ADAPTATION IN THE NORTH

An Integrated Regional Vulnerability Assessment

VOLUME 1

Northern Alliance for Greenhouse Action

NAGA
NORTHERN ALLIANCE FOR GREENHOUSE ACTION

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David Meiklejohn
NAGA Executive Officer

CONTENTS

ACRONYMS

ABS	Australian Bureau of Statistics
AEP	Annual Exceedance Probability
AR5	Fifth Assessment Report
ARI	Average Recurrence Interval
CaLD	Culturally and Linguistically Diverse
CASBE	Council Alliance for a Sustainable Built Environment
CBD	Central Business District
CEDA	Committee for Economic Development of Australia
CMA	Catchment Management Authority
COAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEPI	Department of Environment and Primary Industries
DIICSRTE	Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education
DOH	Department of Health
DSE	Department of Sustainability and Environment
DTPLI	Department of Transport, Planning and Local Infrastructure
EPA	Environment Protection Authority
ESD	Environmentally Sustainable Design
EVC	Ecological Vegetation Class
FDI	Fire Danger Index
FDR	Fire Danger Rating
FFDI	Forest Fire Danger Index
FO	Floodway Overlay
GFDI	Grassland Fire Danger Index
GIS	Geographic Information Systems
HACC	Home and Community Care
IPCC	Intergovernmental Panel on Climate Change
IRSD	Index of Relative Socio-Economic Disadvantage
IRSAD	Index of Relative Socio-Economic Advantage and Disadvantage

IRVA	Integrated Regional Vulnerability Assessment
ITS	Intelligent Transport Systems
LGA	Local Government Area
LSIO	Land Subject to Inundation Overlay
MAV	Municipal Association of Victoria
MCA	Multi-Criteria Analysis
MEFL	Moreland Energy Foundation Limited
NAGA	Northern Alliance for Greenhouse Action
NCCARF	National Climate Change Adaptation Research Facility
NGO	Non-Government Organisation
NRM	Natural Resource Management
OESC	Office of the Emergency Services Commissioner
PIA	Planning Institute of Australia
PPF	Planning Policy Framework
PPWCMA	Port Phillip and Westernport Catchment Management Authority
RCCAP	Regional Climate Change Adaptation Plan
RCP	Representative Concentration Pathways
SBO	Special Building Overlay
SEIFA	Socio-Economic Indexes for Areas
SLA	Statistical Local Area
SRES	Special Report on Emissions Scenarios
UDIA	Urban Development Institute of Australia
UFZ	Urban Floodway Zone
UHI	Urban Heat Island
UNFCCC	United Nations Framework Convention on Climate Change
URP	Usual Resident Population
VCCCAR	Victorian Centre for Climate Change Adaptation Research
VCOSS	Victorian Council of Social Service
VEAC	Victorian Environmental Assessment Council
WSUD	Water Sensitive Urban Design

1. INTRODUCTION

1.1 Overview

The Northern Alliance for Greenhouse Action (NAGA) consists of nine northern Melbourne metropolitan councils: Banyule, Darebin, Hume, Manningham, Melbourne, Moreland, Nillumbik, Whittlesea and Yarra, as well as the Moreland Energy Foundation Limited (MEFL).

Since 1910, there has been almost a degree increase, 0.9°C, in the average surface temperature across Australia (CSIRO and Australian Bureau of Meteorology: 2014) and climate events, such as flooding, heatwaves and bush and grassland fires have been acutely felt in the NAGA region over recent years. On the basis of historic and current rates of carbon emissions it is almost certain that there will be a further increase in the average surface temperature and additional climatic shocks and stresses in the future.

For local government, the climatic changes experienced to date and those projected for coming decades represent a significant source of risk, both from a corporate and community perspective. At a corporate level, the ability to deliver services across council can be impinged by impacts associated with climatic shocks and stresses. During these periods of climatic shocks and stresses it is often the most vulnerable in the community that are at greatest risk and councils are called on to respond, compounding the strain on resources and in turn exacerbating the potential risk to council.

Over the past decade NAGA has forged a reputation as a leader in carbon mitigation, reducing the emissions of carbon from member councils and the community through fostering regional scale collaboration, capacity building and governance and action. In response to the current and potential climate related risks to councils, NAGA's focus is now shifting to include a regional approach to adapting and building resilience to the impacts of climate change. A regional approach provides benefits in terms of the sharing of resources, enhanced communications and advocacy and the building of networks across the region to enable cooperative analysis and problem solving.

> **Local government bears the brunt of the challenges, so they are best to act. But individually we cannot get necessary momentum, sufficient buy-in, sufficient data, and sufficient resources, so as a group we have more clout. And also the problem of climate change like other environmental problems doesn't mimic or stop at local government borders – best to act regionally/locally.**
>
> *- Response to member survey in May 2014 on being asked the benefits of working regionally*

In response and through funding from the Victorian Government, NAGA has conducted an integrated regional vulnerability assessment (IRVA) that forms the basis of this regional climate change adaptation plan, *Adaptation in the North*. The plan is the first assessment of the potential impacts of projected climatic changes for the NAGA region (Figure 1), the degree of risk associated with these impacts and an assessment of who or what is most vulnerable to the most significant risks. Adaptation to a changing climate is and will be an ongoing process requiring adjustment and refinement over the coming years.

Development of *Adaptation in the North* has been based on an IRVA approach, where the climatic impacts, risks and vulnerabilities have been considered across six sectors: human services, emergency management, infrastructure, industry, natural ecosystems and planning.

Adaptation in the North is structured in two parts:

- Volume I represents the main strategy and contains all relevant information in relation to the approach to the IRVA, projected climatic changes for the region, impacts, risks, vulnerabilities, sectoral findings and relevant actions.
- Volume II contains all relevant supporting information and provides a resource to inform the development of further council specific action by NAGA members.

In preparing a wide ranging document such as this numerous people have provided time, energy and input to inform its content and structure. The Project Working Group wishes to thank all those who have generously participated and provided their time in developing this plan.

Figure 1 - The NAGA Region

1.2 Terminology

To aid in the reading of the RCCAP the following terms have been defined. The primary source for these definitions is *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC: 2014a).

Adaptation

The process of adjustment to actual or expected climate change and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate change and its effects (IPCC: 2014a).

Confidence

A synthesised representation of the validity of a finding from evidence and level of agreement. Levels of confidence include five qualifiers: very low, low, medium, high and very high (IPCC: 2014a).

Exposure

The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected by climatic shocks or stresses (IPCC: 2014a).

Impact

The term impacts is used primarily to refer to the effects on natural and human systems of climate events and. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period, and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts and sea level rise, are a subset of impacts called physical impacts (IPCC: 2014a). Impacts are classified as 'direct' if there is an immediate causal relationship between a climatic exposure and the impact. Impacts are considered 'indirect' if they occur as a result of an interaction between a climatic exposure and the natural, built or socioeconomic environment.

Mitigation

A human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC: 2014b).

Risk

The effect of uncertainty on objectives (ISO: 2009).

Resilience

The capacity of social, economic, and environmental systems to cope with a hazardous event, trend or disturbance by responding or reorganising in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation (IPCC: 2014a).

Uncertainty

The degree of certainty in each finding of an assessment based on the type, amount, quality and consistency of evidence and degree of agreement (IPCC: 2014a).

Vulnerability

The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC: 2014a).

Vulnerability Indicators

Measurable characteristics of populations, infrastructure, services and natural ecosystems that can be monitored by a council to effectively understand the vulnerabilities within its municipality.

2. CLIMATE ADAPTATION IN THE NAGA REGION

Representing a region of approximately 1.1 million people, or just over a quarter of Greater Melbourne's population, the NAGA region contains a multitude of urban forms, populations and environments.

These range from the central business and high density living areas of the City of Melbourne to the historical strip shopping and creative areas of the inner north, in the City of Yarra and City of Moreland. Moving northward, the predominantly residential areas of the middle ring municipalities of the City of Manningham, City of Banyule and City of Darebin give way to the growth areas of the City of Hume and City of Whittlesea where, in addition to current and planned residential areas, lies large areas of industrial and commercial land. These municipalities and the Shire of Nillumbik also contain semi-rural areas within the Green Wedge Zone, areas outside of the Urban Growth Boundary reserved for non-urban development land uses.

In future years, the rate of population increase in the NAGA region is projected to grow by more than 50 per cent by 2031, representing almost 30 per cent of the 2031 Greater Melbourne population. Across the NAGA region the largest proportional growth is expected amongst those aged 35-49, coupled with growth in the proportion of older people in the population.

Over recent years the region has been impacted by a number of climate events, bringing into sharp focus the vulnerability of the region to these shocks and stresses and the question of how projected climatic changes will further exacerbate the impacts associated with such events over coming decades.

The most high profile of these events, the Black Saturday fires of 7 February 2009, resulted in a multitude of catastrophic impacts, including the loss of 173 lives and the dislocation of whole communities (2009 Victorian Bushfires Royal Commission: 2010). The fires had been proceeded by a week-long heat wave that lead to 374 excess deaths above what would normally be expected for this period (Department of Human Services: 2009), with the greatest number of deaths occurring in those aged 75 years and older.

In addition to fire and heatwaves, over recent years there have also been events of extreme rainfall across the eastern seaboard. Victoria experienced significant flooding of rural areas between September 2010 and February 2011, with several communities being subjected to successive flood events and associated impacts. Across Melbourne's North, an extreme storm event on Christmas Day 2011 led to flash flooding of residential and commercial premises.

From an economic perspective, these events place considerable strain on those directly impacted as well as indirectly through flow on effects, such as increased insurance premiums. An indicator of the order of these effects is provided by the Insurance Council of Australia which has calculated the cost, based on insured loss, of the Black Saturday fires as exceeding $1.2 billion (based on 2011 dollars) and the
Christmas Day floods in 2011, as approximately $728 million (Insurance Council of Australia: 2015). There is a clear role for all levels of government and decision makers to ensure that the projected impacts and vulnerabilities are considered and actively addressed as part of the decision-making processes for the NAGA region.

Already across the NAGA region, member councils are undertaking a range of actions to address projected impacts and vulnerabilities, either through defined climate change adaptation strategies, complementary issue specific (e.g. health and wellbeing or integrated water management) strategies or via projects jointly delivered with Victorian Government or Commonwealth Government funding.

An overview of relevant NAGA council strategies is presented in Table 1 and examples of actions implemented to date across the region include the formation of the North West Metro Region Collaboration Project for Emergency Management, development of the Banyule Stormwater Harvesting Project, the City of Melbourne Urban Forest Strategy and the City of Whittlesea internal cross council forum for addressing climate change issues.

COUNCIL	CLIMATE CHANGE RELATED COUNCIL STRATEGIES
Banyule	Banyule People: Health and Wellbeing Policy and Strategy 2013-2017
	Banyule City Council Municipal Emergency Management Plan
	Banyule Community Emergency Risk Management (CERM) Plan
	Banyule Planet Environmental Sustainability Policy and Strategy 2013-2017
Darebin	City of Darebin Climate Change and Peak Oil Adaptation Plan 2009
	City of Darebin Community Health and Wellbeing Plan 2009-2013
	City of Darebin Municipal Emergency Management Plan 2012
	Darebin Heatwave Strategy 2013-2017
Hume	Hume City Council Climate Change Adaptation Plan 2013
	Hume City Council Climate Change Adaptation Action Plan 2013-2017
	Hume Health and Wellbeing Plan 2013-17
	Hume City Council Heatwave Plan 2010
	City of Hume Emergency Management Plan 2011
	Hume City Council Health and Wellbeing Plan 2013-2017

COUNCIL	CLIMATE CHANGE RELATED COUNCIL STRATEGIES
Manningham	Securing the Future: Responding to climate change, peak oil and food scarcity, July 2012 Adaptation Plan
	Manningham Healthy City Plan 2013/2017: Municipal Public Health and Wellbeing Plan
	Manningham Municipal Emergency Management Plan 2013
	Manningham Climate 2020 Action Plan
	Manningham Green Wedge Action Plan 2020
Melbourne	City of Melbourne Climate Change Adaptation Strategy
	NCCARF Climate Change Adaptation Good Practice - Case Study: City of Melbourne Climate Change Adaptation Strategy and Action Plan
	City of Melbourne 2014 Heatwave Business Impacts - Social Research
	Melbourne Council Plan 2013-2017: Municipal Public Health and Wellbeing Plan
	Urban Forest Strategy 2012 - 2032
	Total Watermark Strategy 2014
Moreland	Moreland Municipal Public Health and Wellbeing Plan 2013-2017
	Moreland City Council Municipal Emergency Management Plan 2013
	Zero Carbon Evolution Strategy (2014 – 2020)
Nillumbik	Nillumbik Shire Council Health and Wellbeing Plan 2013-2017
	Nillumbik Municipal Emergency Management Plan 2014-2017
	Climate Change Action Plan 2010-2015
Whittlesea	City of Whittlesea Council Plan 2013-2017: Municipal Public Health and Wellbeing Plan
	City of Whittlesea Environmental Sustainability Strategy 2012-2022
	City of Whittlesea Community Emergency Risk Management Risk Register and Treatment Plan
Yarra	Yarra Climate Change Adaptation Plan 2013-2014
	City of Yarra Health Plan 2013-2017
	City of Yarra Heatwave Plan
	City of Yarra Municipal Emergency Management Plan

Table 1 - Existing NAGA member council climate change strategies

The split of roles and responsibilities between the three levels of government - Commonwealth, state and territory and local - as well as those of business and the community, is defined by the Council of Australian Governments (COAG) through a Statement of Common Understanding on the *Roles and Responsibilities for Climate Change Adaptation in Australia* (Department of the Environment: 2012). The COAG statement notes that:

local governments are on the frontline in dealing with the impacts of climate change, having a critical role to play in ensuring that particular local circumstances are adequately considered in the overall adaptation response and in involving the local community directly in efforts to facilitate effective change. Further, they are strongly positioned to inform state and Commonwealth Governments about the on-the-ground needs of local and regional communities, to communicate directly with communities, and to respond appropriately and in a timely manner to local changes.

Specifically, COAG states that local governments have responsibility to:

- administer relevant state and territory and / or Commonwealth legislation to promote adaptation as required including the application of relevant codes, such as the Building Code of Australia;
- manage risks and impacts to public assets owned and managed by local governments;
- manage risks and impacts to local government service delivery;
- collaborate across councils and with state and territory governments to manage risks of regional climate change impacts;
- ensure policies and regulations under their jurisdiction, including local planning and development regulations, incorporate climate change considerations and are consistent with state and Commonwealth government adaptation approaches;
- facilitate building resilience and adaptive capacity in the local community, including through providing information about relevant climate change risks;
- work in partnership with the community, locally-based and relevant NGOs, business and other key stakeholders to manage the risks and impacts associated with climate change; and
- contribute appropriate resources to prepare, prevent, respond and recover from detrimental climatic impacts.

The Victorian Government has adopted this common understanding to frame development of the *Victorian Climate Change Adaptation Plan* (Victorian Government: 2013). The *Climate Change Adaptation Memorandum of Understanding* (MoU) signed between the Victorian Government, the Municipal Association of Victoria (MAV) and the VAS Partnership Ministerial Advisory Committee formalises the partnership between state and local government to increase clarity of responsibilities in climate change adaption.

The MoU identifies priority areas for both local and state government to focus on in climate change adaptation. The priority areas (Victorian Government: 2014) most applicable to NAGA region member councils include:

- ***Agricultural productivity and economic development*** – this recognises the specific impacts on regional
  and rural areas as a result of projected changes in temperature and rainfall.
- ***Community engagement, empowerment and information provision*** – this recognises the importance of a community understanding climate risks. The provision of information and guidance can help build capacity and empower the community for climate change adaptation.
- ***Resilience to extreme weather events*** – this recognises the need to build resilience to particular extreme weather events, incorporating areas of preparedness, response and recovery.
- ***Vulnerable communitie***s – this recognises that there are certain populations within Victoria that are socially, economically, culturally or geographically more vulnerable to climate change impacts, with a lower capacity to adapt.

The COAG requirement for local government to 'collaborate across councils and with state and territory governments to manage risks of regional climate change impact' defines a clear role for a regional strategy, across municipalities that addresses projected climatic impacts.

For NAGA, *Adaptation in the North* provides a collaborative approach for councils to address climate change impacts and vulnerabilities in the region, many of which align with the *Climate Change Adaptation Memorandum of Understanding*. Regional collaboration has been identified as an effective method of accumulating and sharing resources and insights of each individual council, which are small in size and commonly lack adequate staff and budget for undertaking climate change planning individually (Wales, Khanjanasthiti, Savage and Earl: 2012). In addition, a regional approach recognises that while there will be variances in the distribution of climate change impacts, there will be commonalities in terms of the types of impacts, vulnerabilities to these impacts and in appropriate management actions.

Adaptation in the North provides the NAGA region with the framework for ongoing collaboration and action across municipal boundaries in relation to projected climatic impacts, risks and vulnerabilities.

3. APPROACH

3.1 Introduction

Preparation of *Adaptation in the North* was based on an IRVA approach that sought to determine:

- projected climatic changes and associated impacts for the region;
- infrastructure, services, ecosystems and populations of greatest vulnerability;
- adaptation actions required to reduce this vulnerability; and
- barriers to actions and enabling processes to overcome these.

The following provides an overview of the approach and a description of each stage of the methodology implemented.

3.2 Theoretical basis

The methodology for the NAGA IRVA is based on the South Australian *Guidelines for Developing a Climate Change Adaptation Plan and Undertaking an Integrated Climate Change Vulnerability Assessment* (Local Government Association of South Australia: 2012) and the New South Wales *Guide to Integrated Regional Vulnerability Assessment (IRVA) for Climate Change* (NSW Office of Environment and Heritage: 2013).

3.2.1 Consideration of risk

Neither the South Australian or New South Wales methodologies provide significant guidance on the role or place of risk assessment in an IRVA. This is despite the central role of risk in the intersection between hazard, vulnerability and exposure, as identified in the latest Intergovernmental Panel on Climate Change (IPCC) report on impacts, adaptation and vulnerability produced as part of the Fifth Assessment Report (AR5), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC: 2014a).

The NAGA IRVA approach involves identification of climate impacts and risks, as well as vulnerabilities and is focused on both outcome and process, as set out in Figure 2.

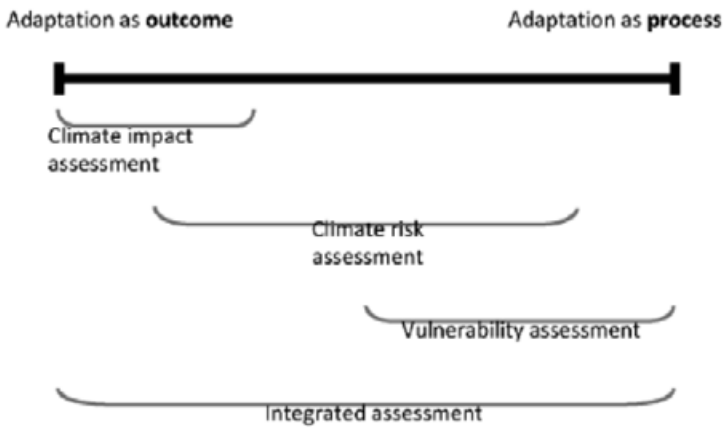

Figure 2 - Climate change assessment methods (Source: Fünfgeld: 2012)

Within this context, outcome based approaches are focused on determining an end point solution where, if implemented, an entity or system will be 'adapted' to climate change. Responses tend towards hard infrastructure solutions, such as an increase in drainage size, to address climate impacts. Process based approaches focus on climate change adaptation as an ongoing process of learning and capacity buildings, acknowledging that there are a range of uncertainties in both the climate change science, impacts, risks and vulnerabilities.

Outcome based approaches tend to work well in conjunction with linear decision-making processes due to the emphasis on cause and effect relationships and quantitative information, which help reduce risks in the face of uncertainty. As such, outcome based approaches are often preferred for top down approaches to climate adaptation. Alternatively, process-based approaches support a bottom-up approach to adaptation and are well suited to place-based adaptation. Both outcome and process approaches are required for an effective adaptation response (Fünfgeld: 2012).

To identify the risks and vulnerabilities and develop a response that takes account of both processes and outcomes, this IRVA report:

- provides a summary of the region (Section 3.4);
- documents relevant climatic trends projected to impact upon the NAGA region (Section 4);
- documents potential vulnerabilities for each sector (Section 5).
- identifies potential climate impacts based on existing literature and assigns a risk to these, based on likelihood and consequence, and identifies relevant vulnerabilities (Section 6).

The following sections of this report describe in further detail this process and the associated outcomes.

3.2.2 Creating an adaptation pathway

Climate change adaptation is an ongoing process of reflection and decision-making, recognises that projected climatic changes are just one of a multitude of inputs to a decision making cycle, as set out in Figure 3 (Reisinger A, Kitching R L, Chiew F, Hughes L, Newton P C D, Schuster S S, Tait A, and Whetton P: 2014).

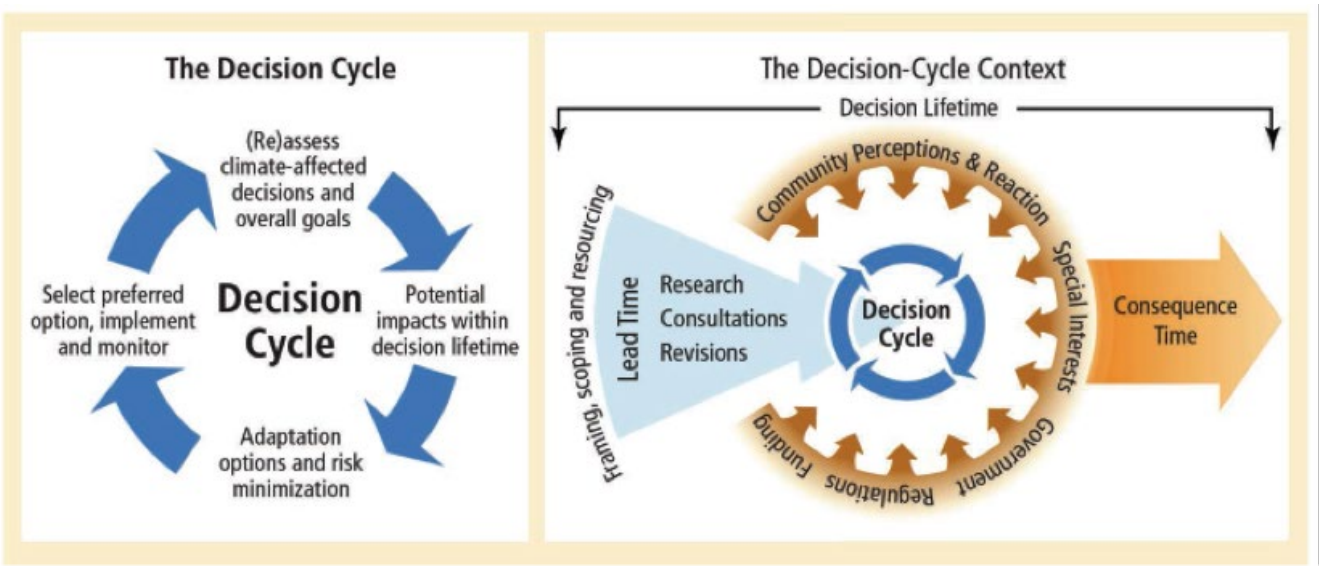

Figure 3 - Climate change adaptation decision cycle

Under current emission scenarios it is projected that there will be an increase in the frequency and intensity of climate related shocks and stresses over coming years. As a result, actions appropriate for this iteration of *Adaptation in the North* may be inappropriate or insufficient to address future impacts, risks and vulnerabilities. In addition, it is to be expected that as understanding and the capacity of NAGA and its member councils improves over time, so too will the capacity and effectiveness of its responses.

This fluid scenario can be accounted for in the development of an adaptation pathway for the region. This sets out a stated long-term objective but does not narrowly define the path taken to attain it. Rather, it allows for future decision-making based on changes in circumstance, such as pre-determined climate change impact triggers for action and improved knowledge and capacity of the participating organisations.

Crucially, actions and decisions taken along the adaptation pathway journey need to avoid potential maladaptive outcomes, such as contributing to an additional level of carbon emissions, or negatively impacting another sector of the region, as set out in Figure 4 (Reisinger A et al: 2014).

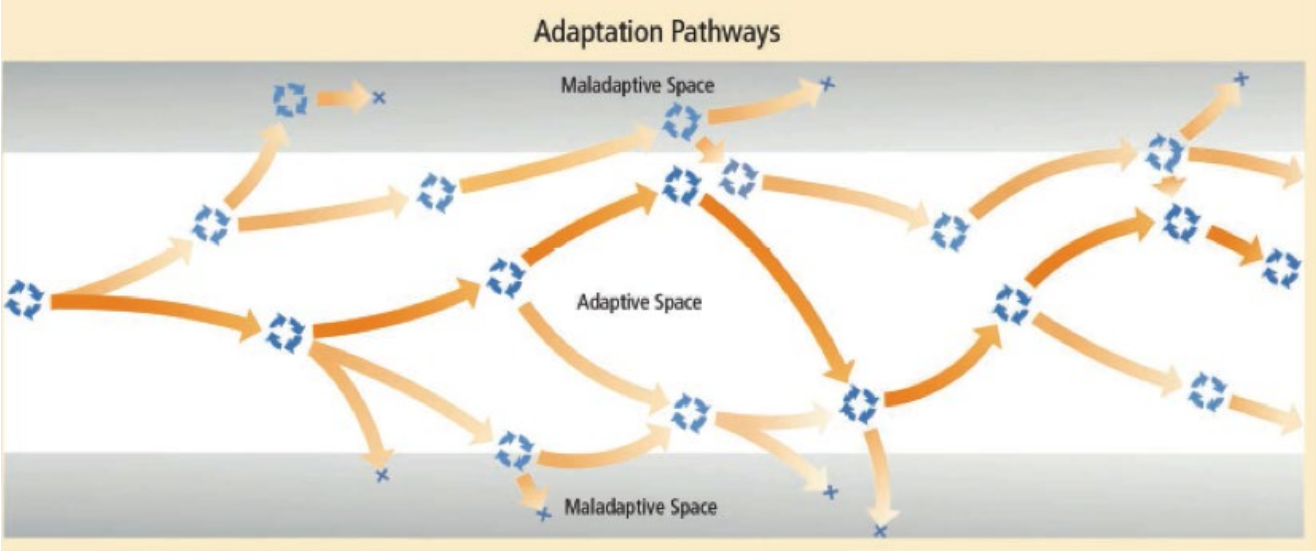

Figure 4 - Adaptation pathways

This desire to avoid maladaptation responses and promote those that derive economic, social and environment benefits and/or contribute to carbon mitigation, has been incorporated in the adaptation action prioritisation process for *Adaptation in the North.* The development of fuller adaptation pathways for the various climate change impacts for the NAGA region is identified as a core action in this plan.

3.3 Methodology

The methodology to prepare *Adaptation in the North*, brought together an assessment of the risks associated with regional climate change impacts and the vulnerabilities of populations, ecosystems, services and infrastructure at risk from those impacts, for key sectors across the NAGA region. The combination of risks and vulnerabilities were considered in developing appropriate regional response actions. The overall methodological approach applied in developing *Adaptation in the North* is illustrated in Figure 5.

The key steps to achieve this outcome were:

- a regional profile, including profiles for each NAGA council with relevant projected trends across the six sectors under consideration (Volume II, Appendix E);
- a climate risk assessment for the NAGA region, incorporating projected impacts and the development of a risk assessment process (Section 3.5);
- a vulnerability analysis, examining selected indicators amongst populations, natural ecosystems, services and infrastructure (see Section 3.6 and Section 5); and
- the development of actions to respond to extreme and high identified risks and vulnerabilities (see Section 7).

