:

council members:

- Buloke Shire Council;
- Campaspe Shire Council;
- Central Goldfields Shire Council;
- City of Ballarat;
- City of Greater Bendigo;
- Gannawarra Shire Council;
- Hepburn Shire Council;
- Loddon Shire Council;
- Macedon Ranges Shire Council;
- Mount Alexander Shire Council;
- Northern Grampians Shire Council;
- Pyrenees Shire Council;
- Ararat Rural City Council;
- Swan Hill Rural City Council;

115. South East Councils Climate Change Alliance, *SECCCA: local governments in the south - east responding to climate change*.

corporate / business / NGO members:

- Bendigo Access Employment;
- Bendigo bank;
- Bendigo Health Care Group;
- La Trobe University;
- North Central CMA;
- WestWind;
- Hepburn Wind;
- Embark;

community groups:

- Ballarat Renewable Energy and Zero Emissions Inc (BREAZE);
- Sustainable Hepburn Association (SHARE);
- Sustainable Living in the Mallee (SLIM); and
- Bendigo Sustainability Group (BSG).¹¹⁶

116. Central Victorian Greenhouse Alliance, *CVGA Members*, in Central Victorian Greenhouse Alliance, 2011, retrieved 21 August 2012, <http://www.cvga.net.au/main/index.php?option=com_content&task=view&id=17&Itemid=42>.