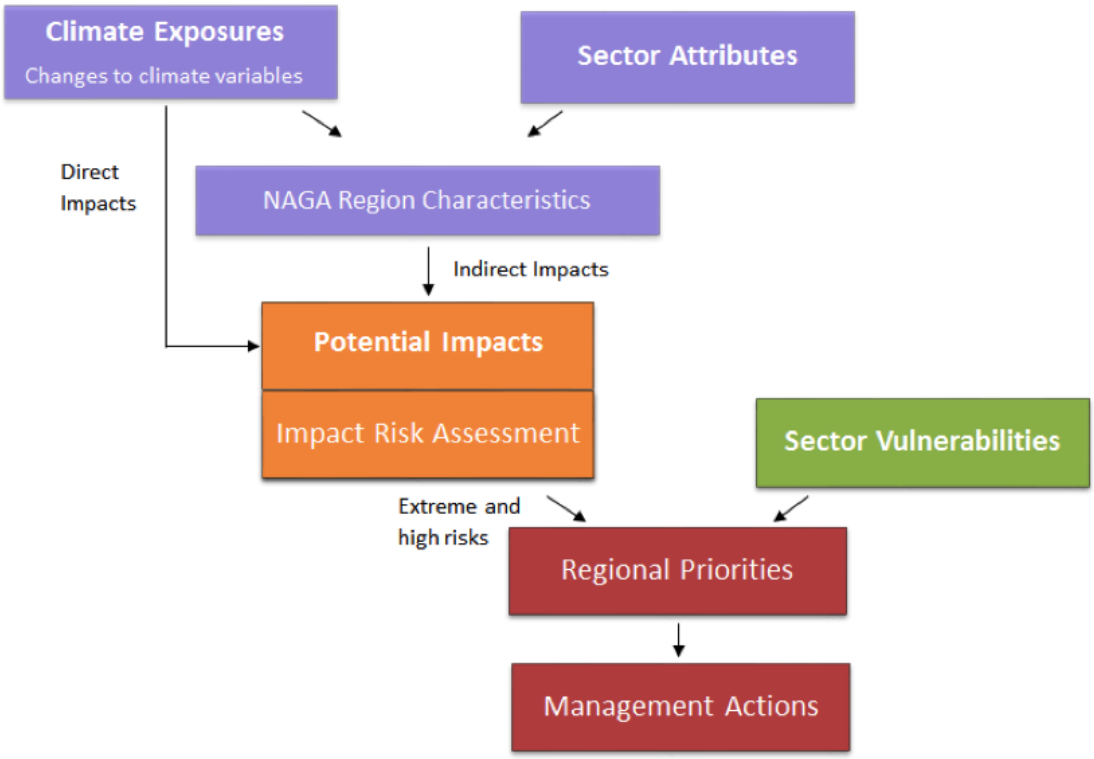

Figure 5 - NAGA Regional Climate Change Adaptation Plan IRVA process

The first step in undertaking the climate impact and risk assessment was the identification of the local government sectors that may be affected by climate exposures, leading to potential impacts. Sectors were identified using guidance from the *Guide to Integrated Regional Vulnerability Assessment (IRVA) for Climate Change* (NSW Office of Environment and Heritage: 2013) and reviewed by the NAGA stakeholder group at a project working group meeting.

Five sectors were initially selected for the study:

- infrastructure;
- human services;
- natural ecosystems;
- industry; and
- emergency management.

The New South Wales guidance includes 'planning' as part of the 'infrastructure and planning' sector. However, for this IRVA, it was agreed that the two sectors be considered separately, due to the differing functions of council that manage infrastructure and planning.

Planning was not included in the impact and risk assessment process as it cuts across all of the sectors and has the potential to influence (positively or negatively) the degree of risk associated with the sector specific impacts.

3.4 Regional profiles

Profiles were developed for each NAGA council providing a snapshot of each council, along with discussion on future projections and trends, across the six sectors; collectively these constitute a NAGA regional profile. The full council profiles are available in Volume II, Appendix E of this report.

A range of indicators were included for each sector, in addition to geographic information and demographic profiles. The indicators were drawn from existing South Australian IRVA climate change vulnerability indicators, which were reviewed and amended during an early project workshop and again following a literature review for each sector. The vulnerability indicators represent measurable characteristics of populations, infrastructure, services and natural ecosystems that can be monitored by council to understand the vulnerabilities within their municipality. The indicators for each sector are identified in Volume II, Appendix A.

3.5 Risk assessment

3.5.1 Literature review

A literature review was conducted to identify the potential impacts of climate change in the region. This included:

- existing council climate change related documentation (Table 1); and
- existing state-wide literature (Table 2).

The climate change impacts of relevance to the NAGA region are listed by sector in Volume II, Appendix B.

LIST OF SOURCES
2009 Victoria Bushfires Royal Commission (2010) *Final Report Summary*
Burton, P et al. (2013) *Urban food security, urban resilience and climate change*, NCCARF
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Parks Victoria (2010) *Climate Change Strategic Risk Assessment*
Sweeney Research (2014) *2014 Heatwave Business Impacts – Social Research for City of Melbourne*
United Nations International Strategy for Disaster Risk Reduction for Making Cities Resilient (2014) *Disaster Resilience Scorecard for Cities*

Table 2 - Existing state-wide literature reviewed

3.5.2 Risk assessment methodology

Overview

The climate change impacts identified in the literature review and later on through the sector specific workshops (as described in Section 3.6.2), formed the basis of the risk assessment process.

As per Figure 6, the risk assessment process included consideration of the likelihood of an impact (i.e. the chance of the impact happening) and its consequence (i.e. the outcome of an impact), as per the Australian Standard for risk assessment, AS / NZS ISO 31000:2009 *Risk management – Principles and guidelines* (ISO: 2009). To determine the likelihood of an impact, the assessment considered two probabilities. These were the probability of the relevant climate exposure occurring, to account for the uncertainty associated with climate change, and the probability that the impact under consideration will then occur.

The likelihood and consequence ratings were combined to enable an allocation of risk from low to extreme. Risk assessment tables have been prepared for each sector and are included in Volume II, Appendix B.

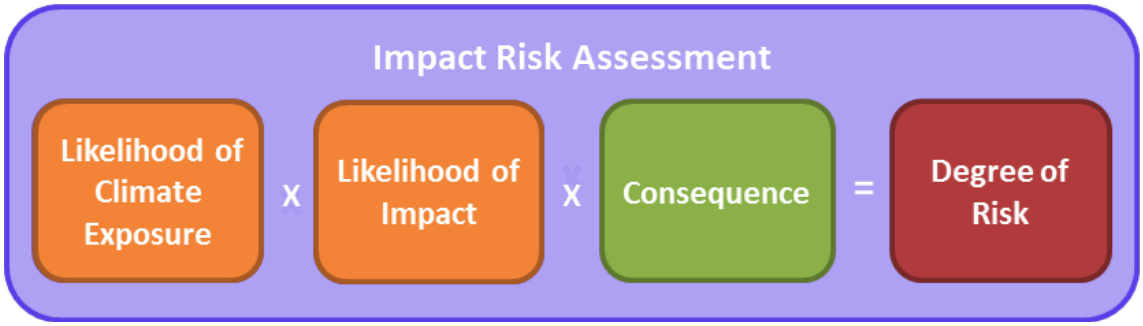

Figure 6 - Risk assessment overview

To ensure alignment with the vulnerability assessment, the risk assessment process considered the impact on five of the six sectors (excluding planning).

Likelihood

Likelihood was determined through consideration of both the probability of the climate event occurring and the probability of the potential impact occurring as a result of the event.

Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Stocker T F, Qin D, Plattner G-K, Tignor M, Allen S K, Boschung J, Nauels A, Xia Y, Bex V and Midgley P M: 2013) (Climate Change 2013: The Physical Science Basis) defines the probability of identified climatic exposure events occurring in the early (2016 – 2035) and late 21st century (2081-2100), based on the descriptors contained in Table 3. To enable determination of the degree of risk, a likelihood score has been added to the AR5 table. This table was also applied in assessing the probability of the identified impact occurring as a result of the exposure event.

The climatic exposure trends identified in AR5 (Stocker T F et al: 2013) and associated likelihood

TERM	LIKELIHOOD OF THE OUTCOME	LIKELIHOOD SCORE
Virtually certain	99 - 100% probability	9
Extremely likely	95 - 100% probability	8
Very likely	90 - 100% probability	7
Likely	66 - 100% probability	6
About as likely as not	33 - 66% probability	5
Unlikely	0 - 33% probability	4
Very unlikely	0 - 10% probability	3
Extremely unlikely	0 - 5% probability	2
Exceptionally unlikely	0 - 1% probability	1

Table 3 - Likelihood descriptors and score allocation

scores, through application of Table 3, are in Table 4.

ID	LIKELIHOOD OF THE OUTCOME	LIKELIHOOD SCORE
1	Warmer and/or fewer cold days and nights over most land areas	6
2	Warmer and/or more frequent hot days and nights over most land areas	6
3	Warm spells/heat waves. Frequency and/or duration increases over most land areas	6
4	Heavy precipitation events, increase in the frequency, intensity and/or amount of heavy precipitation	6
5	Increases in intensity and/or duration of drought	5
6	Increase in intense tropical cyclone activity	Not applicable to the NAGA region
7	Increase incidence and/or magnitude of extreme high sea level	6
8	Changes in wind velocity	5
9	Increased bushfire frequency and intensity (Combination of 2, 3, 5 and 8)	6

Table 4 - Climate Exposure Likelihoods for 2016 – 2035

Consequence

To enable an assessment of the significance of each impact, a table was developed that considers the potential regional consequences for each sector (Table 5), with the Australian Greenhouse Office publication, *Climate Change Impacts & Risk Management Guide for Business and Government* (AGO: 2006) providing a key input to inform its development.

3.6 Vulnerability, risk and opportunity analysis

3.6.1 Vulnerability analysis

The vulnerability analysis is focused on understanding how impacts and potential risks for each sector vary across the NAGA region, as well as who or what is more likely to be vulnerable to the impacts and risks identified. To undertake this analysis an initial review of literature was carried out in order to develop an understanding of the vulnerabilities present within the NAGA region. These were then organised to align with the sectors in a council most relevant to the management of each vulnerability.

The list of vulnerabilities was then overlaid with vulnerability indicators, measurable characteristics of populations, infrastructure, services and natural ecosystems that can be monitored by council to effectively understand the vulnerabilities within their municipality. A list of the relevant vulnerable groups for the NAGA region and vulnerability indicators, organised by sector, is provided in Volume II, Appendix A and described in Section 5. Ultimately this provides a means for measuring the effectiveness of identified management actions for adaptation over coming years and decades.

3.6.2 Workshop process

The NSW IRVA guidance notes that a key element of an integrated assessment is the engagement of stakeholders in participatory processes. These facilitate the inclusion of qualitative information and non-scientific knowledge, values and preferences into vulnerability assessments. It enables the capturing of current practices and issues across the NAGA region that a review of historic data may not highlight. In order to capture these insights, a series of workshops were held to supplement the desktop analysis.

Six sector workshops were conducted during the IRVA each tailored to its particular sector. The workshops considered appropriate climatic scenarios (e.g. flash flood, heatwave, bushfire, post-event recovery) and attendees reviewed the impacts, risks and vulnerabilities identified through the desktop analysis to verify their accuracy and to capture points not identified in the literature review.

In addition, potential management actions were put forth by workshop attendees for consideration and potential inclusion within *Adaptation in the North*. Management actions were then prioritised in a management actions workshop. A summary of the workshops held during preparation of *Adaptation in the North* is included in Table 7.

WORKSHOP	NUMBER ATTENDING	DATE
Human Services	25	21 July 2014
Planning	24	24 July 2014
Emergency Management	20	29 July 2014
Industry	27	5 August 2014
Infrastructure	28	7 August 2014
Natural Ecosystems	24	13 August 2014
Management Actions	12	8 October 2014

Table 7 - Workshops carried out during the IRVA process.

3.6.3 Prioritisation of management actions

From the sectorial workshops a thorough list of potential management actions was developed. These formative actions were further developed through consideration of existing actions being undertaken by NAGA members that could be expanded to a regional approach and insights gained from consultation with state agencies and other organisations undertaken through the project.

A multi-criteria analysis (MCA) process was developed, following the recommendations of Fünfgeld (Fünfgeld: 2012) and UNFCCC (UNFCCC: 2002, UNFCCC: 2009), assigning a list of criteria and scoring each management action against the criteria. The primary criteria were:

- Does the action address regional impacts and associated vulnerabilities?
- What is the significance of the risk and extent of the vulnerability being addressed?
- What are the positive and negative environment, social and economic (triple bottom line) impacts associated with the action? Specifically, will benefits in one area of environment, community and economy create problems in another?
- What are the potential barriers to implementation of the management action? Factors may include the degree of council control, funding, regional coordination, community resistance or others.

This approach is in broad alignment with the prioritisation process developed by the City of Melbourne, through its Prioritisation Tool.

The scoring was performed in two stages:

1. Initial shortlisting of actions, based on primary assessments of the effectiveness and relevance of identified actions. This process included a removal of duplicate suggestions arising out of the sector workshops. The specific factors were considered and their relative weightings were presented in a MCA matrix. Approximately ten actions per sector were shortlisted.
2. Identification of triple bottom line benefits, co-benefits for council operation, maladaptation issues and the role of NAGA for each action. This was conducted during a management actions workshop with Arup and NAGA members. The workshop involved attendees refining and selecting key actions for each sector.

All potential management actions assessed have been included in Volume II, Appendix C. These management actions addressed the impacts, risks and vulnerabilities for each sector, and were organised as short, medium and long term. This serves as the basis for an adaptation pathways approach and will allow for NAGA to efficiently allocate its resources for maximum benefit. Furthermore, a number of issues were raised during the management actions component of the sector workshops. While not being specifically defined as actions, these have been included in Volume II, Appendix C as contextual issues.

4. CLIMATE CHANGE

4.1 Overview

Climate Change 2013: The Physical Science Basis represents the latest global assessment of climate change science. Within this document (Stocker T F et al: 2013) it states:

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.

It notes that since the publication of the previous IPCC Fourth Assessment Report in 2007, certainty surrounding our collective knowledge on a changing climate has increased due to advances in the availability, acquisition, quality and analysis of observational data sets for the atmosphere, land surface, ocean and cryosphere. The increasing certainty in AR5 reflects similar Australian publications, such as *The Critical Decade 2013 Climate Change Science, Risks and Responses* (Steffen and Hughes: 2013). This report states that since publication of the original, *The Critical Decade* in 2011, the evidence for a rapidly changing climate has continued to strengthen and it is clear the climate system has already shifted.

In Victoria, the preamble to the Climate Change Act 2010 enshrines in legislation that the *Parliament of Victoria recognises on behalf of the people of Victoria the overwhelming scientific consensus that human activity is causing climate change*. As required under this Act, the Victorian Government in 2012 published its first biennial report on climate change and greenhouses gases, *Report on Climate Change and Greenhouse Gas Emissions in Victoria* (DSE: 2012b). The report notes:

The overall warming of the climate in Victoria over the past century has been linked to greenhouse gas-related climate change. The recent decline in autumn rainfall and the southward shift in some rain-bearing weather systems may also be partially caused by greenhouse-gas related climate change. Continued global emissions of greenhouse gases, depending on their level, are likely to lead to warmer conditions in Victoria, reduced rainfall in some seasons, and sea level rise.

4.2 Past, present and future

4.2.1 The climate system and global warming

The climate system is a complex, interactive system consisting of the atmosphere, the oceans and other bodies of water, land and ice – and the associated processes of energy and mass transfer around the planet.

A key feature of the climate system is the greenhouse effect as depicted in Figure 7. The effect occurs as a result of several gases present in the atmosphere, known as greenhouse gases. Incoming solar radiation largely passes through these gases, with some of this radiation being reflected back out to space by clouds and bright surfaces, and the remainder being absorbed by the Earth's surface.

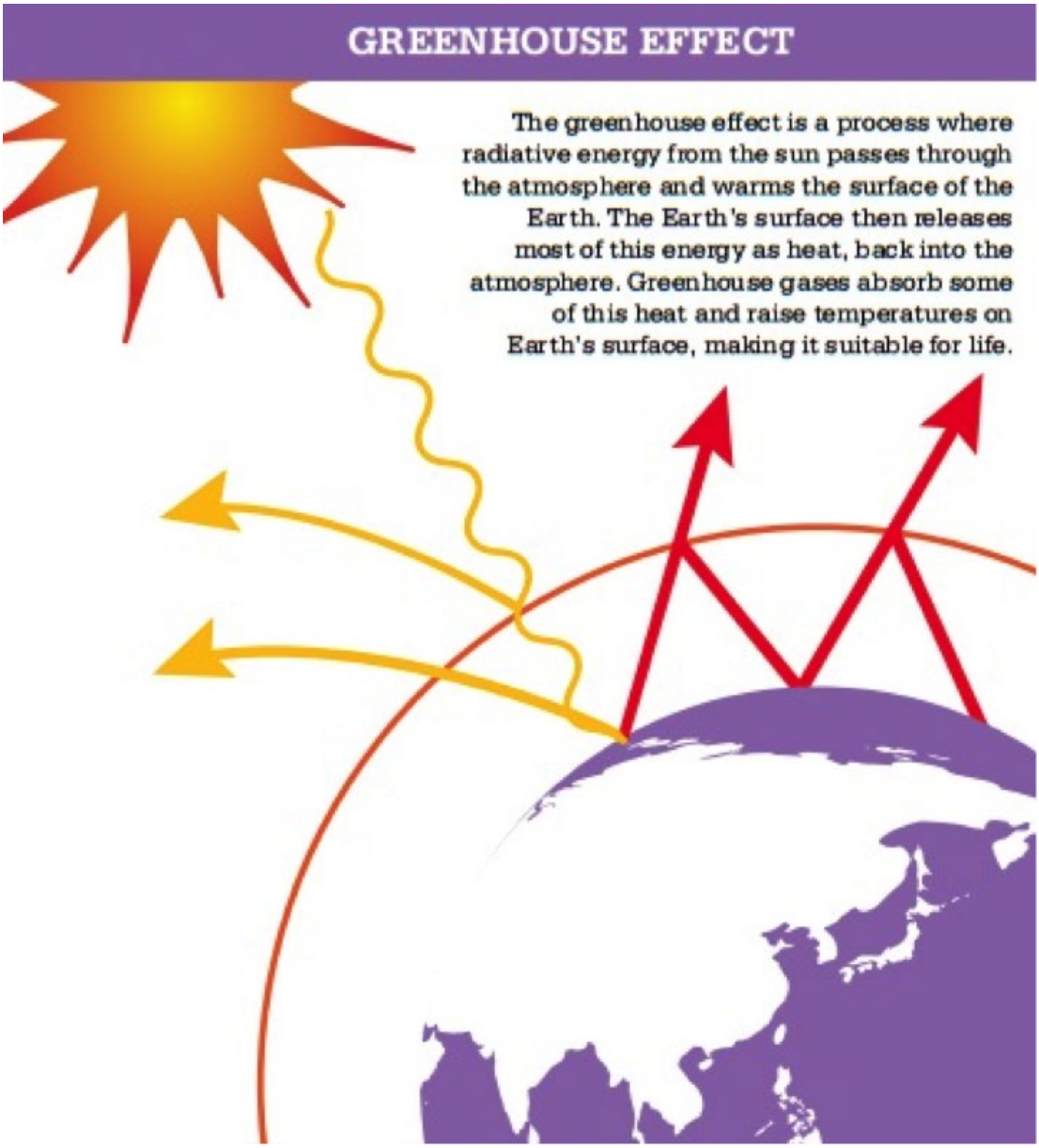

Figure 7 - The greenhouse effect (Steffen and Hughes: 2013)

In order to maintain its energy balance, the Earth emits energy equivalent to the energy, which is absorbed back into space. This energy is emitted as infrared radiation, or heat.

Greenhouse gases trap some of the outgoing heat, keeping the Earth's atmosphere warmer than it otherwise would be in the absence of these gases (Steffen and Hughes: 2013). The most significant greenhouse gases are carbon dioxide, methane and nitrous oxide. As the concentrations of these gases increase, particularly carbon dioxide, due to the burning of fossil fuels and other human activities, an increasing fraction of the infrared radiation emitted by the Earth's surface is trapped within the atmosphere. This additional trapped heat energy warms the Earth's surface and oceans, resulting in climate change or global warming.

4.2.2 Global observations and projections

Since 1990, the IPCC has produced assessment reports that synthesise the existing published literature and research on climate change. Through this process the IPCC has come to be recognised as the most authoritative source of information in relation to climate change observations and projections.

Assessment reports are released as three volumes (one for each Working Group of the IPCC). The first, *Climate Change 2013: The Physical Science Basis*, synthesises the most recent knowledge of each aspect of the climate system by considering historic and current trends and applying this knowledge to better understand and predict future changes. This is achieved through considering direct and proxy observations of changes in all components of the climate system.

Historic and current trends are considered separately in recognition that since 1950, there have been detectable changes in trends in components of the climate system from historic averages. Commentary on these changes is provided through an assessment of the likelihood both that the change has occurred and that it has been influenced by anthropogenic emissions. This addresses the degree of uncertainty associated to specific changes in climatic exposures. The likelihoods (i.e. degree of certainty) applied to the observed changes have been previously described in Table 3.

Climate Change 2013: The Physical Science Basis identifies the following observed and projected climatic changes in components of the climate system:

- warmer and/or fewer cold days and nights over most land areas;
- warmer and/or more frequent hot days and nights over most land areas;
- warm spells/heat waves increasing in frequency and/or duration over most land areas;
- heavy precipitation events, increases in the frequency, intensity and/or amount of heavy precipitation;
- increases in intensity and/or duration of drought;
- increases in intense tropical cyclone activity; and
- increased incidence and/or magnitude of extreme high sea level.

In considering past, current and future climatic change, the report provides greater clarity on the level of certainty for each observed trend in the climate component or exposure (Table 8).

CHANGE IN CLIMATIC EXPOSURES AND DIRECTION OF TREND	LIKELIHOOD OF FURTHER CHANGES	
	2016 - 2035	2081-2100
Warmer and/or fewer cold days and nights over most land areas	Likely	Virtually certain
Warmer and/or more frequent hot days and nights over most land areas	Likely	Virtually certain
Warm spells/heat waves. Frequency and/or duration increases over most land areas	Likely	Very likely
Heavy precipitation events, increase in the frequency, intensity and/or amount of heavy precipitation	Likely	Very likely
Increases in intensity and/or duration of drought	About as likely as not Low confidence	Likely Medium confidence
Increase in intense tropical cyclone activity	Low confidence	More likely than not
Increase incidence and/or magnitude of extreme high sea level	Likely	Very likely

Table 8 - Global-scale assessment of projected climatic changes (2016-2035) and (2081-2100)

Notably, this report also introduces new emissions projections, known as Representative Concentration Pathways (RCPs). The IPCC has defined four RCPs based on their total radiative forcing (cumulative measure of human emissions of GHGs from all sources expressed in Watts per square meter) pathway and level by 2100.

ID	DESCRIPTION
8.5	Rising radiative forcing pathway leading to 8.5 W/m2 in 2100.
6	Stabilization without overshoot pathway to 6 W/m2 at stabilization after 2100.
4.5	Stabilization without overshoot pathway to 4.5 W/m2 at stabilization after 2100.
2.6	Peak in radiative forcing at ~ 3 W/m2 before 2100 and decline.

Table 9 - Representative Concentration Pathway descriptions (Source: IPCC: 2015)

The RCPs represent different plausible future scenarios in terms of rate of economic growth, cultural norms and the extent to which human society is decarbonised. They differ to previously developed scenarios in that they focus on climate forces based on the most recent science, enable better encapsulation of current socio-economic changes and allow for improved efficiency in climate modelling. The use of these scenarios over time indicates that global temperatures are likely to increase between 2°C to 4.5°C by 2100, on current projections (Figure 8).

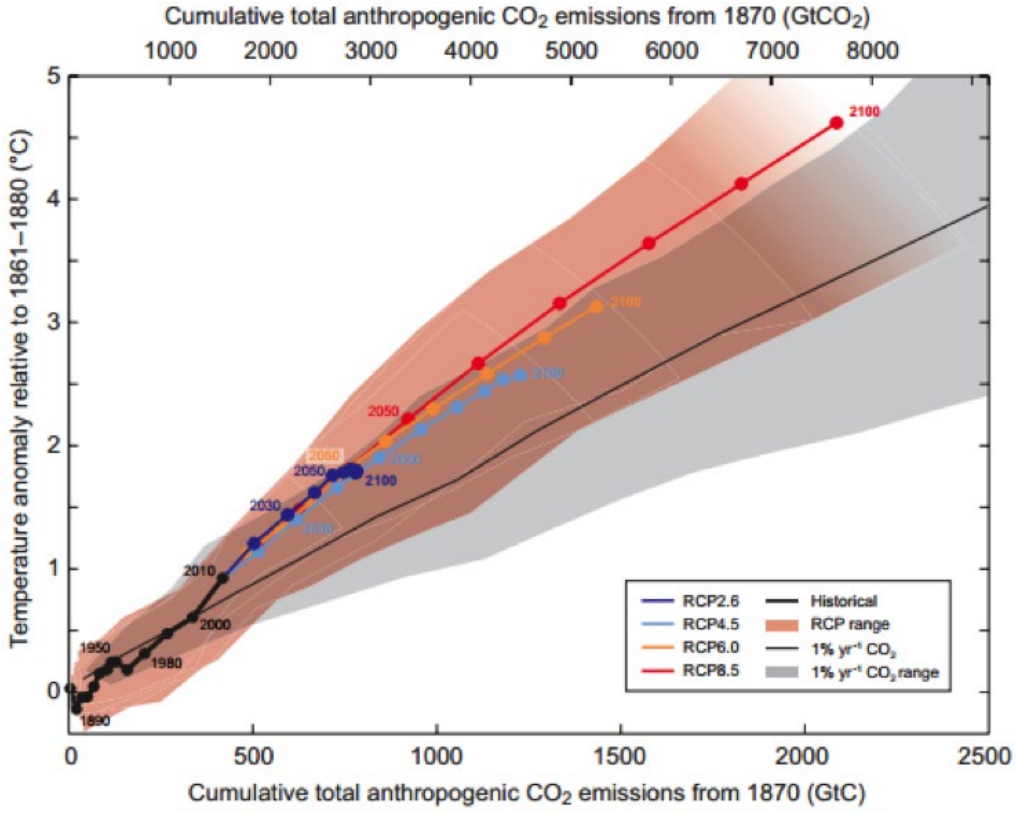

Figure 8 - Global mean surface temperature increases as a function of cumulative total global CO2 emissions according to the RCP scenarios developed for the most recent IPCC AR5 (Source: Stocker T F et al: 2013).

4.2.3 Climate change in Victoria and Melbourne's North

In Victoria, the key publication that still forms the basis of climate change projections from which risk and vulnerability assessments are undertaken is *Climate Change in Victoria: 2008 Summary* (DSE: 2008a) which provides an overview of the projected climatic changes for Victoria to 2030 and 2070.

The projections are derived from the CSIRO and Australian Bureau of Meteorology publication *Climate Change in Australia – Technical Report* (CSIRO and Australian Bureau of Meteorology: 2007). In addition to the Victorian summary report, regional climate change projections were prepared for each of the catchment management areas across the State. The relevant publication for the councils within the NAGA region is *Climate Change in Port Phillip and Westernport* (DSE: 2008b).

The projections contained in *Climate Change in Victoria: 2008 Summary and Climate Change in Port Phillip and Westernport* were derived from the IPCC emission growth (SRES) scenarios developed in 2000 (IPCC: 2000), and therefore should be noted as not being as up to date as the RCP-based scenarios used in the IPCC AR5. Actual emissions have trended in alignment with the most fossil fuel intensive emissions scenario (Commissioner for Environmental Sustainability: 2012). Under such a scenario, the average number of days with peak temperature is expected to increase dramatically (Figure 9).

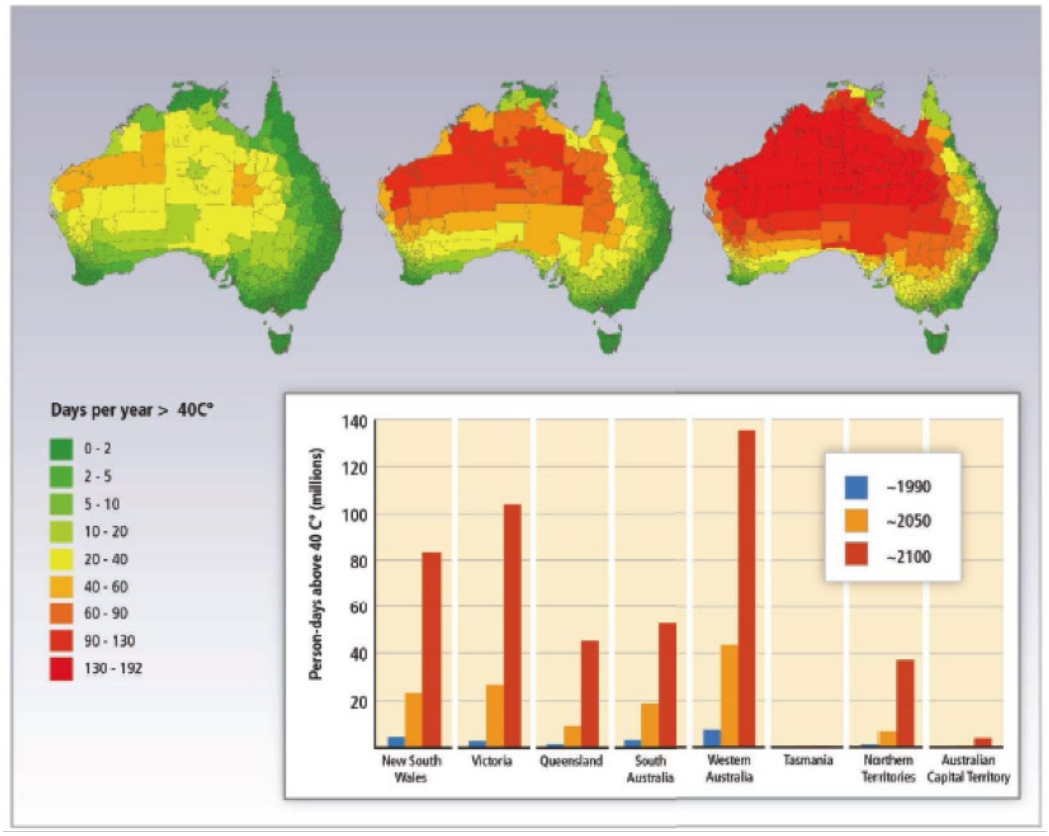

Figure 9 - Projected changes in exposure to heat under the SRES high emissions scenario (A1F1). Maps indicate the average number of days with peak temperatures >40°C for ~1990, ~2050 and ~2100.

RCPs have recently been applied to produce the most up to date projections of temperature changes until the end of the century in Australia (Figure 10).

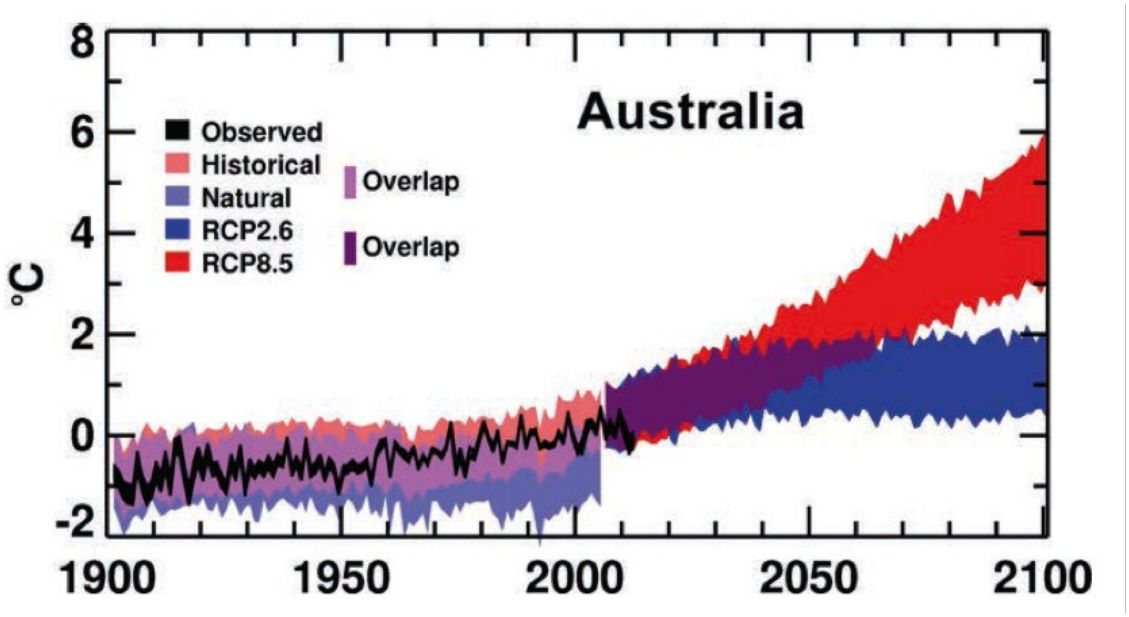

Figure 10 - Australian observed and projected near-surface air temperature changes over land areas utilising IPCC RCP emission scenarios (Reisinger A et al: 2014).

At the commencement of 2015, the CSIRO and BoM released new climate change projections based on Australia's natural resource management (NRM) regions that apply the AR5 RCPs: *Climate Change in Australia – Projections for Australia's NRM Regions* (CSIRO and BoM: 2015). The NAGA region is located in the Southern Slopes Victoria West sub-cluster and the climate exposure trends identified in the projections are:

- an increase in average temperatures across all seasons;
- more hot days and warm spells (very high confidence) and fewer frosts (high confidence);
- less rainfall in the cool season (high confidence);
- increased intensity of extreme rainfall events (high confidence);
- rise in mean sea height and increase in extreme sea-level events (high confidence);
- harsher fire weather climate (high confidence); and
- on an annual and decadal basis, natural variability can act to either mask or enhance long-term induced trend, particularly in the next 20 years and for rainfall.

In addition to the above there have been a series of both climate events and publications that have provided a greater understanding of the implications for Victoria and the NAGA region of a changing climate.

In relation to events, the most high profile, the Black Saturday fires of 7 February 2009, resulted in a multitude of catastrophic impacts, including loss of 173 lives and the dislocation of whole communities. The fires had been proceeded by a week-long heat wave that lead to 374 excess deaths beyond what would be expected for this period (Department of Human Services: 2009), with the greatest number of deaths occurring in those 75 years and older.

In addition to fire and heatwaves, over recent years there have also been events of extreme rainfall across the eastern seaboard. Victoria experienced significant flooding of rural areas between September 2010 to February 2011, with several communities being subjected to successive flood events and associated impacts. Across Melbourne's North, an extreme storm event on Christmas Day 2011, led to flash flooding of residential and commercial premises.

Reports by the former Climate Commission, such as *The Angry Summer* and *The Critical Decade – Climate Change Science, Risks and Responses*, together with the Commissioner for Environmental Sustainability's *Foundation Paper Volume One - Climate Change* and the CSIRO and Bureau of Meteorology, *State of the Climate* series, highlight and document these recent observations and events, and their associated impacts.

4.3 Climatic exposures for the NAGA region

In the context of the identified trends in climate exposures (Table 8), the following provides an overview of recent observations and the projections of these trends as they relate to the NAGA region. The potential for increase in intense tropical cyclone activity has not been further considered as it is not viewed as a relevant impact for the NAGA region.

4.3.1 Temperature

Overarching trends

The IPCC identifies three trends in relation to the surface air temperature. These are a reduction in the number of colder days, an increase in warmer and more frequent hot days and an increase in the frequency of consecutive hot day events: heatwaves. Figure 11 illustrates the reason for these changes: as the surface air temperature increases, the temperature distribution curve shifts to a warmer norm, reducing the number of cold days and increasing the number of warm and extreme days.

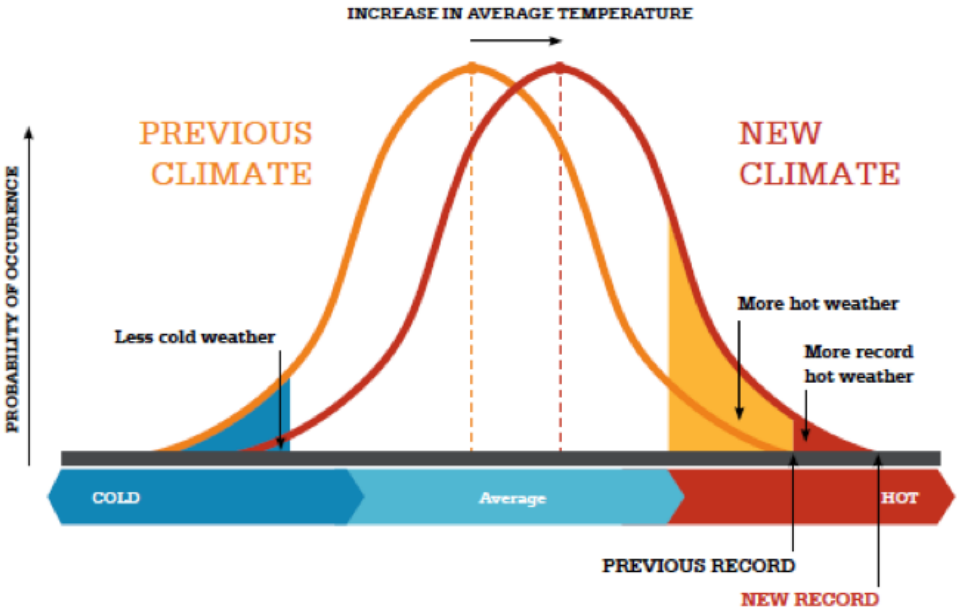

Figure 11 - Relationship between average and extremes temperature changes with climate change (Source: Steffen and Hughes: 2013)

Across Australia, there has been almost a degree increase, 0.9°C, in the average surface temperature since 1910 (CSIRO and Australian Bureau of Meteorology: 2014). As illustrated in Figure 12, the most significant increase has occurred since 1950. In line with global projections, there has also been an increase in extreme heat events and a decrease in colder extremes.

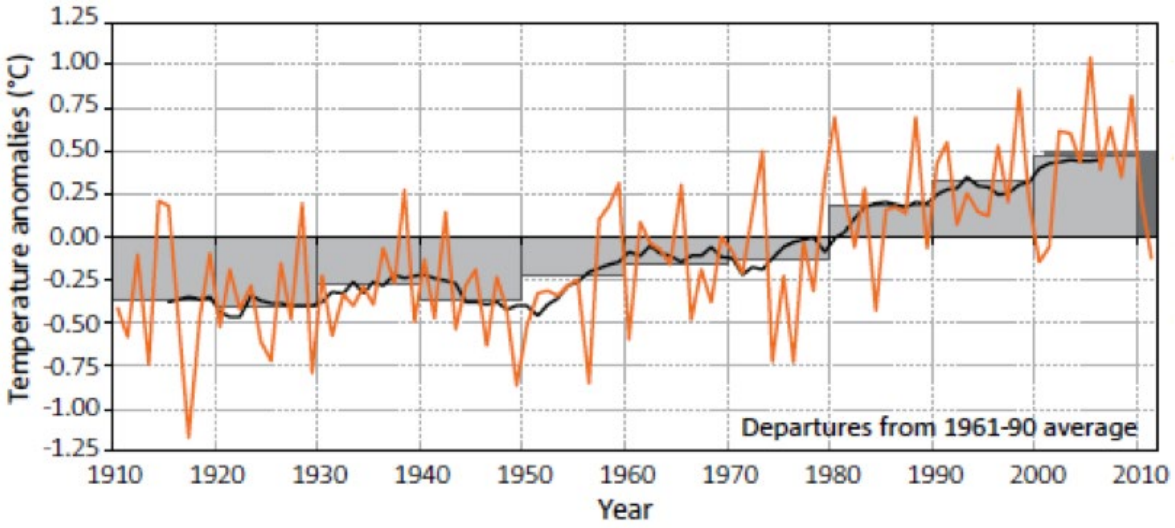

Figure 12 - Average Australian temperature changes over the past century for each year and decade

This trend is replicated in Melbourne (Figure 13), where, despite the evident annual variability, the maximum temperature increased by 0.24°C per decade, the minimum by 0.38°C per decade and the average by 0.31°C per decade, between 1950 and 2010 (Suppiah and Wheatton: 2011).

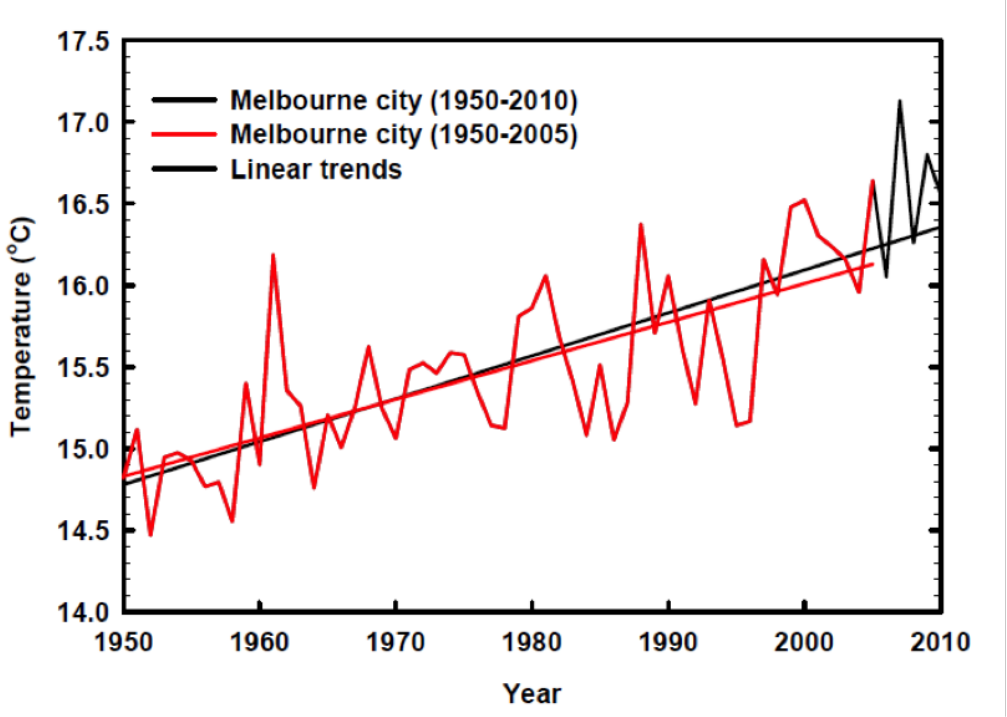

Figure 13 - Variations and trend in annual average temperature at Melbourne central weather station (station number 86071) from 1950 to 2010

The projected increases in extreme temperatures have been realised in recent years, with 24 of the 35 temperature recording stations in Victoria recording record temperatures on Black Saturday, 7 February 2009, including Melbourne where the temperature peaked at 46.4 oC (DSE: 2012a). These trends follow similar experiences along the eastern seaboard, with 44 weather stations logging record temperatures over the summer of 2012 / 2013 (Steffen: 2013) .

The current trends being observed in relation to the warming of the air temperature and heatwaves are projected to continue. The 2008 projections prepared by DSE indicate that there will be:

- Fewer frosts (days where the minimum temperature falls to 2°C or less) from 3 in 2007, to 2 in 2030, to 0 in 2070;
- An increase in average annual temperature by 0.8°C by 2030 and 2.6°C by 2070; and
- An increase in the average number of days >30°C, from 30 in 2007, to 34 in 2030, to 49 in 2070.

It should be noted that the 2030 projections are based on the SRES A1B scenario. Recently, emissions have been tracked as following the high SRES scenario of A1FI, suggesting that these projections likely underestimate the extent of change in these temperature parameters.

Climate Change in Australia – Projections for Australia's NRM Regions (CSIRO and BoM: 2015) projects that by 2030 annual average temperatures will have increased by 0.4°C to 1.1°C above the 1986 – 2005 climate and later in the century, 2090, by 2.4°C to 3.8°C under the high emissions scenario, RCP8.5 and 1.1°C to 1.9°C under RCP4.5.

Heatwaves

A heatwave is defined as a period of abnormally and uncomfortably hot weather that could impact on human health, infrastructure and services (DOH: 2011). In Victoria, the Department of Health has determined that for Melbourne, a health alert is issued for heat if it is predicted that a heat threshold of an average of 30°C over a 24 hour period will be exceeded.

In urban areas, such as the inner and middle ring councils of the NAGA region, the impacts associated with heatwaves are exacerbated by the absorption of solar radiation by buildings and infrastructure, leading to localised warming of the surrounding area, known as the urban heat island (UHI) effect. Urban form can play a significant role in influencing both the day and night-time surface and air temperatures, with significant variations between differing urban forms in close proximity (Figure 14).

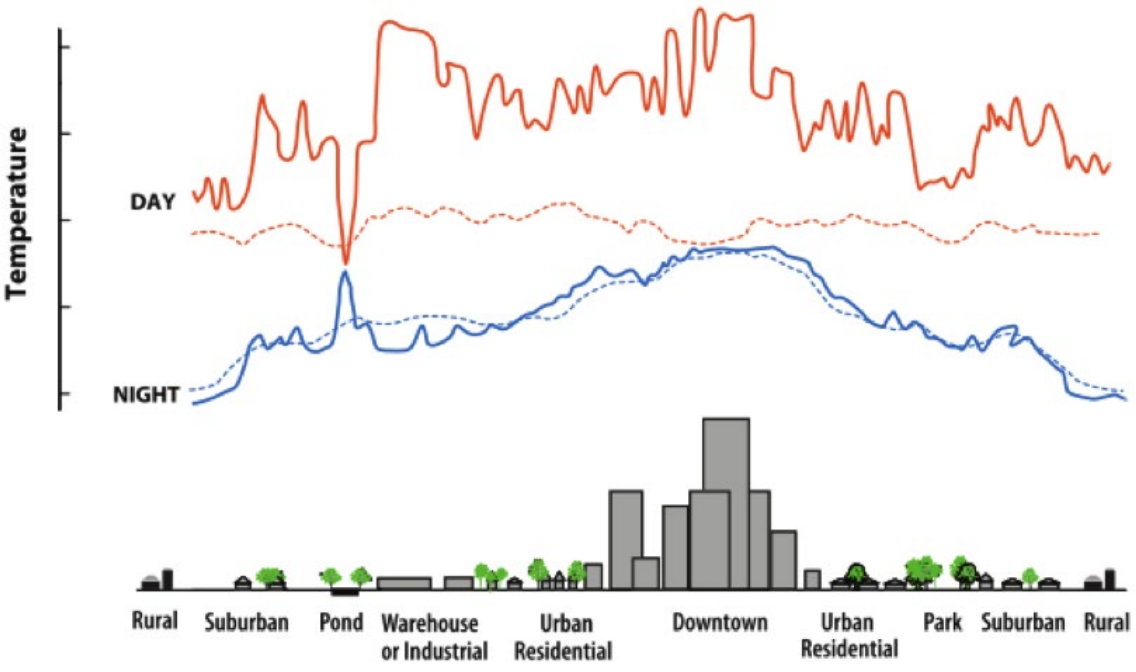

Figure 14 - Day and night surface (line) and air (dashed) variations by urban form

Monash University has undertaken a significant level of research in this area and Figure 15 illustrates the night time UHI, with the higher temperatures clearly illustrated in the central, higher density urban areas of the Melbourne metropolitan area (Loughnan M, Nicholls N and Tapper N: 2009).

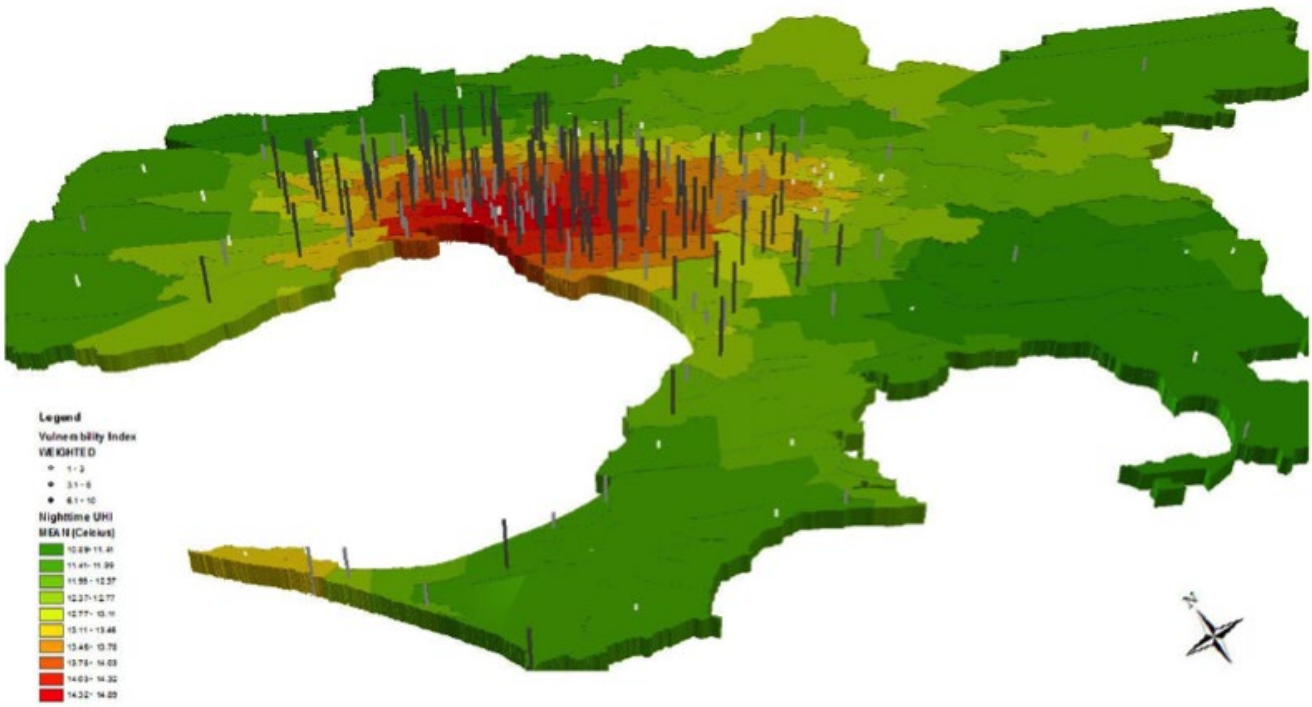

Figure 15 - Melbourne night time UHI and vulnerability index

During the preparation of *Adaptation in the North*, Professor Nigel Tapper of Monash University provided a presentation to interested council officers of the NAGA region at Moreland City Council offices on his research. His latest research highlighting the significant contribution that even small areas of urban greening can make to surface and air temperatures during heatwave events (Tapper: 2014).

One of our urban designers went back and immediately started reworking a new public park he was working on

Comment after the Workshop on Urban Heat Island with Prof Nigel Tapper, 25 June 2014

4.3.2 Heavy rainfall events

Heavy rainfall events are described in terms of occurring beyond a particular percentile of a rainfall distribution curve, or in comparison with a return period, (i.e. 1 in 100 year or 1 in 20 year event). The influence that climate change has on rainfall is illustrated in Figure 16.

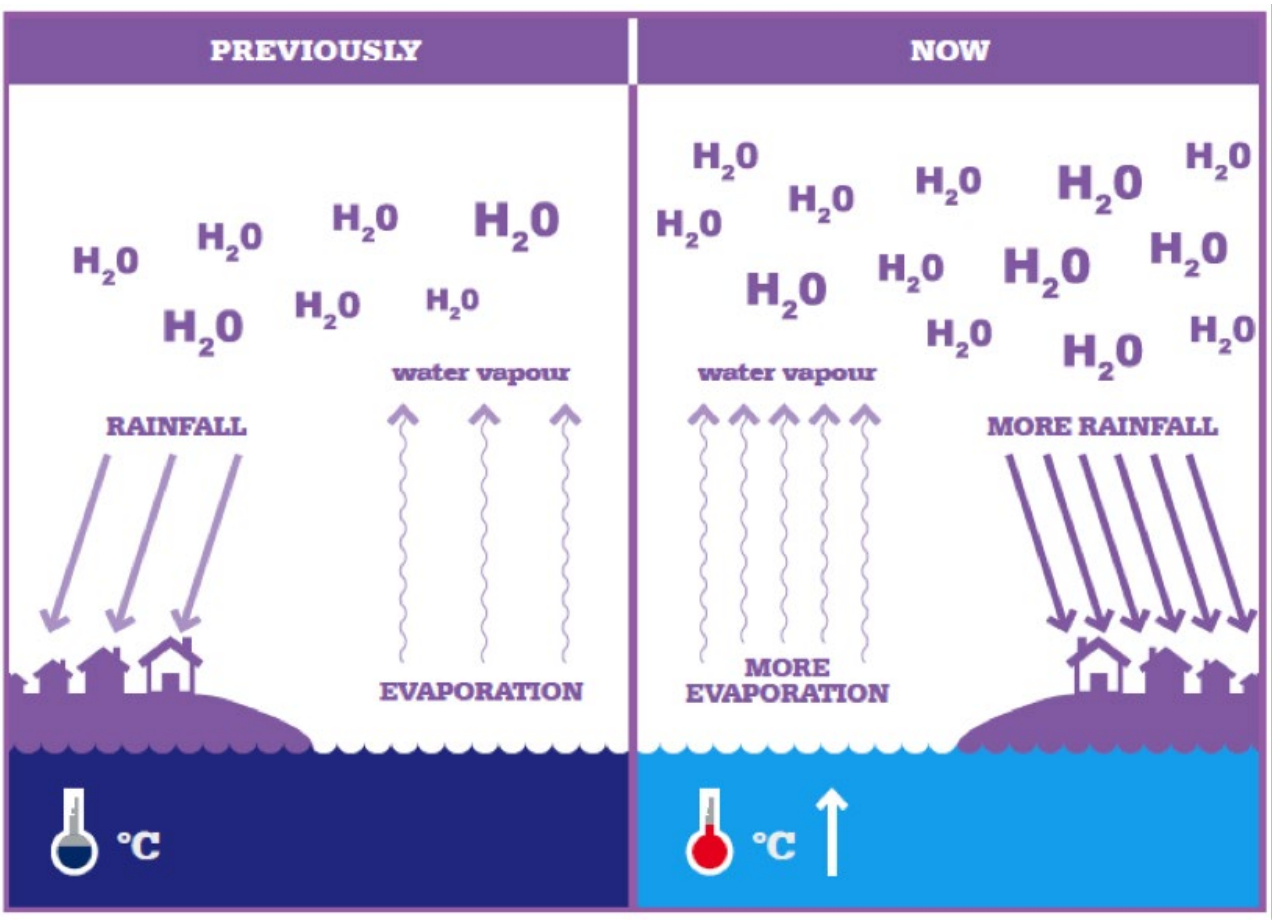

Figure 16 - Climate change and rainfall (Source: Steffen and Hughes: 2013)

As the surface temperature of the ocean increases, there is an increase in evaporation and intensification of the water cycle. As this trend continues it is likely that the frequency of heavy precipitation or the proportion of total rainfall as heavy falls will continue to increase (Steffen: 2013). Due to the variability of topography across the Melbourne metropolitan region, in particular to the north east of the central city, the frequency and extent of heavy rainfalls events will vary across the NAGA region (Figure 17).

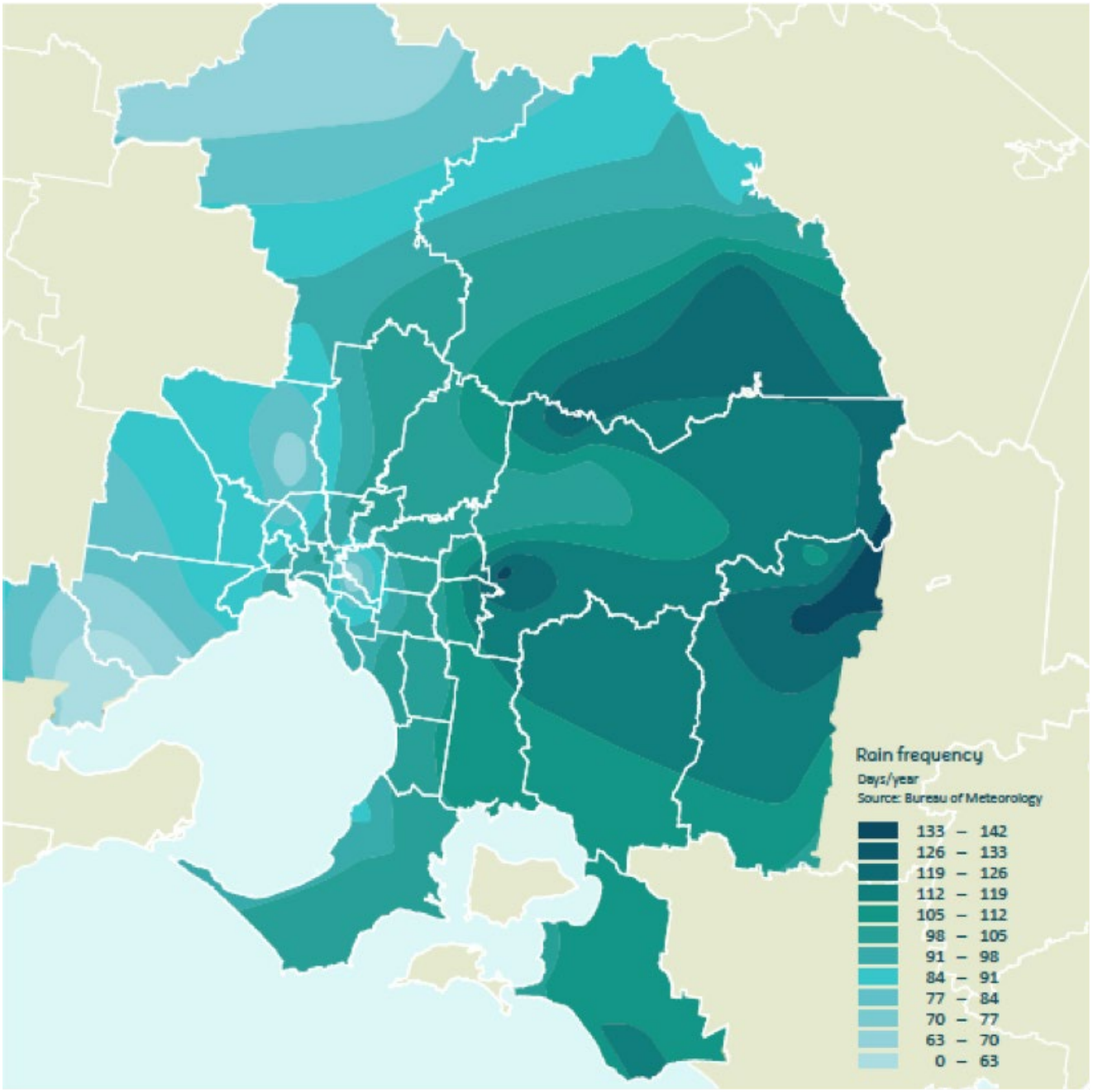

Figure 17 - Rain frequency across the Melbourne metropolitan area (Source: Office of Living Victoria: 2013)

In the summer of 2010-2011 Victoria experienced its highest summer rainfall on record (Figure 18). The rainfalls had the greatest effect on western, central and north-eastern regions, resulting in three major flood episodes (DSE: 2012b).

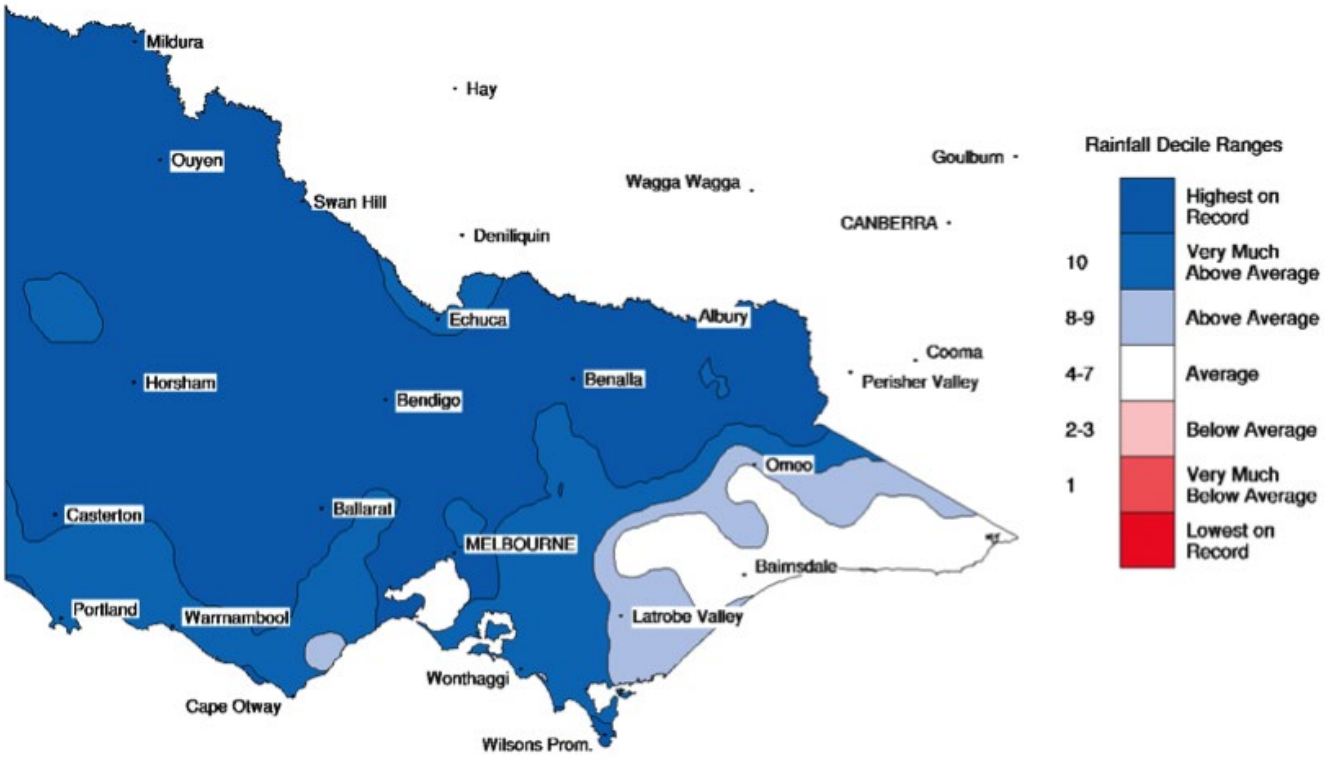

Figure 18 - Victorian rainfall deciles for 9 month period 1 July 2010 to 31 March 2011

These trends are expected to continue with the 2008 projections indicating an increase in rainfall intensity during winter months of 2.6 per cent by 2030 and 17 per cent by 2070, alongside more frequent and severe storm events.

It is noted that the 2030 projections are based on the SRES A1B scenario. Recently, emissions have tracked as following the high SRES scenario of A1FI, suggesting that these projections likely underestimate the extent of change in rainfall intensity. At the time of writing, analysis based on the more recent RCP scenarios is not yet available.

4.3.3 Drought

Drought is a prolonged, abnormally dry period when there is not enough water for the normal needs of users and ecosystems.

From the 1950s there has been a reduction in the frequency of weather systems over Victoria associated with wetter conditions. Between 1997 and 2009 Victoria experienced its longest period of sustained rainfall deficit since the commencement of records (DSE: 2012a). This period was associated with a reduction in the average rainfall of approximately 15 per cent. A characteristic of this drought was a significant reduction in autumn rainfalls and the absence of very wet years.

The drought led to significant pressure being placed on the water supply network and ecosystems through severely reduced runoff throughout much of Victoria. In response to potential future water shortages for metropolitan Melbourne the Victorian Government commissioned the construction of its first desalination plant at Wonthaggi. It is projected that drought conditions will become more frequent for Melbourne in future years, with a reduction in:

- average rainfall of four per cent by 2030 and 11 per cent by 2070, with the greatest reduction to occur during spring; and
- rainy days during summer of six per cent by 2030 and 20 per cent by 2070, alongside an increased occurrence of drought.

It is noted that the 2030 projections are based on the SRES A1B scenario. Recently, emissions have tracked as following the high SRES scenario of A1FI, suggesting that these projections likely underestimate the extent of change in average rainfall and rainy days. At the time of writing, analysis based on the more recent RCP scenarios is not yet available.

In terms of stream and river flow, it is projected that long-term stream flow will potentially be reduced by between three per cent and 11 per cent by 2020 and seven per cent to 35 per cent by 2035, as a consequence of reduced overall rainfall (Howe et al: 2005).

4.3.4 Increased incidence and/or magnitude of extreme high sea level

The IPCC in Climate Change 2013: The Physical Science Basis states that the rate of sea level rise since the mid-19th century has been greater than the mean rate during the previous two millennia. Since the 1970s the majority of sea level rise can be attributed to large-scale glacier loss and ocean thermal expansion.

The most extreme sea levels along Victoria's coastline occur when high tides coincide with storm surges associated with weather systems that bring westerly winds to the southern coast of Australia (DSE: 2012c). This is represented diagrammatically in Figure 19.

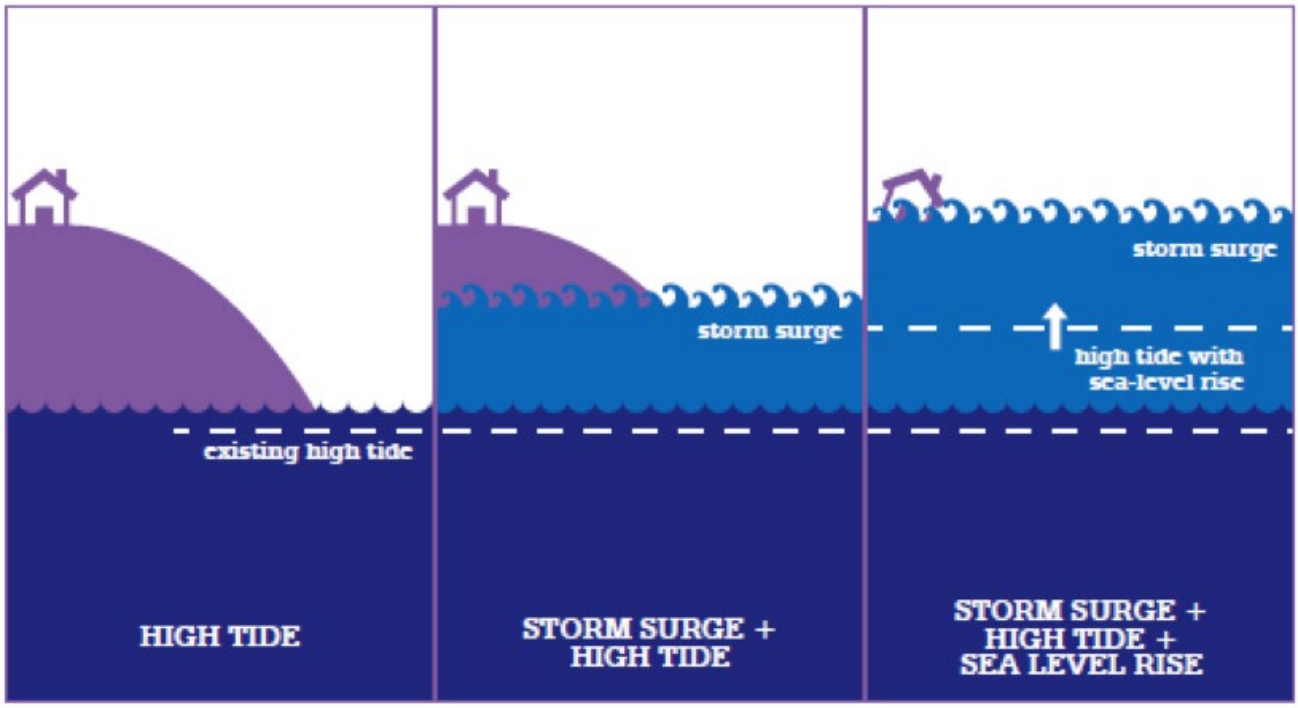

Figure 19 - Influence of sea level rise on storm surge (Source: Steffen and Hughes: 2013)

Climate change is likely to alter the nature of coastal hazards and, at many locations, make existing hazards worse. The Victorian Government has modelled the potential extent of sea level rise combined with a 1 in 100 Year Storm Tide Event for the Victorian coastline. This has been modelled for 2040, 2070 and 2100 in comparison to a 2009 base year. The relevant mapping for the coastal section of the NAGA region associated with the City of Melbourne is *Central Section Lorne to Wonthaggi* (DSE 2012). In 2100, along the foreshore area, this is characterised by the proposed Fishermans Bend urban renewal area (City of Port Phillip) and Port Melbourne. These potential impacts extend along the initial reaches of the Yarra River and the Maribyrnong River.

4.3.5 Fire

The danger posed by fires is defined as a combination of factors that influence the development, spread and difficulty of control of fires. Certain factors—slope and fuel load—change relatively slowly over time, whereas other factors—wind speed, relative humidity and temperature—change rapidly with time and have the greatest potential to be influenced by climate change.

The danger posed by fire is measured by the McArthur Forest Fire Danger Index (FFDI), developed in 1967 and the Grassland Fire Danger Index (GFDI), which are determined on both climatic and existing condition inputs (Table 10). Together these indices comprise the fire danger index (FDI) (2009 Victorian Bushfires Royal Commission: 2010); the relationship to the historic fire danger ratings is provided in Table 11. The original design of the FDI was capped at a maximum of 100.

FIRE INDEX	CLIMATIC INPUTS	EXISTING CONDITION INPUTS
FFDI	Drought, recent precipitation levels, temperature, relative humidity and wind speed.	Normative fuel load
GFDI	Temperature, relative humidity and wind speed.	Curing or fuel moisture

Table 10 - Forest and grass fire danger indices inputs

RATINGS	FFDI	GFDI
Low danger rating	0-4	0-2
Moderate danger rating	5-11	3-7
High danger	12-23	8-19
Very High danger rating	24-49	20-49
Extreme danger rating	50+	50+

Table 11 - Historic FFDI and GFDI ratings

For the NAGA region, it was the combination of conditions faced on Black Saturday (extreme temperatures with a strong prevailing northerly wind followed by a rapid change in wind direction) that posed the greatest threat.

The fire danger ratings for FFDI and GFDI on Black Saturday, 7 February 2009, highlight that the majority of Victoria had a rating well in excess of 100. Areas in proximity to the NAGA region, such as Tullamarine and Coldstream had a FFDI of 164 and GFDI of 175 and a FFDI of 142 and GFDI of 186 respectively. The *2009 Victorian Bushfires Royal Commission – Interim Report* noted that 'there is a significant difference between a day with an FDI of 50 and a day on which the FDI is 100 or even 200. Following the 2009 Victorian Bushfires Royal Commission the fire danger rating system for Victoria was amended. This stemmed from shortcomings associated with 'extreme' fire danger ratings above 50.

In October 2010 and in response to these observations the indices were revised and a new Fire Danger Rating (FDR) system established. The Bureau of Meteorology provides fire agencies with the FDI who then provide a Fire Danger Rating to guide the community and business on the potential behaviour of a fire, should one alight, as set out in Table 12.

FIRE DANGER RATING	FIRE DANGER INDEX	POTENTIAL FIRE BEHAVIOUR
Catastrophic (Code Red)	100+	Fires will likely be uncontrollable, unpredictable and very fast moving with highly aggressive flames extending high above tree-tops and buildings.
Extreme	75-99	Fires will likely be uncontrollable, unpredictable and fast moving with flames in the tree tops, and higher than roof tops.
Severe	50-74	Fires will likely be uncontrollable and fast moving with flames that may be higher than roof top
Very High	25-49	Fires can be difficult to control and present a very real threat
High	12-24	Fires can be controlled but still present a threat.
Low - Moderate	0-11	Fires can be easily controlled but still present a threat.

Table 12 - Fire Danger Rating and Fire Danger Index

To guide its future program of controlled burns, the fomer Department of Environment and Primary Industries, documented the area of land in Victoria burnt from historic events (Figure 20). This clearly illustrates that uncontrolled bushfires have a significant impact in terms of the area of the state burnt during these events. Furthermore, when compared to grass fires, bushfires (or forest fires) impact a significantly larger area of the state.

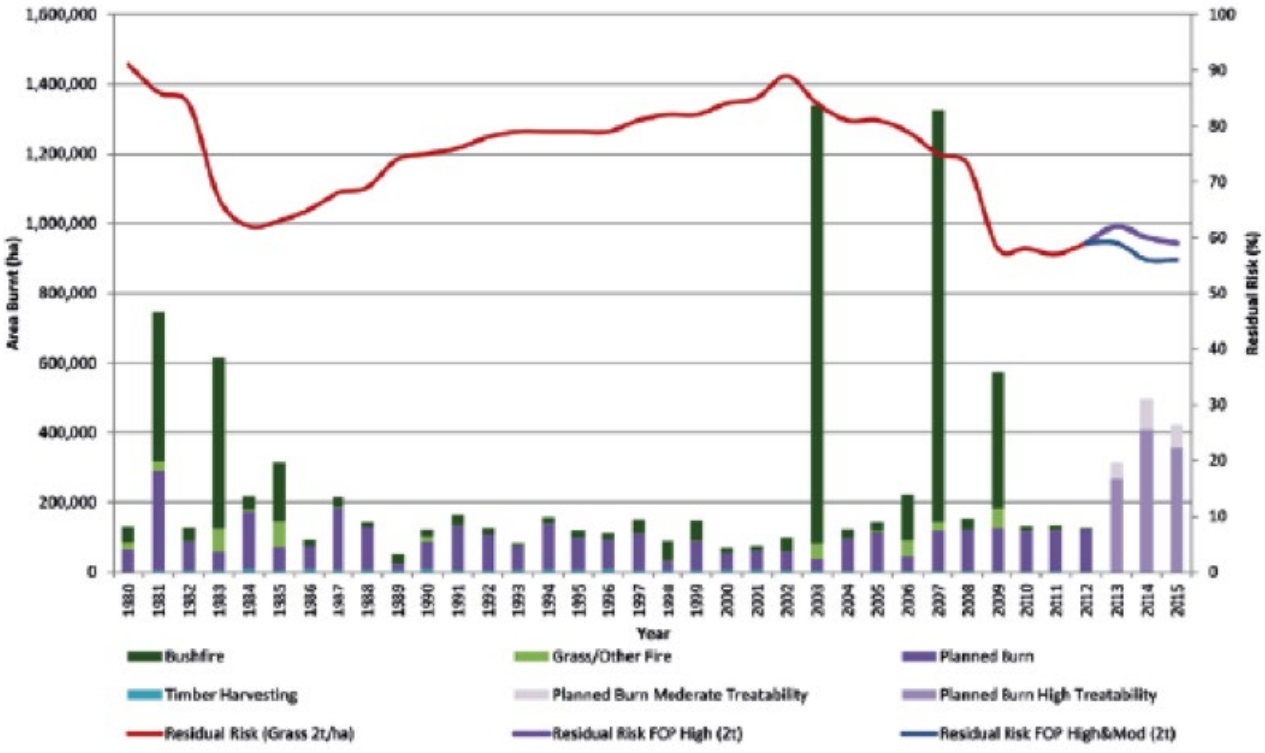

Figure 20 - Residual fire risk profile – Victoria

To manage the risk to communities and infrastructure from fire the Victorian Government introduced the *Integrated Planning and Building Framework for Bushfire in Victoria* (Department of Transport, Planning and Local Infrastructure: 2011). Under the Framework, the Bushfire Management Overlay addresses extreme and significant bushfire hazard and places specific planning and building approval requirements on new development.

The Bushfire Prone Area designation is for areas of moderate to high bushfire hazard and provides for bushfire specific building approval requirements. The application of the relevant bushfire overlays for the NAGA region are illustrated in Figure 21. This clearly highlights that the outer municipalities of the City of Hume, City of Whittlesea, Shire of Nillumbik and City of Manningham are most vulnerable to the potential direct impacts of grassland or bushfire. This vulnerability is associated with residents and businesses being present within areas designated as Bushfire Management Overlay or Bushfire Prone Area and also through the proximity of existing urban and residential development areas to these designations.

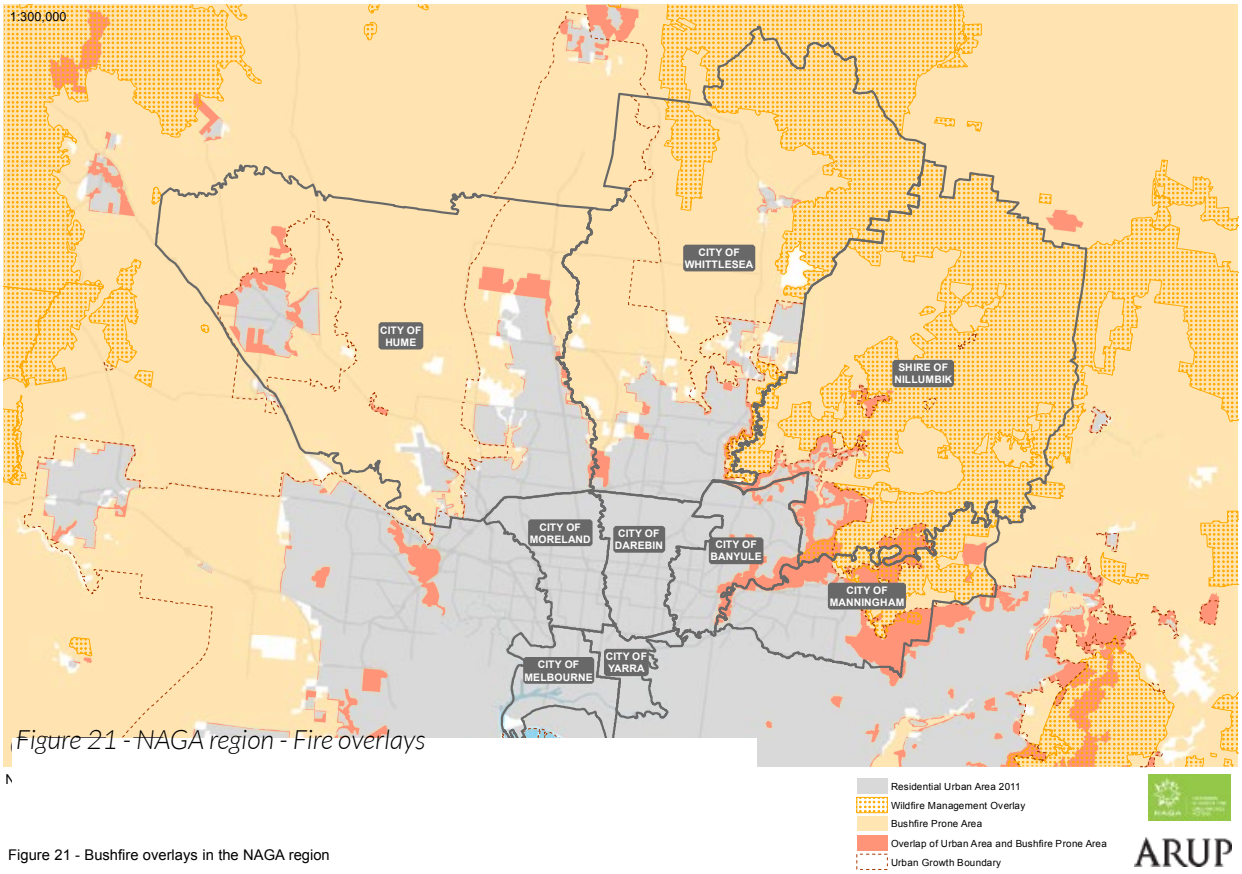

Figure 21 - NAGA region - Fire overlays

Figure 21 - Bushfire overlays in the NAGA region

4.3.6 Flooding

Flooding is directly related to the climate exposure of heavy rainfall events. The extent of flooding associated with heavy rainfall events varies depending on the presence of impermeable surfaces, location of waterways, direction of underground and surface flows and type of vegetation present.

Melbourne Water in its publication *Guidelines for Development in Flood-prone Areas* (Melbourne Water: 2008) provides an overview of flooding and the associated planning controls in the *Planning and Environment Act 1987*. It notes that 'flooding occurs when runoff from heavy or widespread rainfall fills drains, channels, depressions and watercourses and then continues to rise, inundating adjacent areas'. In Victoria, the 1 in 100 year Average Recurrence Interval (ARI) or 1 per cent Annual Exceedance Probability (AEP) is the current measure by which the potential for flooding is identified.

Flooding can be categorised as either mainstream or stormwater flooding. Mainstream flooding is associated with runoff from a catchment in waterways that continues until the water level exceeds the waterway channel and impacts on surrounding areas. Areas impacted by mainstream flooding are referred to as being located in a floodplain. Stormwater flooding is when catchment runoff exceeds the capacity of underground or piped drainage and passes overland.

The planning scheme in Victoria seeks to guard against unsuitable development in flood prone areas. The various controls under the *Planning and Environment Act 1987* are outlined in Table 13 and are sourced from *Guidelines for Development in Flood-prone Areas* (Melbourne Water: 2008). Flood modelling is based on the *Australian Rainfall and Runoff: A Guide to Flood Estimation*. This document is currently being updated and will guide the next iteration of flood modelling for the NAGA region.

PLANNING MECHANISM	DESCRIPTION
Urban Floodway Zone (UFZ)	Land affected by flooding in urban areas where the primary function of the land is to convey active flood flows. Applies to urban floodway areas where the potential flood risk is high due to the presence of existing development or pressures for new or more intensive development.
Floodway Overlay (FO)	Applies to mainstream flooding in both rural and urban areas. Conveys active flood flows or store floodwater in a similar way to the UFZ, but with a lesser flood risk.
Land Subject to Inundation Overlay (LSIO)	Applies to mainstream flooding in both rural and urban areas. In general, areas covered by the LSIO have a lower flood risk than UFZ or FO areas.
Special Building Overlay (SBO)	Applies to land affected by overland flooding from the piped system during a 1 in 100 year storm. With the redevelopment of existing urban areas and the proposed development of new areas, there is growing pressure to develop within overland flow path areas.

Table 13 - Flooding controls under the Planning and Environment Act 1987

The presence of the differing flood overlays across the NAGA region is provided in Figure 22. In general these overlays are associated with the presence of waterways. The majority of the NAGA region is located in the Yarra Catchment and significant water courses include the Middle and Lower Yarra River, Darebin Creek, Moonee Ponds Creek, Merri Creek, Plenty River and Diamond Creek. The other catchment of note in NAGA region is Maribyrnong Catchment. Key waterways of note are the Maribyrnong River, Jacksons Creek, Moonee Ponds Creek and Steele Creek.

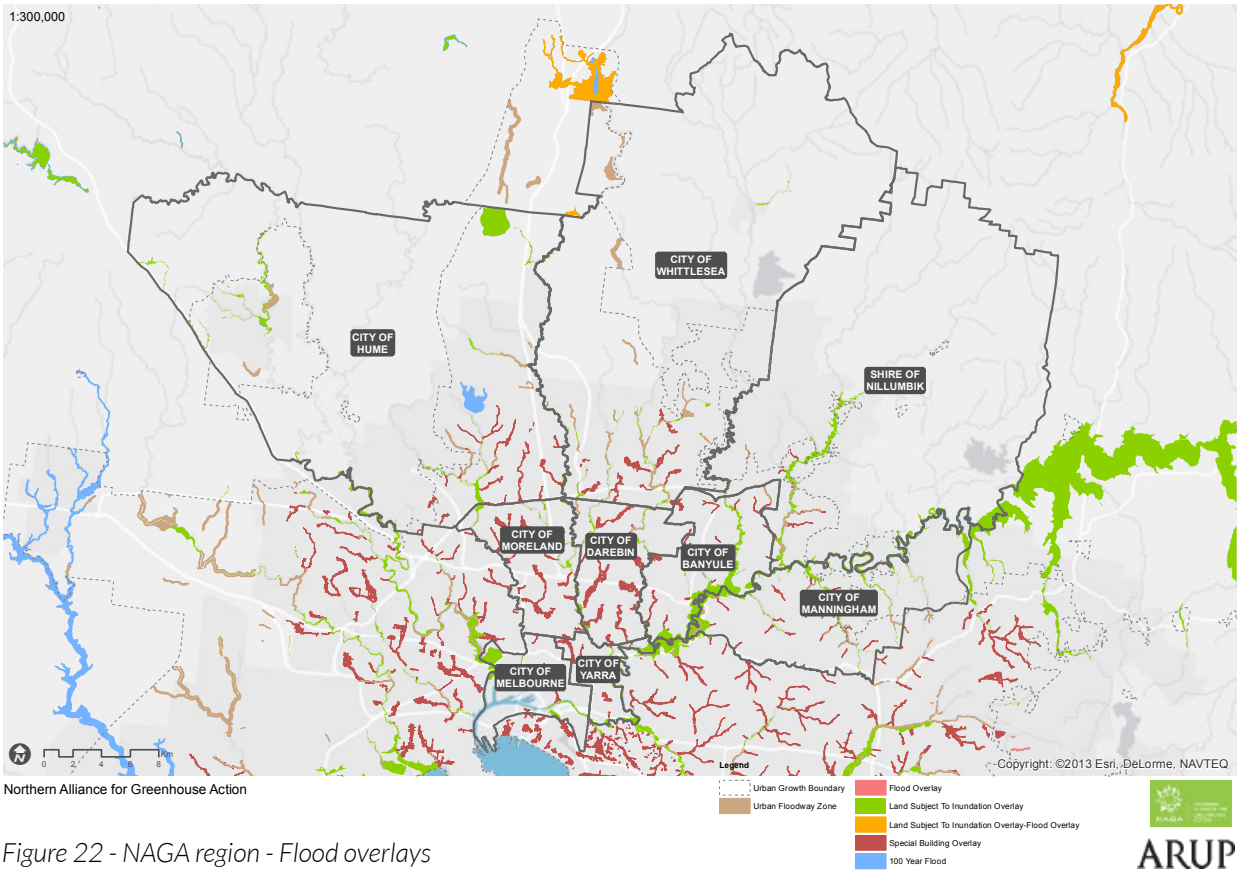

Figure 22 - NAGA region - Flood overlays

5. VULNERABILITIES

5.1 Introduction

Vulnerability is defined as the degree to which a population, individual, object or the environment is susceptible to and unable to cope with adverse effects of climate change. It is a function of the character, magnitude, variability and rate of climate change to which a population, individual, object or environment is exposed, including their sensitivity and adaptive capacity (IPCC: 2007).

Across an area as diverse and complex as the NAGA region there will be multiple and varying vulnerabilities to identified climate change impacts and associated risks. These vulnerabilities encompass not only individuals and communities, but also infrastructure and the natural environment.

For the NAGA region, the main climate exposure events are heatwaves, fire and flooding. Over recent years considerable effort has been focused on understanding the vulnerability of individuals and populations to these events. The following provides a description of the populations, infrastructure and aspects of the natural and socioeconomic environment most vulnerable to these climate exposure events. These vulnerabilities are listed for each sector in in Volume II, Appendix A.

For a number of these vulnerabilities, indicators and supporting data have been identified to enable an understanding of the proportion of a population or presence across the NAGA region. This has been undertaken at a local government area (LGA) level and where the data has been available, at sub LGA, Statistical Local Area (SLA) level. The resultant tables from this assessment are included in Volume II, Appendix A. It is noted that suitable indicators and data sets were not identified for all vulnerabilities. Over coming years, as knowledge increases around vulnerabilities and approaches to measuring, it is expected that suitable indicators and supporting data sets will be developed.

Figures 23 to 28 are derived from available data sets and included as part of the description below. To enhance the localised understanding of the distribution of vulnerabilities within each municipality, these figures are presented at the smallest unit of Census data, SA1. SA1 units generally have a population of between 200 and 800 persons, with an average population of 400 persons. Across the NAGA region there are significant variances in population density and hence the land area associated with SA1's. Areas of white represent locations where there was insufficient or poor quality data.

5.2 Exposure vulnerabilities

5.2.1 Populations

The impact of climate change is likely to be more severe for vulnerable groups within the NAGA region. Socially disadvantaged people and communities are disproportionately affected during emergencies as they have limited resources to prepare for and recover from disasters.

A Victorian Council of Social Service (VCOSS) report, *Disaster and disadvantage: Social vulnerability in emergency management* (VCOSS: 2014), identifies key vulnerable groups in emergency situations. From the NAGA region perspective, this is particularly relevant to flood and fire events. The *Heatwave Plan for Victoria* (Department of Health: 2011) was developed to protect the health of Victorians, particularly vulnerable groups, during a heatwave. In considering the vulnerable groups identified within these two reports, the following vulnerabilities have been identified as relevant to the human services sector:

- those in poverty;
- children and young people;
- older people;
- migrant and refugee population;
- people with a disability;
- people with poor quality housing;
- people with mental health issues;
- people with multiple and complex needs;
- people with alcohol and drug issues;
- victims of family violence;
- those with existing illnesses;
- obese and overweight people; and
- Indigenous communities.

Note that there is often overlap between the groups mentioned above and there can be multiple as well as complex relationships between these vulnerabilities.

Poverty

The impact of climate change exposures, irrespective of the event, on poor people is greater due to their lack of financial capacity to prepare for and recover from emergency events. Poor people are generally unable to afford the protection and security of preparing for an emergency by purchasing insurance.

Indicators

Three indicators of poverty across the region have been used. The first is median average weekly income and the second and third are indices from the Index of Relative Socio-Economic Disadvantage (SEIFA), specifically the:

- Index of Relative Socio-Economic Disadvantage (IRSD); and
- Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD).

These two indices have been chosen as *Disaster and disadvantage: Social vulnerability in emergency management* identifies 'people who are socioeconomically disadvantaged' as a cohort with the same vulnerability as low-income people, this being the potential to 'lack the resources to prepare for, mitigate and recover from disasters'.

The IRSD and IRSAD have been collated for the NAGA region to provide both an understanding of areas of relative disadvantage, as represented by the IRSD, and whether these areas are interspersed by populations of relatively advantaged, as represented by the IRSAD.

Both of the above indices combine a range of variables from the 2011 Census and are replicated in Table 14. The Australian Bureau of Statistics (ABS) publication *Socio-Economic Indexes for Areas (SEIFA) Technical Paper* (ABS: 2013) emphasises the need to consider that the outputs represent the population across an area and not individuals. The IRSD summarises variables that indicate relative disadvantage, with a low score indicating a high proportion of relatively disadvantaged people in an area. The IRSAD includes a similar set of disadvantaged variables, but also includes additional advantaged variables.

In an area which contains pockets of disadvantaged and advantaged, the IRSD will represent this area as disadvantaged, whereas the IRSAD will represent this as a more moderate ranking, picking up the advantaged aspects of the area.

INDEX OF RELATIVE SOCIO-ECONOMIC DISADVANTAGE (IRSD)	INDEX OF RELATIVE SOCIO-ECONOMIC DISADVANTAGE AND ADVANTAGE (IRSAD)
DISADVANTAGE VARIABLES	**VARIABLES**
People with stated annual household equivalised income between $1 and $20,799 (approx. 1st and 2nd deciles)	People with stated annual household equivalised income between $1 and $20,799 (approx. 1st and 2nd deciles)
Families with children under 15 years of age who live with jobless parents	Families with children under 15 years of age who live with jobless parents
Occupied private dwellings with no internet connection	Occupied private dwellings with no internet connection
People aged 15 years and over whose highest level of education is Year 11 or lower. Includes Certificate I and II	People aged 15 years and over whose highest level of education is Year 11 or lower. Includes Certificate I and II
Employed people classified as 'labourers'	Employed people classified as 'labourers'
One parent families with dependent offspring only	One parent families with dependent offspring only
People (in the labour force) unemployed	People (in the labour force) unemployed
People aged under 70 who have a long–term health condition or disability and need assistance with core activities	People aged under 70 who have a long-term health condition or disability and need assistance with core activities
Occupied private dwellings paying rent less than $166 per week (excluding $0 per week)	Occupied private dwellings paying rent less than $166 per week (excluding $0 per week)
People aged 15 and over who are separated or divorced	People aged 15 and over who are separated or divorced
Employed people classified as Machinery Operators and Drivers	Employed people classified as Machinery Operators and Drivers
Employed people classified as Low Skill Community and Personal Service Workers	Employed people classified as Low Skill Community and Personal Service Workers
Occupied private dwellings with no cars	Occupied private dwellings with no cars
Occupied private dwellings requiring one or more extra bedrooms (based on Canadian National Occupancy Standard)	Occupied private dwellings requiring one or more extra bedrooms (based on Canadian National Occupancy Standard)

INDEX OF RELATIVE SOCIO-ECONOMIC DISADVANTAGE (IRSD)	INDEX OF RELATIVE SOCIO-ECONOMIC DISADVANTAGE AND ADVANTAGE (IRSAD)
DISADVANTAGE VARIABLES	**VARIABLES**
People aged 15 years and over who have no educational attainment	People aged 15 years and over who have no educational attainment
People who do not speak English well	Occupied private dwellings with three or more cars
	People aged 15 years and over at university or other tertiary institution
	Occupied private dwellings with one or more bedrooms spare
	Occupied private dwellings paying rent greater than $370 per week
	Employed people classified as Managers
	Occupied private dwellings with four or more bedrooms
	Employed people classified as Professionals
	People aged 15 years and over whose highest level of education attainment is a diploma qualification
	Occupied private dwellings paying mortgage greater than $2,800 per month
	People with stated annual household equivalised income greater than $52,000 (approx 9th and 10th deciles)

Table 14 - IRSD and IRSAD Variables

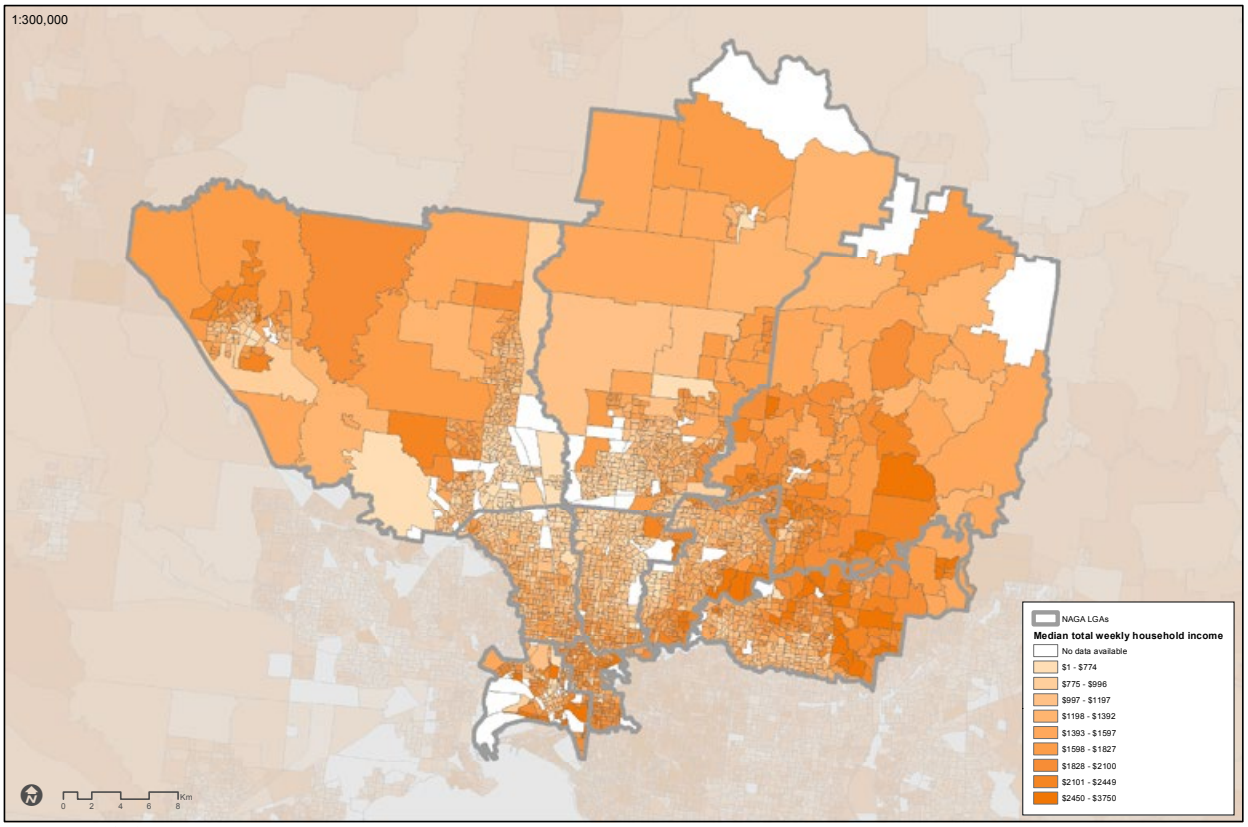

Figure 23 - Median total weekly household income for the NAGA region

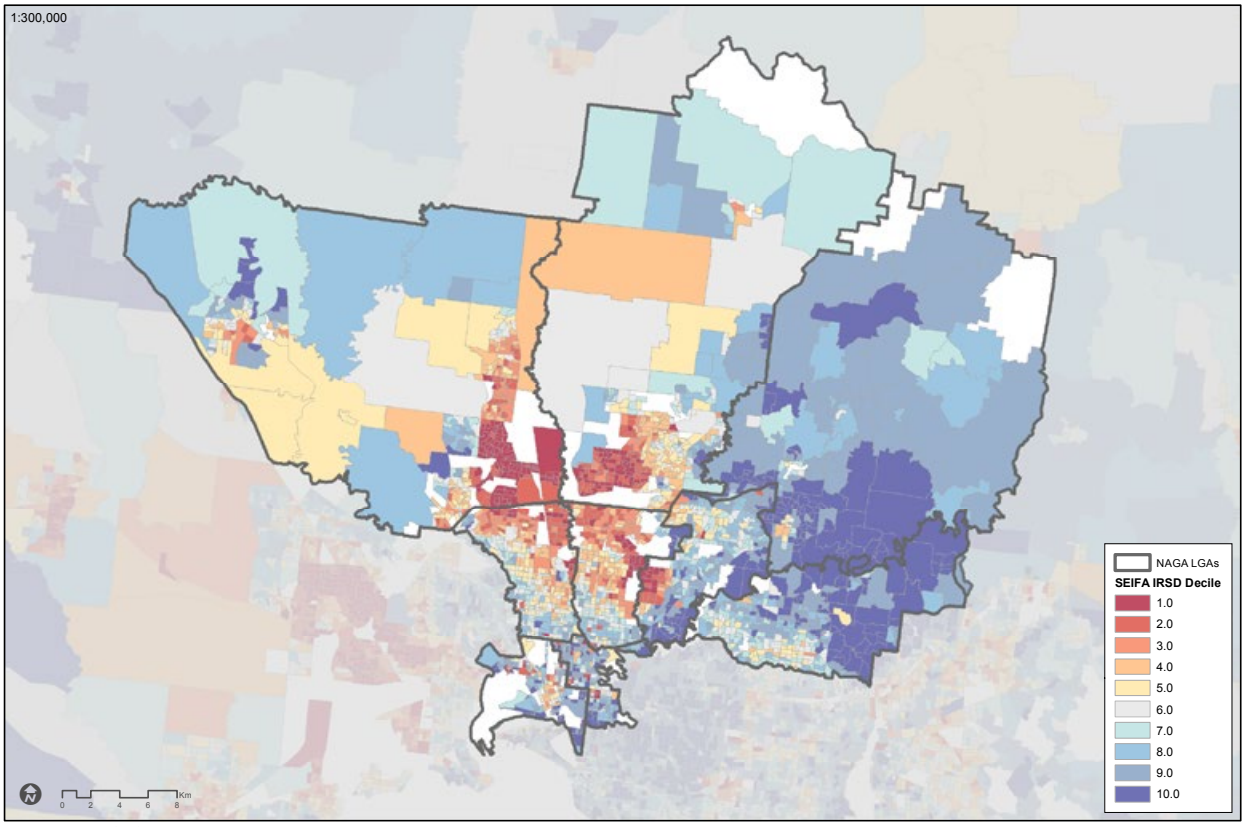

Figure 24 - Index of Relative Socio-Economic Disadvantage (IRSD) for the NAGA region

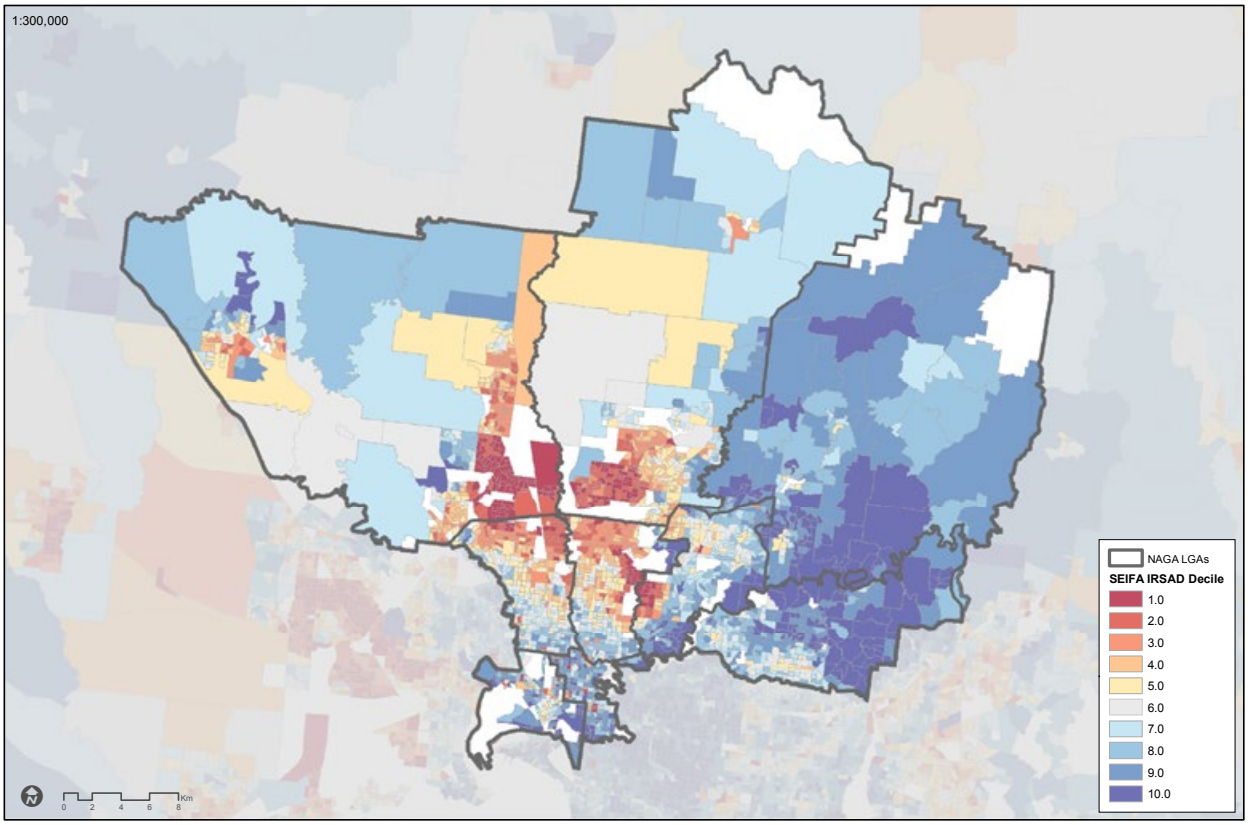

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Figure 25 - Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) for the NAGA region

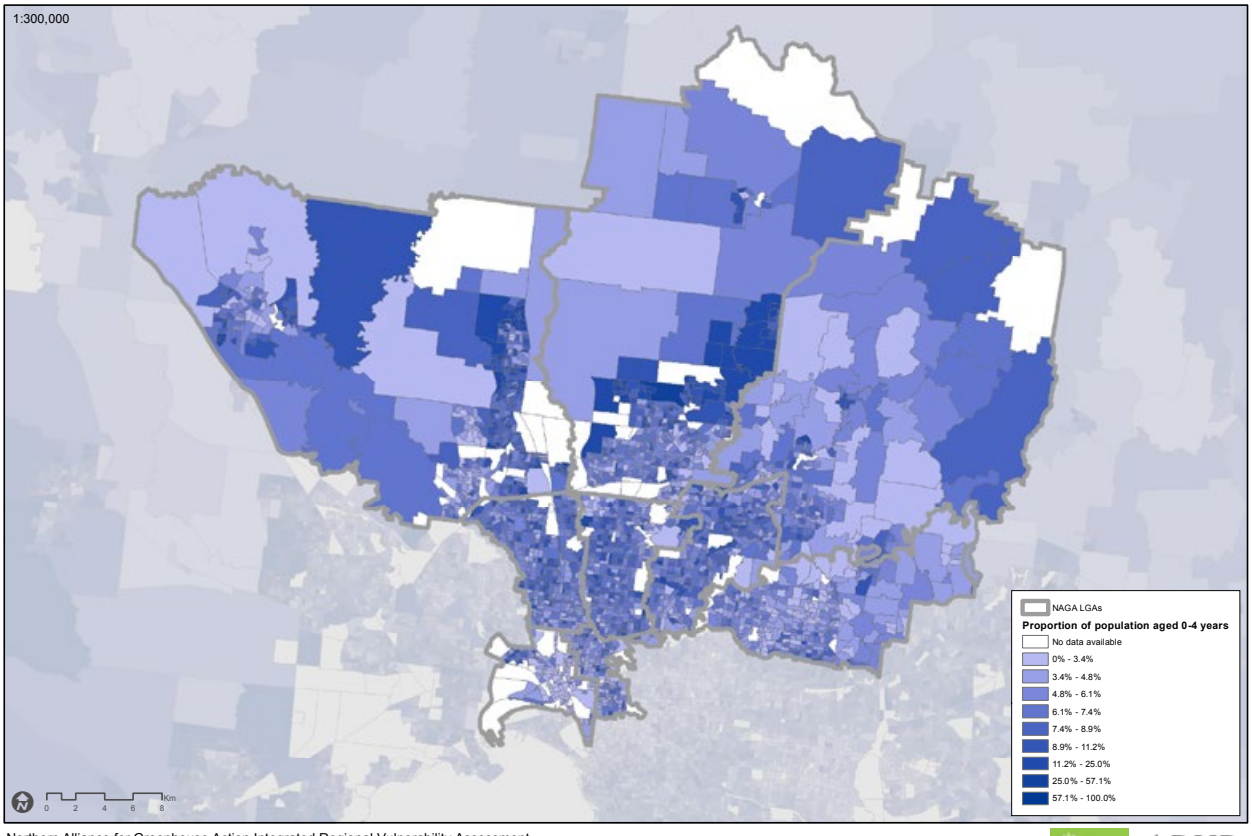

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Figure 26 - Proportion of residents aged 0 to 4 years for the NAGA region by SA1

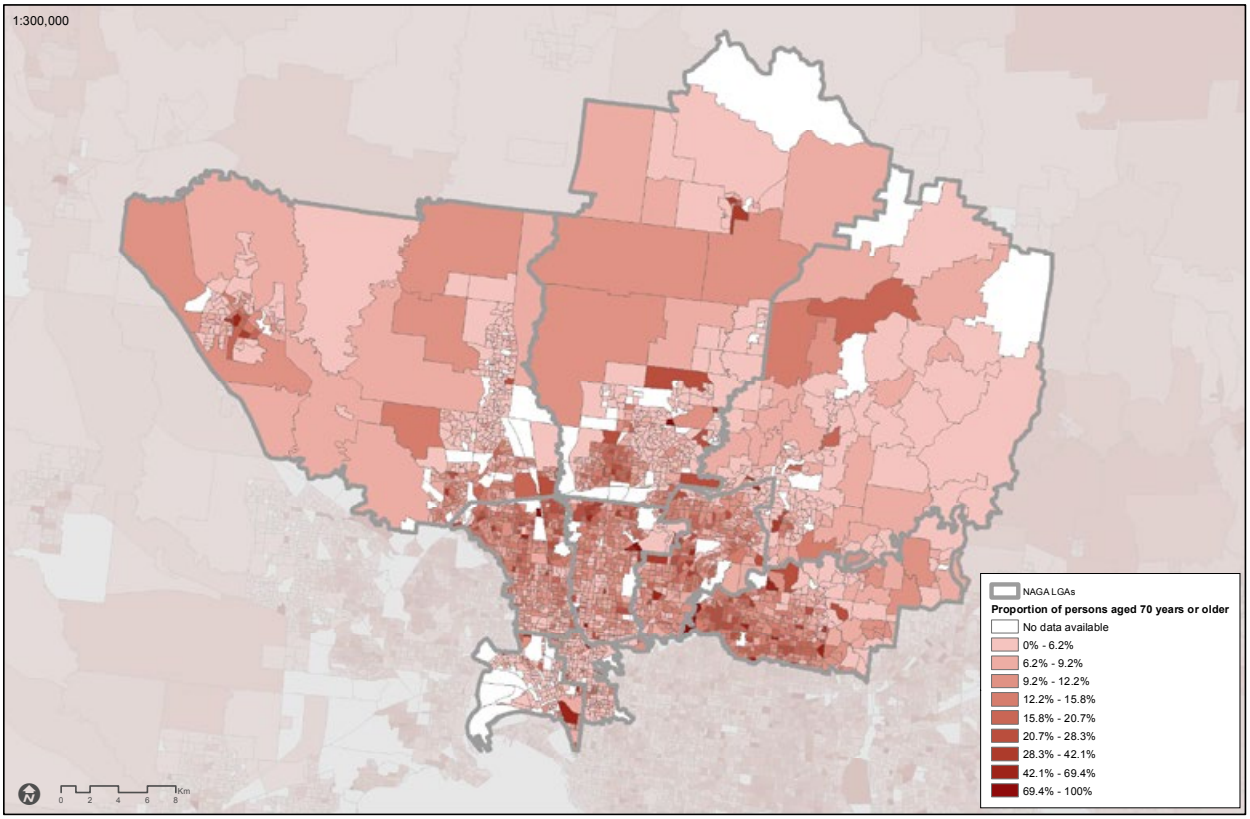

Figure 27 - Proportion of residents aged 70 years or older for the NAGA region by SA1

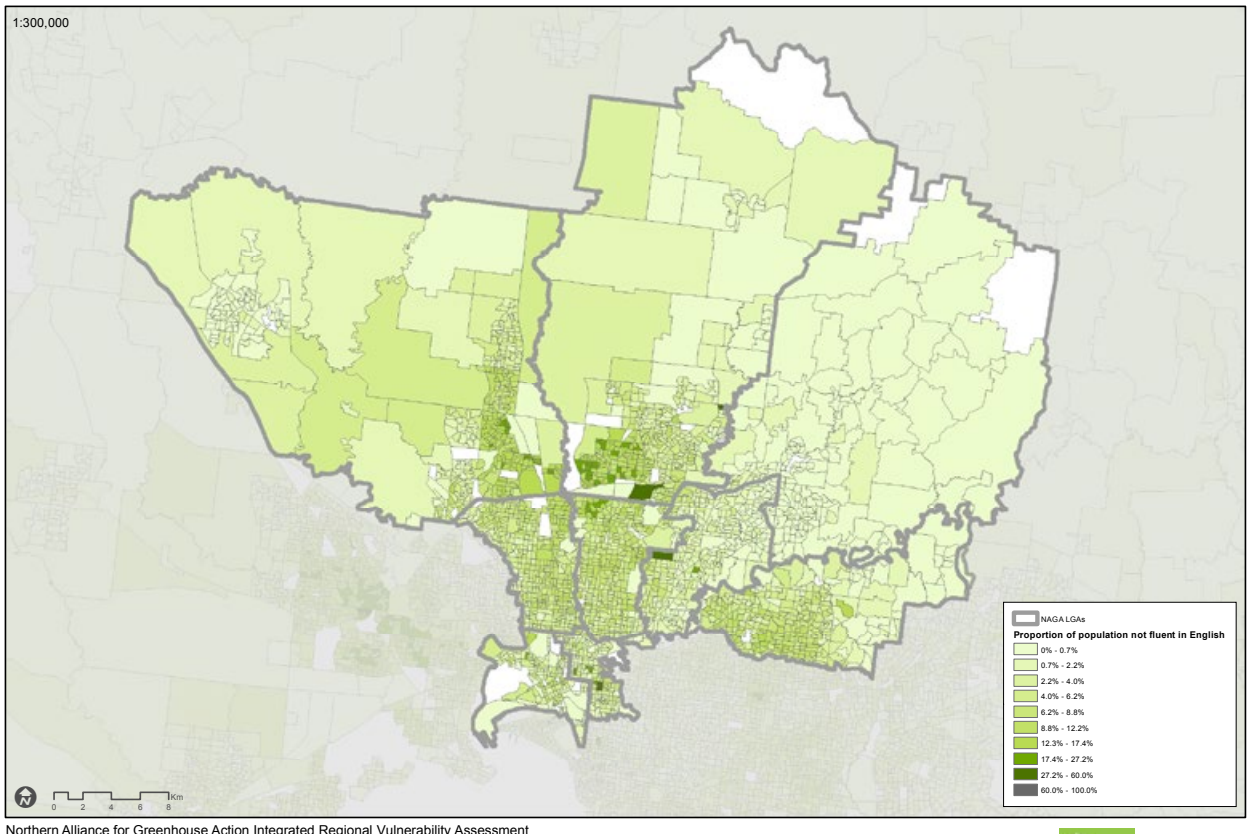

Figure 28 - Proportion of persons who speak another language and speak English not well or not at all for the NAGA region

NAGA region

The assessment of the variance of median average weekly household income is tabulated at LGA level in Volume II, Appendix A and represented graphically at SA1 level in Figure 23. At an LGA level the LGAs within the NAGA region with the lowest median total household weekly income are the City of Darebin, City of Moreland and City of Hume, while the highest are the Shire of Nillumbik and City of Yarra.

When this information is reviewed at an SA1 level (Figure 23) it is evident that the areas of lowest median average weekly household income are located in areas to the immediate north and south of the Metropolitan Ring Road in the aforementioned municipalities. Also of note is that areas of high average weekly household income are congregated along the Yarra River corridor to the east to the NAGA region and that large disparities in incomes exist in the City of Manningham, City of Melbourne, City of Whittlesea and City of Banyule.

At an LGA level the overall trend in ISRAD rankings generally reflect the ISRD, with the City of Hume having the lowest IRSAD ranking followed by the City of Whittlesea, the City of Darebin and the City of Moreland. The Shire of Nillumbik has the highest ranking followed by the City of Manningham and the City of Melbourne.

When comparing IRSAD and IRSD at the LGA level, it is noted that the ranking for both City of Melbourne and City of Yarra are 25 and 23 places higher for IRSAD than the IRSD ranking, indicating that across the municipality there are areas of relative socioeconomically advantaged populations, which are driving the increased ranking.

The ISRAD at SA1 (Figure 24), highlights the areas of relative socioeconomic disadvantage within the City of Hume, in particular in the Broadmeadows and Campbellfield areas, and to a lesser degree the City of Moreland. Areas of relative socioeconomic disadvantage are also present in the southern western part of the City of Whittlesea in proximity to Lalor and Thomastown, and on border of the City of Darebin and City of Banyule, in Reservoir. There are significant areas of relative socioeconomic advantage through the Shire of Nillumbik and the eastern and northern extents of the City of Manningham.

Children and young people

Children are vulnerable during climate change exposure events as they lack the resources, knowledge and life experiences to cope with the situation, and must rely on others to protect them. Children in out-of-home care, with child protection considerations or whose parents are refugees and migrants face increased vulnerability.

Indicators

The indicator applied to determining the presence of children and young people is the percentage of the population aged 0 – 4 years in 2011 and the projected percentage in 2030. The distribution of the 2011 populations have been mapped to a SA1 level as represented in Figure 26.

NAGA region

The growth area municipalities of the City of Hume and the City of Whittlesea have the highest proportion of the population of 0 to 4 years, with over seven per cent each. Following these municipalities, the City of Moreland, Banyule and Darebin all have 6.5 per cent of the population between 0 to 4 years. The City of Melbourne and Manningham having the lowest proportions.

In 2030 it is projected that the proportion of the population 0 to 4 years will generally decrease in the NAGA region. The City of Hume and City of Whittlesea will still have the highest proportion of this age group (7.6 and 7.4 per cent respectively) and the City of Manningham and Melbourne will have the lowest proportions (4.6 and 4.8 per cent respectively).

Older people

Factors associated with ageing increase the vulnerability of older people to climate events. Vulnerability factors associated with ageing include reduced mobility and sensory awareness, pre-existing health conditions and social and economic constraints.

Across Australia there is an overarching trend of an ageing population, with VCOSS predicting that 20 per cent of Victorians will be over 60 by 2021. One outcome will be in the growth of age-related conditions, such as dementia; just under 1 million Australians and 250,000 Victorians are predicted to have dementia by 2050 (Access Economics: 2011). Of this population, across Australia those aged 85-89 with dementia is projected to increase from 65,471 in 2011, to approximately 225,000 in 2050.

Indicators

The indicator applied to determine the population of older people across the NAGA region is the percentage of the population aged 70 or over in 2011 and projected to 2030. This has been chosen as it corresponds to the indicator the Victorian Department of Health uses to determine the number of aged care facilities across each LGA (Department of Health: 2013a). The 2011 populations have been mapped to a SA1 level as represented in Figure 27.

A secondary indicator has been applied, which is the percentage of the population aged 80 or over present within each municipality in 2011 and the projected populations to 2030. This has been included as certain vulnerabilities, such as mobility and pre-existing medical conditions increase in prevalence as a population ages.

NAGA region

Across the NAGA region, he largest proportion of the population aged 70 and over are in the City of Manningham and City of Moreland, with the smallest percentages in the City of Melbourne and the Shire of Nillumbik.

In regards to the proportion of the population who are 80 and older, the City of Moreland and City of Banyule have the highest percentages and City of Melbourne and the City of Hume the smallest percentages.

In 2030 the proportion of the population over 70 and over 80 will greatly increase across the NAGA region. In 2030, the highest proportion of individuals over 70 and over 80 will be found in the City of Manningham and the Shire of Nillumbik, while the lowest proportion will be in the City of Melbourne.

Migrant and refugee populations

Culturally and linguistically diverse (CaLD) people are often more vulnerable during climate events due to communication barriers, poor quality housing, cultural issues and socioeconomic disadvantage. It is difficult for people with limited English proficiency to find information on how to deal with emergency situations, and also to understand and hence respond to emergency communications. A lack of knowledge of the Australian context may also increase vulnerability to certain climate events such as fire. Furthermore, prior traumatic experiences in their country of origin may impact migrant and refugee responses to natural disasters.

Indicators

The indicators applied to determine the presence of populations of CaLD is the percentage of people who were born overseas and who speak English not well and the proportion of the population who speak English well or not at all. The second indicator has been mapped at SA1 as illustrated in Figure 28.

NAGA region

Across the NAGA region, the largest populations are present within the City of Darebin, followed by the City of Whittlesea, City of Moreland and City of Hume, who all have greater than six percent of the population who were born overseas and who speak English not well or not at all.

Figure 28 illustrates that populations who speak English well or not at all are generally present across the City of Darebin, with greater concentrations of populations present in the northern part of the municipality, south of the Metropolitan Ring Road in proximity to Reservoir. Relatively large populations are also present in the southern areas of the City of Whittlesea in Thomastown and Lalor and across the City of Moreland, in particular in the vicinity of Fawkner. Within the City of Hume comparatively large populations are present in a north south corridor including Broadmeadows, Meadow Heights, Roxburgh Heights and to a lesser extent Craigieburn.

People with a disability

People with physical, intellectual, hearing and vision disabilities have increased vulnerability during a climate event. They are more likely to be left out of planning processes, overlooked during emergency evacuations, and excluded in longer term recovery efforts. People with disabilities are often unable to access information or services as they are not made available in accessible forms.

Indicators

Two indicators have been applied to provide an understanding of those with a disability across the NAGA region. At a LGA level, this is the percentage of the population with a need for assistance with core activity (i.e. self-care, mobility and communication) and those aged 0 to 64 years with a profound or severe disability living in the community.

NAGA region

The City of Moreland and City of Darebin, with greater than six per cent of the population, have the largest presence of those with a need for assistance with a core activity. The City of Melbourne and the Shire of Nillumbik have the lowest population percentages.

In regards to those aged 0 to 64 years with a profound or severe disability living in the community, the City of Hume has the highest proportion of the population at 3.4 per cent, followed by the City of Darebin (2.4 per cent) and City of Moreland (2.3 per cent). As per the previous indicator, the City of Melbourne and Shire of Nillumbik have the lowest population percentages.

People with poor quality housing

Poor quality housing encompasses a range of housing types, such as caravan parks, temporary housing or sub-standard or overcrowded or hazardous housing as well as those who are homeless. In addition, housing may appear to be high quality but be lacking in a certain way that increases vulnerability, such as inadequate thermal performance.

The quality and location of housing can influence vulnerability to climate events. Those without access to stable and secure housing can be unaware of emergencies due to a lack of access to communications or have the impacts of climatic shocks and stresses exacerbated by the housing type. The homeless risk being exposed to extreme weather and not being factored into evacuation plans.

Indicators

The indicator for people with poor quality housing is the number of persons homeless which is measured at a LGA level.

NAGA region

The largest population across with the NAGA region of homeless is within the City of Melbourne (1,254) followed by the City of Darebin (992). The City of Moreland and City of Hume have the next highest populations of 782 persons. The Shire of Nillumbik has the lowest population of homeless (76).

People with mental health issues

People with mental health issues are less likely to have an emergency plan and are more dependent on others for assistance during climate events. Emergencies and the disruptions they cause can trigger or exacerbate symptoms. People with mental health issues will be adversely affected by disruptions to hospital, pharmacy and transport services and may also be more likely to be overlooked during emergency evacuations.

Indicators

Measured at a LGA level, the indicator of the presence of mental health illness within the NAGA region is the percentage of the population registered as mental health clients.

NAGA region

The City of Yarra has the highest percentage of registered mental health clients across the NAGA region, 1.24 per cent. Other municipalities with a comparatively high percentage of the population as registered mental health clients are City of Darebin, City of Moreland and City of Hume. The City of Manningham and Shire of Nillumbik have the lowest relative proportions of the population registered as mental health clients.

People with multiple and complex needs

People or families that have multiple interrelated needs are particularly vulnerable as they are likely to be unable to cope with emergency situations. People with complex needs face multiple disadvantages, and may find the impacts of climate events overwhelming and unmanageable.

VCOSS notes that families with multiple and complex needs are typically situated within a broader context of social, economic and structural disadvantage, with poverty interlinked with health and housing, education and employment, lack of social capital, crime and violence, mental health difficulties, substance use or early childhood trauma.

Due to the number of potential and complex interactions, no specific indicators have been developed to measure. Rather consideration should be given when viewing the assessment of the primary vulnerability categories of the potential for additional, compounding vulnerabilities.

Other vulnerable groups

In addition to the previously described vulnerabilities, VCOSS identifies other groups who may be at increased risk during emergencies. In addition, the Department of Health publication *Heatwave Plan for Victoria – Protecting health and reducing harm from heatwaves* (Department of Health: 2011), identifies vulnerabilities specific to the climate exposure of heatwaves. The additional vulnerabilities considered as part of *Adaptation in the North* that draw from these documents are:

- People with alcohol and other drug issues
- Victims of family violence
- Those with existing illnesses
- Obese and overweight people
- Indigenous communities

The prevalence of these other vulnerabilities across the NAGA region is described below.

People with alcohol and other drug issues

People with alcohol and other drug issues are particularly vulnerable as they are consuming these substances at levels that are considered to be high risk to their health. Such individuals may have existing health conditions and they may be limited in their capacity to make sound decisions and participate in society, particularly in emergency situations. In addition, existing health conditions may be exacerbated by non-emergency events, such as heatwaves, which can still cause significant harm and occur more frequently than emergency events. Furthermore people with such issues are also less likely to have an emergency plan, to be informed of planning processes and knowledgeable of longer term recovery efforts.

Indicators

Measured at a LGA and SLA level, the indicators of alcohol and other drug issues within the NAGA region are the number and percentage of persons aged 18 and over consuming alcohol at levels considered to be a high risk to health.

NAGA region

There is little variability in the proportion of population with alcohol and drug issues, ranging from 2.6 per cent to 3 per cent in all municipalities. However differences are more apparent at the SLA Level, with Nillumbik Bal and Sunbury, Hume having the highest individual percentage at 5 per cent, whilst Broadmeadows, Hume had the lowest at 3.3 per cent.

It should be noted that Nillumbik Bal, has the lowest number of individuals (378) with alcohol and drug issues and West Manningham has the highest number, 2,745 people with such issues. When analysed at the LGA level the City of Yarra (2,093 people) represents the lowest overall figure and the City of Hume has the highest number of people (4,058 people) with alcohol and other drug issues.

Victims of family violence

Victims of family violence are likely to be more vulnerable as a result of high support needs and a lack of coping mechanisms that often arises from previous physical and/or mental abuse and trauma.

VCOSS notes that women and children who experience family violence are particularly at risk from increased violence during a recovery period. Furthermore, a loss of shelter and disruptions to routine may increase family stress and victims may be re-traumatised as a result. In addition, heatwaves may compound stresses and contribute to increased instances of family violence.

Indicators

Measured at a LGA level, the indicator is the number of family violence incident reports during 2009-2010. It is important to note, however, that much family violence goes unreported.

NAGA region

The City of Hume has the highest number of reported family violence incidents across the NAGA region, 1,756. This is substantially higher than the City of Whittlesea which with 1,231 reported incidents has the second highest number of reported incidents in the NAGA region. The Shire of Nillumbik has the lowest number of reported incidents (194) followed by the City of Manningham (387).

Those with existing illnesses

People with existing illnesses are more vulnerable to climate change events as they may experience interactive and cumulative effects that exacerbate existing health conditions. Chronic health conditions, such as respiratory system diseases will be adversely affected by heatwaves, bushfires and post-disaster situations such as poor access to health services and a lack of medication can cause acute problems compounding health effects for those with existing illnesses.

Indicators

Measured at a LGA and SLA level, the number and percentage of people with existing respiratory system diseases provides an indicator for those with existing illnesses. The LGA indicator data is from 2011 – 2013, while the SLA data is only available for 2007 – 2008.

NAGA region

The percentage of people with existing illnesses in the NAGA region is quite variable at the LGA level. Banyule with 33.1 per cent represents the highest proportion whilst 25.5 per cent, in the City of Melbourne represents the lowest proportion. There is minimal variability at the SLA Level, with North Whittlesea, Whittlesea and Sunbury, Hume having the highest proportion, whilst Inner Melbourne, City of Melbourne has the lowest proportion of the population with existing illnesses.

The total number of people with existing illnesses in the NAGA region contrasts greatly. The 47,669 people in the City of Hume which has the highest number is much greater than the 19,621 people with existing illnesses in the Shire of Nillumbik which has the lowest number, although as noted above, in percentage terms these numbers are proportionate to the population numbers in each municipality. At the SLA level Nillumbik Bal, Nillumbik which is the outer north eastern part of the municipality, has just 2,692 individuals with existing illnesses and West Manningham has 26,548 people, which is the highest.

Obese and overweight people

Obese and overweight individuals are vulnerable to climate change impacts as they are particularly vulnerable to cardiovascular disease, musculoskeletal conditions, diabetes and some cancers that may be exacerbated by climate events. Across the Australian population there is a trend of increasing obesity and climate events have the potential to increase the incidence of heat-related illnesses, such as exhaustion and heatstroke. Furthermore, environments during climate change shocks and stresses are not conducive to allowing for adequate outdoor exercise, further compounding the effects on health and wellbeing.

Indicators

Measured at a LGA and SLA level, the number and percentage of obese individuals aged 18 is a key indicator for obese and overweight people.

NAGA region

The highest percentage of obese persons within the NAGA region is in the City of Hume (30.1 per cent). The City of Whittlesea also has a comparably high proportion. The lowest proportion of obese people is in the City of Melbourne (13.5 per cent).

The City of Hume (30,712 people) and the City of Whittlesea (28,658 people) also have the highest number of obese individuals. The City of Yarra has the lowest number of obese people (7,933 people) and this is followed closely by the 7,962 obese people in the City of Melbourne and 9,659 in the Shire of Nillumbik. It should be noted that these LGAs are lower than the SLA regions with the highest numbers.

At the SLA Level the south-west of Whittlesea has the highest percentage (22.7 percent) whilst the Inner and Southbank-Docklands areas of Melbourne have the lowest proportion, 12.9 per cent. Nillumbik Bal, Nillumbik and Inner Melbourne have the lowest numbers (1,130 and 1,220 people respectively), while Preston, Darebin and West Manningham have the highest numbers (12,984 and 11,844 respectively).

Indigenous communities

Indigenous communities are susceptible to a number of health and socio-economic inequalities (Dick & Calma: 2008). Elevated levels of social exclusion, poverty and ill health in conjunction with lower levels of employment, education and income have been evident for Indigenous populations (VicHealth: 2008). As a result they are particularly vulnerable to climate change events as a result of cultural issues, a lack of knowledge about mitigation, adaptation and planning processes for climate change.

Indicators

Measured at a LGA level, the indicator of the Indigenous population in the NAGA region is the usual resident Indigenous population.

NAGA region

The highest Indigenous populations are found in the City of Darebin, the City of Whittlesea and the City of Hume where the population ranges from 1,047 to 1,155. In contrast the Shire of Nillumbik has a low Indigenous population of 194.

5.2.2 Infrastructure

The NAGA region is served by differing types of infrastructure: transport, water, electricity and gas, telecommunications, buildings and community infrastructure are vital to providing essential services to businesses and the residents and maintaining quality of life across the region. During periods of climatic shocks and stresses there are potential impacts to each infrastructure type and these have been identified in Volume II, Appendix B. Across the NAGA region the aspects of the network most vulnerable vary in terms of the presence of the infrastructure and the potential risks, in particular from fire and flood, and to a lesser extent, heatwave events. The following provides an assessment of specific infrastructure vulnerabilities across the NAGA region.

Road infrastructure

Road infrastructure is a critical transport network that is vulnerable to climate change. It has a key role in linking the NAGA region and ensuring accessibility to services, facilities and infrastructure. This access can be critical during emergency events and roads in the area are susceptible to emergencies such as bushfires and flooding.

Indicator

Measured at the LGA level, this indicator encompasses the kilometres of main roads (state declared roads) and kilometres of all roads of at risk of flooding or fire (state and council managed). Under the Road Management Act 2004, VicRoads has responsibility for overall management and development of state declared roads (freeways, arterial roads and some non-arterial state roads).

NAGA region

Within the NAGA region, all of the municipalities have roads at risk from flooding. In relation to state declared roads, the City of Melbourne and the City of Yarra have the greatest length of road at risk (12.9 and 14.3 kilometres respectively) in contrast to the Shire of Nillumbik which has just 2.7 kilometres of state declared roads at risk of flooding.

In relation to the length of all roads at risk of flood, the City of Moreland and City of Darebin have the greatest length of roads at risk of flood, between 70 to 80 kilometres. The City of Banyule and of City of Manningham have approximately 60 kilometres of road at risk, with the City of Melbourne, Shire of Nillumbik, City of Whittlesea and City of Yarra having between 40 to 50 kilometres of road at risk. The City of Hume has the least length of road at risk (36.7 kilometres).

In terms of the risk from fire, the City of Banyule, City of Hume, City of Manningham, Shire of Nillumbik and City of Whittlesea have state declared roads at risk. The City of Hume (137.5 kilometres) and the City of Whittlesea (110.2 kilometres) have the highest length of state declared road at risk.

In terms of the total length of all roads at risk from fire, the Shire of Nillumbik (1,337.7 kilometres), City of Whittlesea (933.4 kilometres) and the City of Hume (847.7) have the greatest lengths. The City of Manningham and City of Banyule also have roads at risk from fire.

Rail infrastructure

The heavy and light rail infrastructure network is a critical transport and distribution network that is vulnerable to climate change. It provides a relatively affordable means of accessing goods and services for the population of the NAGA region and the distribution of goods in and out of the region.

Indicator

Measured at the LGA level, this indicator encompasses the kilometres of rail and tram network at risk of flood, coastal threat or bushfire.

NAGA region

The City of Melbourne (9.6 kilometres) is the only municipality with more than 2 kilometres of rail at risk of flooding. Bushfire is a greater risk for some of the municipalities, particularly the City of Whittlesea and the City of Hume which have 31 and 39.3 kilometres of rail respectively at risk from bushfire. The tram network is not at risk from bushfire, however 34.3 kilometres in the City of Melbourne, 15.6 kilometres in the City of Yarra and 8 kilometres of the tram network in the City of Darebin are at risk of flood threat.

Water supply infrastructure

Bulk water for Melbourne is primarily sourced from catchments located to the North and East of the Metropolitan area, augmented as required by water from the Goulburn River, via the North-South Pipeline and the Wonthaggi Desalination Plant. Bulk water is supplied to Melbourne through a network of catchment and service reservoirs, treatment plants and water supply pipes. In the NAGA region the majority of bulk water is provided through the Yan Yean Catchment and Toorourrong Reservoir to the Yan Yean Reservoir, which in turn supplies a number of suburban service reservoirs. Bulk water to the North East of Melbourne's North is also supplied via the Sugarloaf Reservoir. This Reservoir is fed by the Yarra River, Maroondah Reservoir and Goulburn River via the North-South Pipeline.

Indicator

Water infrastructure has been considered from the perspective of the risk to the water supply network from fire. As noted by Melbourne Water (Melbourne Water: 2014), runoff following a bushfire can wash ash and sediment into reservoirs, impacting the ability to provide suitable drinking water for up to several months until water quality improves. As an example the Toorourong Reservoir and catchment was significantly impacted by the 2009 Kilmore-Murrindindi fire. Figure 29 illustrates the location of the key water supply reservoirs in Melbourne in the context of the bushfire management overlays.

NAGA region

As denoted by Figure 29 all reservoirs in the NAGA region are within Bushfire Prone Areas. Yan Yean and Sugarloaf are also located in the Wildlife Management Overlay zone, indicating a significant potential risk to the ability for these reservoirs to be able to supply suitable quality water following a significant fire event.

More generally it is understood that the Department of Environment, Land, Water and Planning is preparing an integrated water management plan for Melbourne's North and for the Central subregions. This will consider the influence of climate change on both water supply and stormwater management.

Electricity and gas distribution

The electricity and gas distribution network is crucial to ensure power is delivered to the NAGA region. The network supplies power to residential and commercial properties and robust networks are required to prevent the degradation of infrastructure. If the networks are disrupted, particularly as a result of emergencies such as bushfires or flooding it would lead to losses of business, decline in services and wellbeing, and disrupt livelihoods across the region. In addition, heatwaves can drive up peak demand as air conditioning use increases, stressing the electricity distribution network.

Indicator

Measured at the LGA level, this indicator incorporates the kilometres of electricity and gas networks at risk from bushfire.

NAGA region

In terms of the electricity network, five of the municipalities in the NAGA region are at risk from fire. The Shire of Nillumbik has 116.3 kilometres at risk from bushfire which is far greater than the City of Hume (55.7 kilometres), the City of Whittlesea (48.3 kilometres), the City of Manningham (48.3 kilometres) and the City of Banyule (6.9kilometres).

In terms of the gas network the same five municipalities are also at risk from bushfire. However, by contrast the City of Whittlesea has 42.2 kilometres at risk and the Shire of Nillumbik has 23.9 kilometres at risk and the City of Manningham has 6.7 kilometres at risk from bushfire.

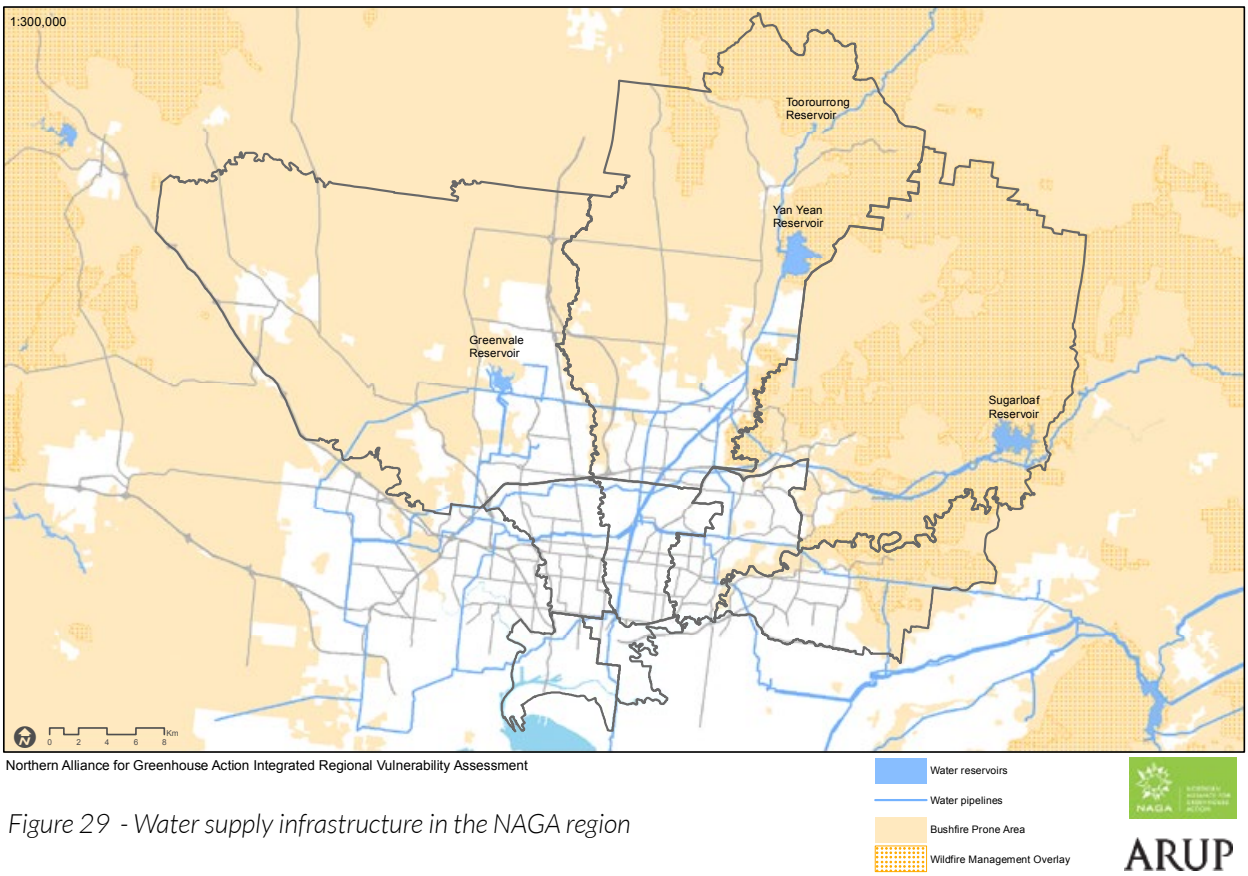

Figure 29 - Water supply infrastructure in the NAGA region

Airports, ports and jetties

Airports, ports and jetties are crucial pieces of the transport network for travel, commercial and development purposes. They provide accessibility to national and international transports hubs and allow for the import and export of goods to the region. They are vulnerable to a range of climate events, including fire, flood and heatwave events.

Indicator

Measured at the LGA, this indicator includes the number of airports, ports and jetties at risk from flooding.

NAGA region

Within the NAGA region there are two identified airport/ports/jetties identified. The Port of Melbourne is located in the City of Melbourne and Melbourne (Tullamarine) Airport is located in the City of Hume.

5.2.3 Industry

In comparison with other sectors, research is still at a relatively early stage in Australia regarding the key vulnerabilities within industry. There are exceptions, such as the work commissioned by NAGA member, the City of Melbourne, which researched the impact on business of the January 2014 heatwaves, *2014 Heatwave Business Impacts – Social Research* (Sweeney Research: 2014). This identified the retail trade sector as being most affected as measured by demand, sales value and profitability.

The United Kingdom, through development of the *UKCIP's Business Areas Climate Impact Assessment Tool* (UKCIP: 2014) provides a framework (Table 15) for considering the potential economic impacts of differing climate events on each aspect of a business or industry.

BUSINESS ASPECT	MARKETS	PROCESS	LOGISTICS
Example considerations	Increasing, decreasing or changing seasonality of demand for product or service	Impacts on climate sensitive processes or activities	Impacts on transport of supplies, delivery of product or staff travel
	PEOPLE	**PREMISES**	**FINANCE**
	Impacts on thermal comfort, health of safety of employees or others inside buildings	Physical impacts on building or the equipment contained within or effects on access	Insurance related issues

Table 15 - Business Areas Climate Impact Assessment

When determining the key industry vulnerabilities for the NAGA region, consideration has been given to those industries that, in the context of the relevant climate exposures for the region, have aspects to their operations that are likely to be at greatest risk.

Outdoor workers

Outdoor workers are exposed to the natural environment and thus are particularly vulnerable to climate events such as increasing temperatures and more extreme weather.

Indicator

At the LGA level, this is the proportion of the population working in the construction industry.

NAGA region

In the NAGA region the proportion of the population working outdoors ranges from 3 per cent in the City of Melbourne to 12.3 per cent in the Shire of Nillumbik. There is large variation among the municipalities.

Agricultural land

Agricultural land provides a source of employment, a local source of food and in some cases access to open space and nature for residents in the NAGA region. This land and industry is particularly sensitive to environmental influences and it is particularly vulnerable to climate change.

Indicator

At the LGA level, the key indicator for agricultural land is the percentage of agricultural zoned land at risk of flooding and bushfire.

NAGA region

Generally in the NAGA region, agricultural land is more at risk of bushfire than flooding. In the City of Banyule 16.1 per cent and 3.2 per cent of the City of Hume is at risk of flooding. In contrast 100 per cent of the land zoned as agricultural within the City of Hume and the Shire of Nillumbik and almost 100 per cent of the City of Whittlesea and the City of Manningham are at risk from bushfire.

Small businesses

Small businesses are a crucial part of economic and commercial activity and provide access to work and training for local residents. However, small businesses often lack the coping mechanisms and capacity to produce effective long term strategies to manage the effects of climate change. Climate change events can impact on the productivity and good and services provided by small businesses, impacting on the local economy and availability of goods and services.

Indicator

At the LGA level, the key indicator for small businesses is the proportion of commercial land at risk of flooding or bushfire.

NAGA region

Generally in the NAGA region flooding is a wider risk in comparison to bushfires which is a risk for just five of the municipalities. However bushfires are a risk for 49.2 per cent of the commercial land in the Shire of Nillumbik and 24.6 per cent in the City of Hume. In contrast, the highest flood risk is in the City of Darebin (11.8 per cent) and the City of Melbourne (8.5 per cent).

Health and social care assistance

Health and social care assistance is a vital piece of social infrastructure that supports vulnerable groups and often improves social cohesion within a community. The provision of such services is vital to ensure the health and wellbeing of communities in the NAGA region and climate events could restrict the accessibility and availability of major healthcare facilities.

Indicator

At the LGA level, the key indicator for health and social care assistance is the percentage of major care facilities at risk of flooding and bushfires.

NAGA region

Within the NAGA region four municipalities are at risk from bushfire and five municipalities are at risk from flooding. Both flooding and bushfire are a risk in the City of Banyule (3.6 per cent for both) and the Shire of Nillumbik (11.1 per cent and 77.8 per cent respectively). The remainder of the municipalities have a low proportion of facilities at risk from either flooding or bushfire with the most notable risks evident in the City of Whittlesea (20 per cent of facilities at risk of bushfire), the City of Manningham (23.1 per cent of facilities at risk of bushfire) and the City of Darebin (12 per cent risk of flooding).

Transport services

Transport services are vital within and around the NAGA region. Roads and rail are vital for both residents and business for amenity, accessibility and economic activity, however the location of the transport infrastructure may make it susceptible to climate change events such as flooding or bushfires which could limit the movement of individuals, goods and/or services.

Indicator

At the LGA level, the key indicator for transport services is the kilometres of roads and rail at risk from either flooding or bushfire.

NAGA region

This indicator reflects that for road and rail infrastructure and as such the distribution of vulnerabilities for transport services mirrors the previous description.

Postal and warehousing

Postal, transport and warehousing represents a key subsector of the manufacturing industry and distribution networks for the commercial sector. It provides employment directly and indirectly supports other sectors through logistics, links commercial activities and allows for the distribution of goods in the area. However due to its reliance on transport infrastructure and external shocks it may be vulnerable to climate change and the implications for road and rail infrastructure from flooding or fire as previously described are relevant when considering the potential impacts on this industry subsector.

Indicator

At the LGA level, this indicator incorporates the proportion of the population working in the transport, postal and warehousing industry.

NAGA region

The highest proportion of the population employed in this sector is found in the City of Hume (10.1 per cent) followed by the City of Whittlesea (6.8 per cent). The lowest proportions are found in the City of Yarra (2.2 per cent) and the City of Melbourne (2.6 per cent).

Retail trade

Retail trade is one of the key service occupation employment sectors that contributes to the local economy. It provides direct employment and often indirectly supports other service occupations such as tourism and leisure in conjunction with providing goods to local commercial and residential occupants of the area. It is reliant on transport and other sectors such as manufacturing, sales and customer service occupations and it is highly influenced by the economic activity and income levels of the population, all of which are susceptible to the effects of climate change.

Indicator

At the LGA level, this indicator incorporates the proportion of the population working in the retail trade industry.

NAGA region

The highest proportion of the population employed in retail trade is in the City of Manningham (12.4 per cent), the City of Whittlesea (12.2 per cent) and this is closely followed by the City of Hume (11.1 per cent). The lowest proportion is in the City of Yarra and City of Melbourne, 7.7 per cent for both.

5.2.4 Natural Environment

In relation to the vulnerability of the natural environment to climate change, Port Phillip and Westernport Catchment Management Authority (PPWCMA), in conjunction with six other Victorian Catchment Management Authorities (CMAs) commissioned a comprehensive Victoria wide impact, sensitivity and vulnerability assessment of natural resource assets, *NRM Planning for Climate Change – Victorian Climate Catchment Management Authorities, Final Project Report 1 – Impact and Vulnerability Assessment Process and Spatial Outputs* (Spatial Vision: 2014).

The assets considered were those assets identified in each CMA's Regional Catchment Strategy. This represented the asset class or key indicators for the purpose of assigning sensitivity and hence potential impact and vulnerability to climate scenarios. The natural resource assets analysed in the research were:

- Native vegetation;
- Wetlands;
- Estuaries;
- Rivers and streams;
- Soils and land; and
- Coasts.

The approach combined information on these natural assets and climate projections to produce spatial data outputs to enable CMAs, such as PPWCMA, to identify priority areas in the landscape for adaptation and mitigation activities. Through the assessment process approximately 120 maps of natural assets climate change vulnerability were produced, applying the RCP4.5 and RCP8.5 emission scenarios for 2030, 2050, 2070 and 2090.

The vulnerability of each asset type was determined through the identification of relevant climatic stressors (exposures), associated sensitivity (the degree to which the assets respond to the climate stressors) and adaptive capacity (ability of an asset to adjust to the predicted changes in climatic stressors).

Those asset types identified as having the greatest vulnerability were soils and land, rivers and streams and native vegetation and the relevant climate stressors, sensitivity and adaptive capacity inputs are replicated in Table 16.

ASSET TYPE	CLIMATE STRESSOR	SENSITIVITY INPUTS	ADAPTIVE CAPACITY INPUTS
Soils and lands	• Total rainfall • November to April – daily maximum temperature	• Land based soil systems • Susceptibility to wind erosion • Susceptibility to water erosion and terrain type	• Native vegetation cover • Site condition and landscape context
Rivers and streams	• March to November rainfall • November to April – daily maximum temperature	• Regulated or not • Perennial / permanent • Terrain category – plains, intermediate, upper	• Per cent native vegetation present with-in 100m • Quality of native vegetation within 100m • Reduction in high flow magnitude • Increase in proportion of low flow • Change in monthly flow variability
Native vegetation	• Total rainfall • November to April – daily maximum temperature	• EVC sub-groups	• Site condition • Landscape connectivity

Table 16 - Climate stressors, sensitivity and adaptive capacity inputs

When analysing results of this research for *Adaptation in the North*, RCP8.5 has been considered for 2030 (as there is little variation between it and RCP4.5 and it most closely aligns with the current global emissions trajectory) and RCP4.5 for 2070, as it represents a global middle range emissions growth trajectory.

When considering RCP4.5 projections in 2070 various rivers and streams in the NAGA region have been identified as vulnerable, particularly to the north and east of the region as shown in Figure 32. However coastal assets such as estuaries and wetlands are not particularly vulnerable.

Native vegetation is another crucial asset and it is particularly vulnerable in the north-east of the NAGA region. RCP4.5 projections in 2070, as shown in Figure 33, reflect the variation in vulnerability across the NAGA region and the concentrated area of native vegetation in the north-east that is vulnerable, however it should be noted that generally the NAGA region, while appreciably vulnerable, is less vulnerable than the rest of the PPWCMA.

In conjunction to this research the project also considered the susceptibility of existing vegetation to flood and fire.

Vegetation susceptible to frequent flood or bushfires

Native vegetation underpins biodiversity and ecology across the NAGA region as well as providing a range of ecosystem services, such as cleansing of the air and contributing to improved waterway quality and health. During flood or fire events there is the potential for significant impacts to native vegetation.

Indicator

At the LGA level, the key indicator is the proportion of the area of native vegetation by vegetation type/ community in flood or bushfire overlay.

NAGA region

The municipalities with largest areas of native vegetation are the Shire of Nillumbik (290.8 square kilometres), the City of Whittlesea (169.7 square kilometres), the City of Hume (82.9 square kilometres), the City of Manningham (46.4 square kilometres) and the City of Banyule (7.7 square kilometres).

All municipalities have native vegetation that is at risk from flood. Measured as a proportion of the native vegetation present within a municipality, the City of Yarra (61.4 per cent), the City of Moreland (51.5 per cent) and the City of Banyule (41.9 per cent) have the highest proportion of susceptible vegetation. In terms of total area, the Shire of Nillumbik (6.4 square kilometres) and City of Manningham (5.8 square kilometres) have the largest areas of native vegetation at risk from flood.

In contrast the proportion of ecosystems susceptible to bushfire is evident within five of the municipalities, however this is greater than 90 per cent in the Shire of Nillumbik (98.9 per cent or 287.6 square kilometres), the City of Manningham (97.7 per cent or 45.3 square kilometres), the City of Whittlesea (95.8 per cent or 162.6 square kilometres) and the City of Hume (93.4 per cent 77.4 square kilometres). 49.7 per cent, or 3.3 square kilometres of native vegetation in the City of Banyule is susceptible to bushfire.

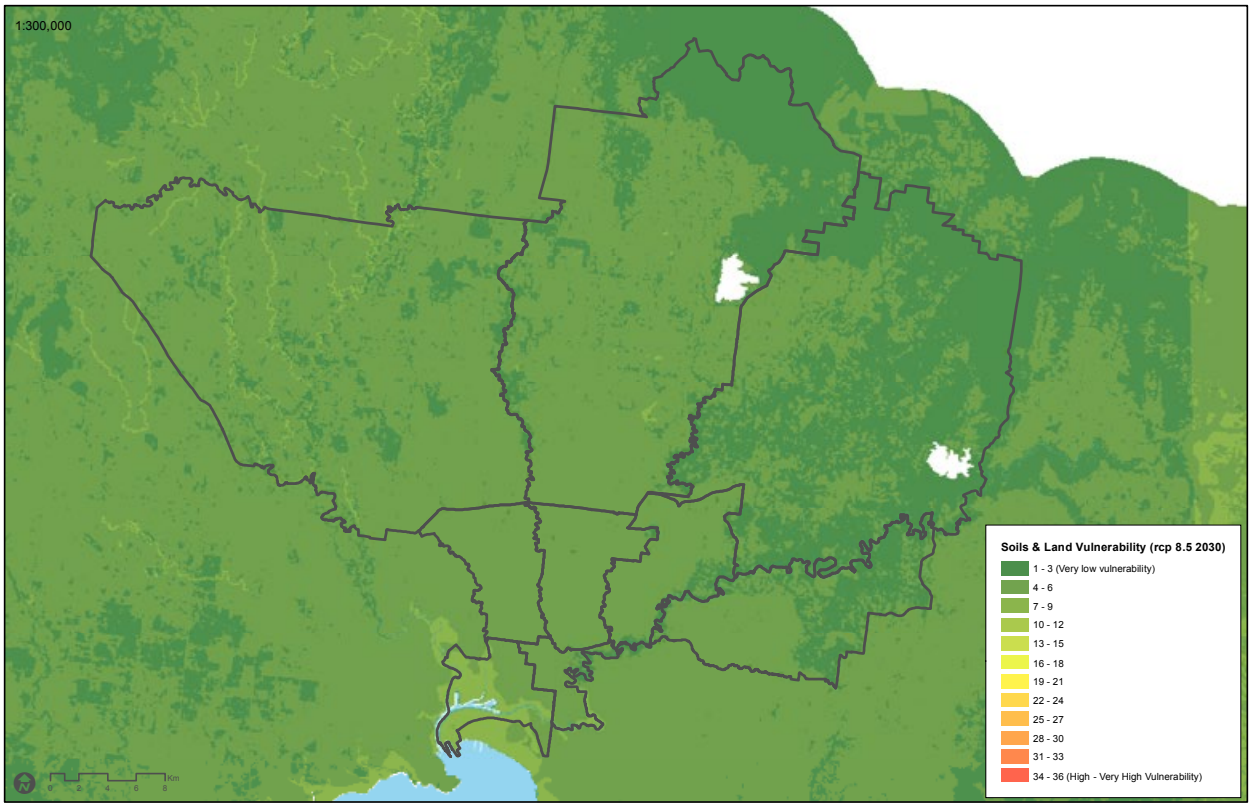

Figure 30 - Soils and Land RCP8.5 – Potential Vulnerability for the NAGA region (2030)

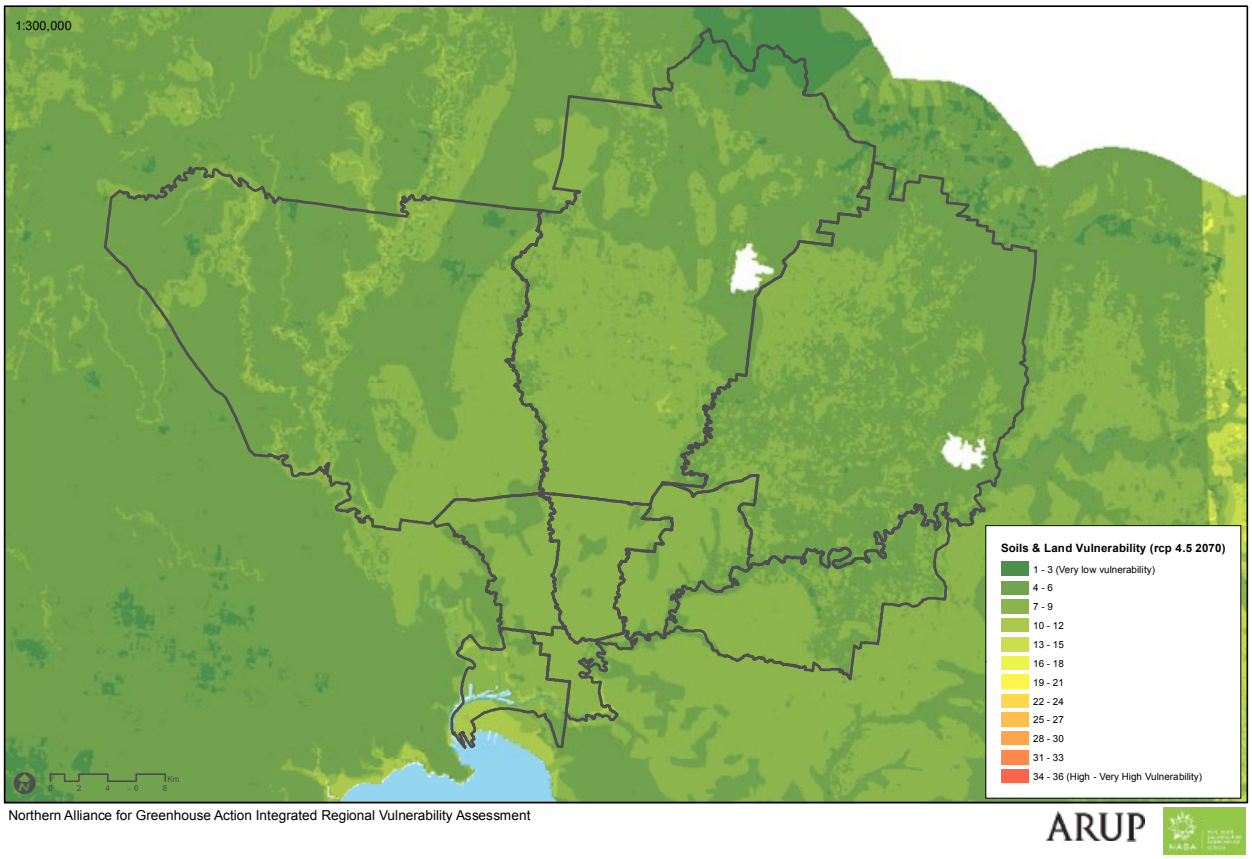

Figure 31 - Soils and Land RCP4.5 – Potential Vulnerability for the NAGA region (2070)

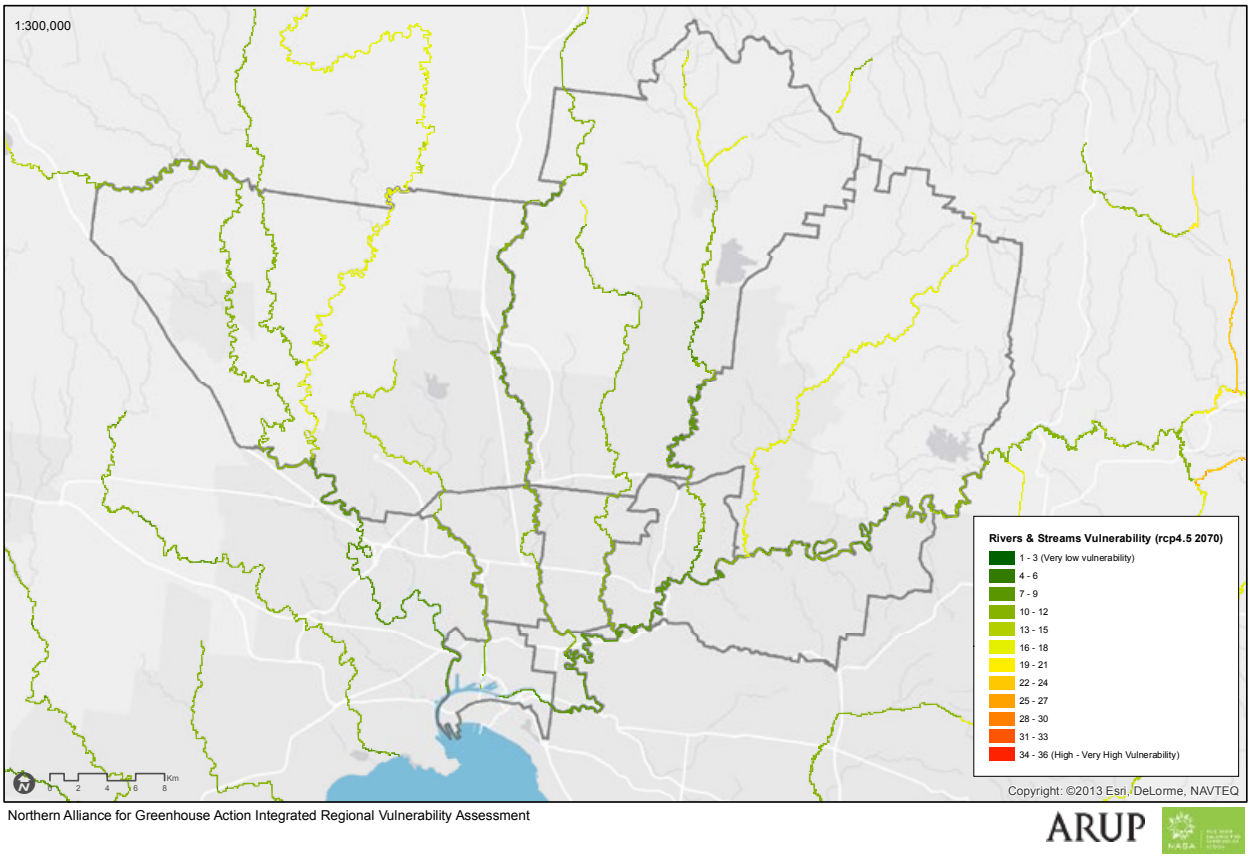

Figure 32 - Rivers and Streams RCP 4.5 – Potential Vulnerability for the NAGA region (2070)

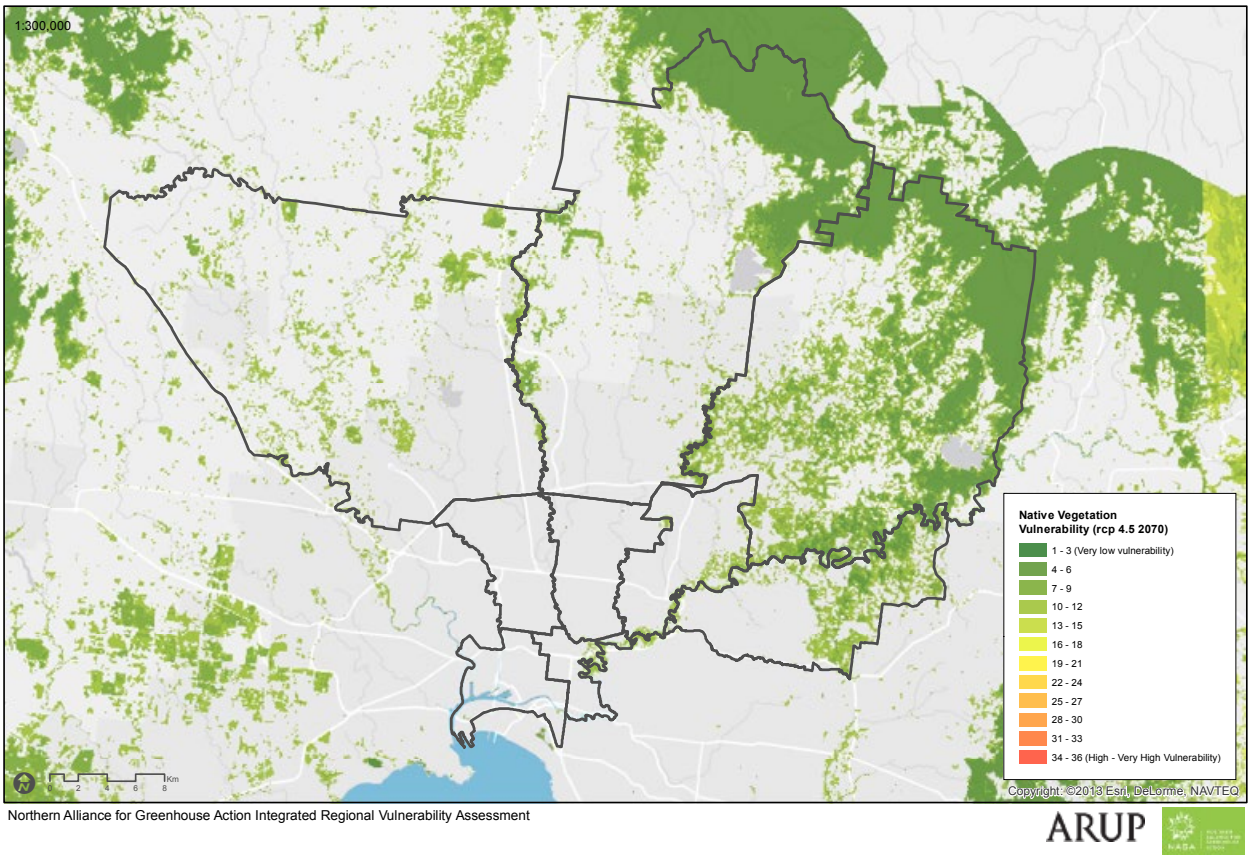

Figure 33 - Native Vegetation RCP 4.5 – Potential Vulnerability for the NAGA region (2070)

6. SECTORAL IMPACTS, RISKS, VULNERABILITIES AND ACTIONS

6.1 Introduction

The following section provides a description of the specific assessment undertaken for each of the six sectors: human services, emergency management, infrastructure, industry, natural ecosystems, and planning. Each sector has been characterised as follows:

- an **overview** of the sector and its regional context;
- a summary of the climate change **impacts** assessed as being high or extreme **risks**, and their relationship to the sector specific **vulnerabilities**;
- a description of **key issues** emerging from the sector workshop; and
- **priority management actions** for the region in that sector.

All management actions described in this plan have been summarised and provided at the end of this section.

6.2 Human Services

6.2.1 Overview

The human services sector is generally involved in providing assistance to those in greatest need in the community. Within council this encompasses the provision of home and community care services, family services, in particular for young people and youth, services for seniors and aged care, multicultural services for CaLD communities, maternal and child health services, preschool and disability services. As previously described, these groups tend to be those most vulnerable to climate events, resulting in acute or chronic health impacts or alterations to the determinants of health.

On a daily basis, council officers provide services to those most in need within their community, to reduce vulnerabilities and address inequalities across their region. The strategic direction of each council is defined through its public health and wellbeing plan as required under the *Public Health and Wellbeing Act 2008*. Section 14 of the *Climate Change Act 2010* requires that local government, as a nominated key government decision maker, must consider climate change when preparing municipal public health and well being plans. To assist local government in incorporating this consideration, in 2012 the Department of Health published *Municipal public health and wellbeing planning – Having regard to climate change* (Department of Health: 2012b). This document, together with the *Heatwave plan for Victoria* (Department of Health: 2011) and *Disaster and disadvantage: Social vulnerability in emergency management* (Victorian Council of Social Service: 2014) and outputs from the human services sector workshop are the key reference sources that have informed the following assessment of the major impacts, risks and vulnerabilities to human services within the NAGA region. A complete workshop summary is contained in Volume II, Appendix D.

Need to have in place a plan for long term support and recovery from events, potential impacts from depression and suicide as people rebuild.

Human Services Workshop Comment, 21 July 2014

6.2.2 Impacts, Risks and Vulnerabilities

On the basis of the information contained in existing literature and generated from the human services workshop, a full human services sector impact and risk assessment was undertaken and this is contained in Volume II, Appendix B. From this assessment the impacts with an extreme or high risk have been tabulated and are contained in Table 17. For each impact, the groups that are likely to be most vulnerable across the NAGA region, as identified in Volume II, Appendix A, have been identified.

CLIMATE EXPOSURE EVENT/S	SCOPE	DESCRIPTION OF IMPACT	DIRECT OR INDIRECT	RISK	VULNERABLE GROUPS												
					Older people	Socioeconomically disadvantaged people	CaLD people	People with a disability	Children and young people	People with poor quality housing	People with a disability	Children and young people	People with poor quality housing	People with a disability	Those with existing illnesses	Obese and overweight people	Indigenous communities
Heatwaves	Regional	More premature deaths	Direct	Extreme	●	●		●	●	●	●	●		●	●	●	
Heatwaves	Regional	Higher incidence of heat-related illnesses, such as exhaustion, heatstroke and related effects, such as falls	Direct	High	●	●		●	●	●	●	●		●	●	●	
Heatwaves	Regional	Exacerbation of existing health conditions, such as predisposition to heart attack and kidney disease	Direct	High	●	●		●	●	●	●			●	●	●	
Heatwaves	Regional	Higher incidence of mental and behavioural disorders	Direct	High	●	●		●	●	●	●	●	●	●	●		●
Bushfire	Regional	Higher incidence of respiratory illness, such as asthma attacks	Direct	High	●	●	●		●			●		●	●	●	
Bushfire	Regional	Higher incidence of mental health problems, including trauma and longer term disruptions to social systems	Direct	High	●	●	●	●	●		●	●		●			
Bushfire	Regional	Increased food- and water-borne illness due to contamination or disruption to essential services affecting fire-prone communities	Indirect	High	●	●	●		●	●					●		

CLIMATE EXPOSURE EVENT/S	SCOPE	DESCRIPTION OF IMPACT	DIRECT OR INDIRECT	RISK	VULNERABLE GROUPS												
					Older people	Socioeconomically disadvantaged people	CaLD people	People with a disability	Children and young people	People with poor quality housing	People with a disability	Children and young people	People with poor quality housing	People with a disability	Those with existing illnesses	Obese and overweight people	Indigenous communities
Bushfire	Outer Ring Councils	Injuries and deaths across a range of community members	Direct	High	•	•	•	•	•	•	•	•	•	•	•	•	•
Bushfire	Regional	Exacerbation of pre-existing conditions during the event and inability to readily access treatment or medication post event	Indirect	Extreme	•	•	•	•	•		•	•		•	•		
Heatwaves and Bushfire	Regional	Inability to communicate with vulnerable populations if power or communication network are impacted	Indirect	High	•	•	•	•	•	•	•	•		•	•		
Heatwaves Bushfire Heavy precipitation / Flood	Regional	Inability of council / essential services to respond to flood or bushfire event, due to: • Workforce not physically able to attend work • Supply chain – good (fuel) and services (employees) for agencies are not able to be provided • Assets are damaged and not operable – power supply	Indirect	High	•	•	•	•	•	•	•	•	•	•	•	•	•

CLIMATE EXPOSURE EVENT/S	SCOPE	DESCRIPTION OF IMPACT	DIRECT OR INDIRECT	RISK	VULNERABLE GROUPS												
					Older people	Socioeconomically disadvantaged people	CaLD people	People with a disability	Children and young people	People with poor quality housing	People with a disability	Children and young people	People with poor quality housing	People with a disability	Those with existing illnesses	Obese and overweight people	Indigenous communities
Bushfire Heavy precipitation / Flood	Regional	People placing themselves at risk to access vulnerable individuals	Indirect	High	•	•	•	•	•	•	•			•			
Bushfire Heavy precipitation / Flood	Regional	Complete collapse of commercial operations due to inadequate insurance, recovery costs, lack of return custom – leading to wider socioeconomic impacts in the area	Indirect	High		•	•	•	•	•	•	•	•	•	•		•
Heavy precipitation / Flood	Regional	Increased injuries, drowning and other accidental deaths	Direct	High	•			•	•		•			•			

Table 17 - Human services sector: Impacts, risks and vulnerabilities in the NAGA region

High-risk impacts have been identified from heatwaves, flooding and bushfire exposure events, or a combination of these. All of these occurrences can result in significant direct or indirect health impacts on the community, with fatalities in extreme cases. Across the NAGA region the number of houses at risk from fire and flood is graphically represented in Figure 34.

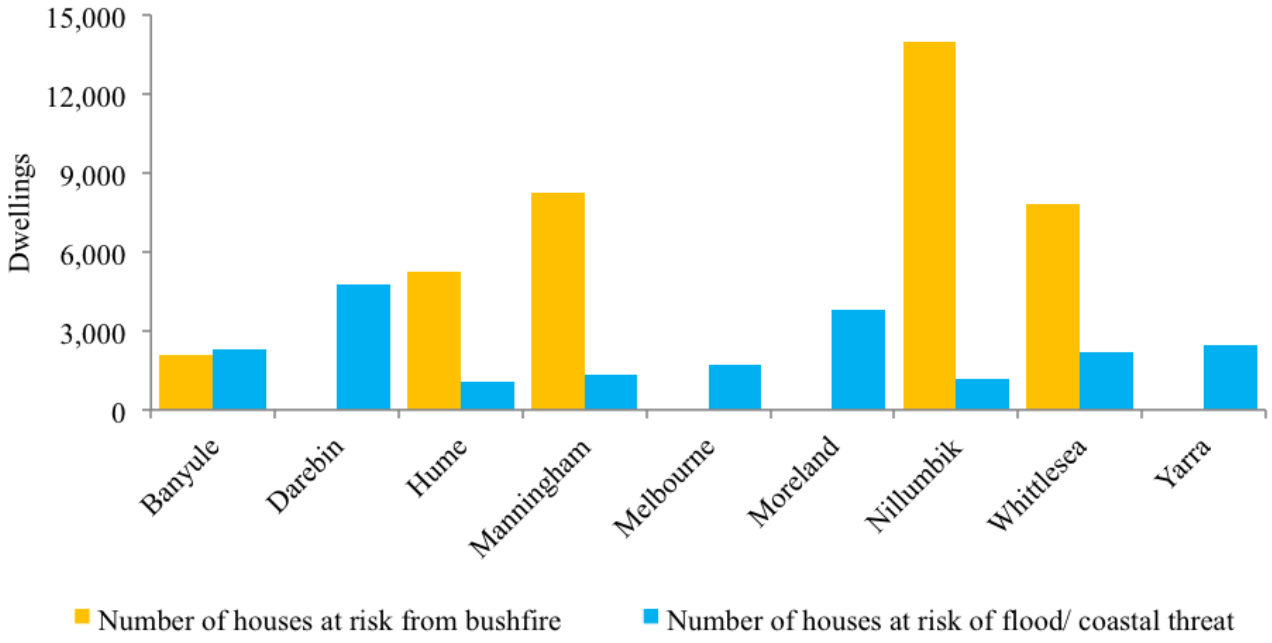

Figure 34 - Number of houses at risk from bushfire and flood/coastal inundation events

Of these exposure events, it is heatwaves and fires that represent the greatest source of risk to the human services sector of the NAGA region.

Heatwaves

The potential extreme and high risk heatwave impacts are associated with an increase in premature deaths and a higher incidence of heat related illnesses and exacerbation of medical conditions and mental and behavioural disorders. From an indirect impact perspective, heatwaves have the potential to reduce the potential for council officers to deliver services to vulnerable communities due to the need to ensure the ongoing health and safety of officers. This has the potential to exacerbate impacts to those most vulnerable.

Many community services workers are disproportionately made up of vulnerable groups e.g. many HACC workers are elderly, and cannot work during heatwaves.

Human Services Workshop Comment, 21 July 2014

Research undertaken by Monash University (Loughnan M, Tapper, N, Phan T, Lynch K and McInnes, JA: 2013) has enabled development of a spatially represented heat related vulnerability index on the basis of eleven variables (Table 18) that research has identified contribute to heat related mortality and morbidity.

RISK FACTORS	
Age (0–4, 65+)	Population density
Aged care facilities (ACF)	Ethnicity
Socioeconomic status	UHI
Urban design (non-single dwellings)	Land cover
Single person households	Accessibility to emergency service
Need for assistance (measure of disability)	

Table 18 - Heatwave spatial vulnerability risk factors

The index incorporates consideration of the presence of vulnerable populations, but also other factors, such as urban design. The spatial distribution of this vulnerability for Melbourne is replicated in Figure 35. As a composite index, vulnerability is denoted on a scale of 1 to 10, with 10 representing areas of highest vulnerability.

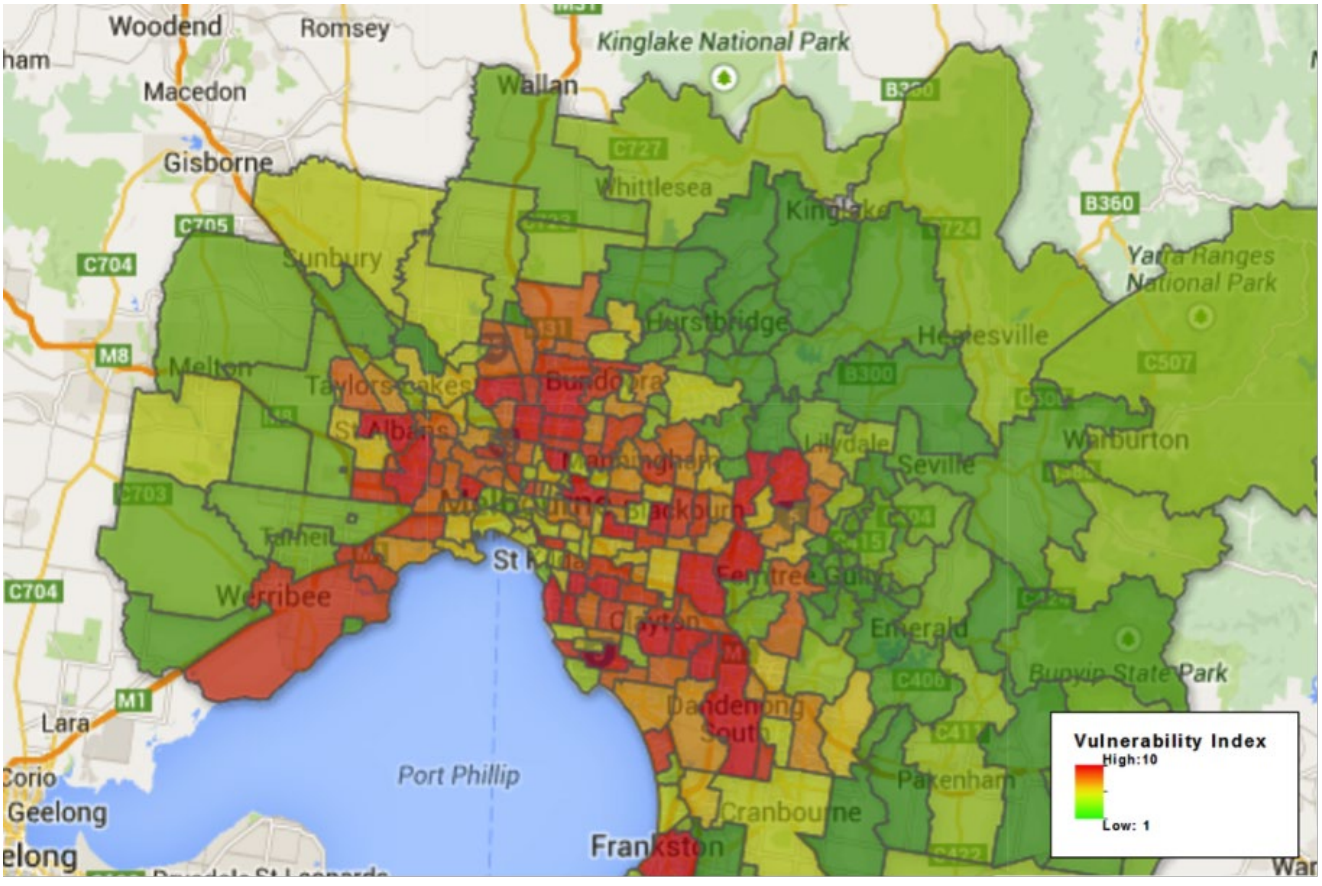

Figure 35 - Heat-related vulnerability index map for Melbourne (Source: Loughnan et al: 2013)

Reference to the heat related vulnerability index for the NAGA region indicates the areas of greatest vulnerability are associated with the outer areas of the City of Moreland and City of Darebin, in particular in the Glenroy, Coburg, Reservoir, Preston and Northcote areas. Other areas identified as having a high vulnerability across the NAGA region are in the Thomastown and Bundoora region and through Ivanhoe, Eaglemont, Heidelberg and Rosanna in the City of Banyule, Doncaster in the City of Manningham and the Parkville and Carlton areas in the City of Melbourne.

As there are eleven variables that contribute to the heat related vulnerability index it can only be inferred, based on knowledge of the distribution of each variable and the potential relative contribution to the index, which individual variables are driving the high levels of vulnerability in a specific location. As illustrated in Figure 15, the UHI is generally associated with the inner municipalities due to increased density of buildings, a higher proportion of paved surfaces and a lack of canopy cover. This is likely to be a driver of vulnerability in these areas. In outer areas, such as Reservoir and Glenroy, it is inferred that it is the presence of populations of high relative socioeconomic disadvantage (Figure 24) and an ageing population (Figure 27) are driving this high vulnerability.

Mortality from previous heatwaves has indicated that older people are at greatest risk from heatwave events (Department of Human Services: 2009). Across the NAGA region the management of impacts associated with heatwave events on older people is expected to become increasingly important as the proportion of the population over 70 steadily increases. The City of Moreland has the highest percentage of the population who are over 70 and over 80, in particular in the northern parts of the municipality. By 2031, it is projected that the City of Manningham and Shire of Nillumbik will have the greatest proportion of individuals over 70 and over 80.

In relation to the other heatwave vulnerabilities not considered by the vulnerability index, the highest percentage of obese and overweight individuals at an LGA level is in the City of Hume and City of Whittlesea. At a SLA level, south-west of Whittlesea has the highest percentage and total population of obese and overweight people.

Fire

In regards to grass and bushfires, it is communities in the outer ring municipalities of the City of Hume, City of Whittlesea, Shire of Nillumbik and City of Manningham that are most vulnerable to the potential direct impacts of grassland or bushfire.

While there is vulnerability associated with the presence of communities and businesses within these designated bushfire risk areas, there are also groups who are particularly vulnerable. It is noted at the SLA Level, North Whittlesea has the highest proportion (28.4 per cent) of those with existing illness, placing them at risk both during a fire event and in the post-recovery period.

In general areas of relative disadvantage are associated with the urban areas of the NAGA region. The ISRD indicates however that there are areas relative socioeconomic disadvantage within the City of Hume in proximity to the Bushfire Prone Area, in particular Craigieburn and in the City of Whittlesea near Epping, Lalor and Thomastown. These areas of relative socioeconomic disadvantage also largely align with areas within the NAGA region with a relatively high proportion of CaLD communities.

In relation to older people, who may be vulnerable due to reduced mobility and sensory awareness, the Shire of Nillumbik and City and Manningham have a significant proportion of the population who are 70 and over and 80 and over, and this trend is expected to continue over coming decades.

Across the NAGA region there are areas with a high proportion of the population aged between 0 and 4 years in proximity to designated fire risk zones. In particular in the growth areas of the City of Hume, Craigieburn and Mickleham and in the City of Whittlesea in Mernda and Laurimar in the east and Epping to the west.

Fires can have indirect impacts, such as poorer air quality impacting on those with pre-existing respiratory conditions and possible limited access medical facilities post event. The LGA with the highest proportion of those with an existing illness is in the City of Banyule. At an SLA level, North Whittlesea, Whittlesea and Sunbury, Hume having the highest proportion of the population with an existing illness, both communities in proximity to fire risk areas.

Flooding

The final climate exposure of relevance is impacts associated with flooding events. *Disaster and disadvantage: Social vulnerability in emergency management* notes that those with mobility challenges are likely to be most vulnerable to flood events. It notes the outcomes of the Queensland Floods Commission inquiry of the floods from December 2010 to January 2011, which found that three of the four people who died in the Grantham floods required walking aids to assist their mobility (VCOSS: 2014).

While all municipalities have housing at risk of flooding, it is the middle ring municipalities of City of Darebin and City of Moreland that have the highest number of houses at risk, with City of Hume and the Shire of Nillumbik, the lowest. In relation to the correlation with vulnerable populations, in particular those with the greatest potential to have mobility challenges, it is noted that the City of Moreland has the second highest population of those over 70 years and the highest population over 80 years.

From a disability perspective, the two municipalities with the highest proportion of housing at risk from a flood event, the City of Darebin and City of Moreland, also have the highest proportion of population in need with assistance with a core activity. This relationship is also largely reflected when considering those 0 to 64 years with a profound or severe disability, with the City of Darebin and the City of Moreland having the second and third highest of populations of this vulnerable group.

Infants and children are vulnerable to floods from a mobility perspective, but also because they may lack the necessary understanding of the appropriate action to take. While the growth area municipalities of City of Hume and City of Whittlesea have the highest proportion of populations aged 0 to 4 years, the City of Moreland and Darebin also have significant populations, representing 6.5 per cent of the total population respectively.

6.2.3 Workshop Outcomes

The human services workshop brought together officers from the relative areas of council from across the NAGA region to consider the key issues associated with climate change and the sector. From this discussion and in the context of the above impacts, risks and vulnerabilities for the following themes emerged as areas to be addressed at a regional level over coming years.

A review of information sharing is needed to ensure dissemination of information to vulnerable communities during extreme weather events

While it was recognised that a number of measures currently exist to provide extreme weather information, there is scope for improvement in messaging to vulnerable members of the community, particularly CaLD or socially isolated individuals. A number of additional communication avenues are available to council which should be evaluated through a review process. This process should also be used to justify the effectiveness of existing communication avenues and/or suggest improvements to them. Such a review is recommended to include consideration of projected demographic changes within an LGA. Identified communication avenues should be culturally appropriate and tailored to specific potential climate events. This would need to be conducted in consultation with the Victorian Multicultural Commission, MAV and Emergency Management Victoria.

Research into messaging prior- and post-heat wave is needed

The need for research into the effectiveness of existing pre- and post- heatwave messaging at a regional level for mutual benefit was identified. This process should be completed in consultation with advisory committees including key community stakeholders (e.g. medical centres, senior citizens groups, public transport providers) so that in the medium term, messaging may be distributed via these stakeholders to greater effect. This would need to be conducted in consultation with the Department of Health and Municipal Emergency Response Committees.

A region-wide program be initiated to improve coordination and relationships with community and vulnerable groups during extreme weather events

During periods of climatic shocks and stresses, it is recognised that community groups often possess unique networks and abilities to reduce harm. A regionally coordinated approach to engagement with appropriate community groups could be used to develop an effective process that takes advantage of community group networks in response to extreme weather events, while simultaneously improving council's relationship with these groups. This program should be implemented as part of a broader goal to improve relationships between council and vulnerable groups. It should be noted that the most vulnerable are often socially isolated and so may not belong to any particular community group.

6.2.4 Nominated Priority Actions

Based on sector workshops, a number of potential management actions were identified, with certain actions prioritised. The following human services actions represent the nominated actions for NAGA and alliance councils to implement. There are a number of additional potential actions that were identified to assist the human services sector address climate impacts, risks and vulnerabilities. These actions have been captured and collated as programs of potential works to be undertaken over coming years and are included in Volume II of the RCCAP.

OBJECTIVE/S	DESIGN AND DELIVER PROGRAMS THAT FACILITATE STRONG, INFORMED, CAPABLE, SELF-RELIANT, CONNECTED AND WILLING COMMUNITIES IN RESPONSE TO CLIMATE CHANGE ACROSS THE NAGA REGION.		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
A1	Conduct review of best practice of community engagement to build resilience to climate change impacts, including programs to build social cohesion before events.		NAGA / NAGA Councils
A2	Conduct review of best practice of heatwave communications for vulnerable communities.		NAGA / NAGA Councils
A3	Undertake analysis of the current heatwave communications to vulnerable communities for the NAGA Region.		NAGA / NAGA Councils
A4	From best practice review and analysis of current approach, identify opportunities for improving or developing additional communication mechanisms.	Implement recommended improvements or additions to heatwave communications across the NAGA region.	NAGA / NAGA Councils
A5	Advocate to existing heatwave committees within NAGA Ccouncils for a research project to evaluate effectiveness of heatwave communications.	Advocate for a research project to understand the implications for Councils in the delivery of services in the context of the projected climatic impacts, risks and vulnerabilities for the NAGA region.	NAGA / NAGA Councils
A6	Conduct a regional level gap analysis of coordination between NAGA councils and community organisations with relationships with vulnerable populations and individuals, during periods of climatic shocks and stresses.	Develop project to address any identified gaps in coordination between NAGA Councils and community organisations with relationships with vulnerable populations and individuals.	NAGA / NAGA Councils
1F.		Conduct research project to understand the implications for Councils in the delivery of human services in the context of the projected climatic impacts, risks and vulnerabilities.	NAGA / NAGA Councils

Table 18 - Nominated priority actions for the human services sector

6.3 Emergency Management

6.3.1 Overview

Looking forward, more frequent rapid-onset events such as bushfire, severe storms, flash floods and particularly heatwaves due to climate change will stress the emergency management sector to effectively respond (OESC: 2012).

The emergency management sector is a complex and important area within the NAGA region. The *Emergency Management Act* (1986) and the *Emergency Management Act* (2013), which has largely superseded the 1986 Act, describe emergency management as comprised of three areas with the following objectives, as represented in Figure 36:

- Prevention – the elimination or reduction of the incidence or severity of emergencies and the mitigation of their effects;
- Response – the combating of emergencies and the provision of rescue and immediate relief services; and
- Recovery – the assisting of people, businesses and communities affected by emergencies to achieve a proper and effective level of functioning.

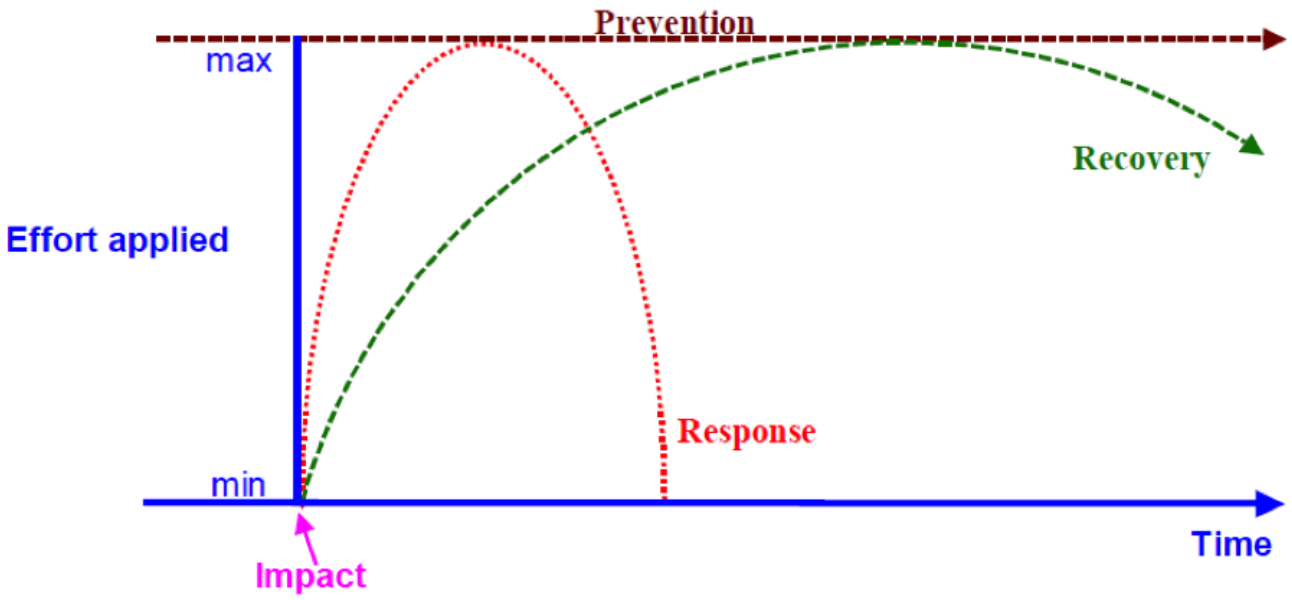

Figure 36 - Emergency management activities in a time sequence (Source: Emergency Management Victoria: 2014)

These three areas are addressed by a range of public, voluntary and private organisations to varying degrees. *Emergency Management Victoria Manual* (Emergency Management Victoria: 2014) is the primary document that defines these roles. Local government has a key role to play in emergency management, as highlighted in recent emergency events such as the 2009 Black Saturday fires, which required committing significant resources from local councils during the relief and recovery stage.

Emergency Risk in Victoria (Department of Justice: 2014) describes the management of emergencies within Victoria as follows:

The vast majority of emergencies are small and handled by locally-placed emergency responders such as the fire services and the Victoria State Emergency Service.

Affected people are also supported by agencies of the not-for-profit sector and municipal councils, all of which fulfil essential roles.

For larger emergencies, resources are brought from further away, and management of those resources escalates to higher levels, up to the state level.

The Department of Human Services is the coordinating agency for emergency relief and recovery at the state and regional levels, working in collaboration with municipal councils which have the responsibility at the local level.

Emergencies can result from a number of natural hazards or major incidents such as bushfires and storms, disease epidemics and industry-related accidents. Bushfire and flood are currently considered to be of high residual risk (i.e. the risk remaining once existing management actions and controls have been implemented) (Department of Justice: 2014), with climate change increasing likelihood of occurring and increased consequence. This is of particular importance given that these have been identified as climate events relevant to the NAGA region.

Emergency management has a vital role in building resilience and responding to the exacerbated impacts due to climate change. Given predictions of more frequent rapid-onset events such as bushfire, severe storms, flash floods and particularly heatwaves due to climate change, emergency management is likely to be stressed to effectively respond and protect against these impacts (OESC: 2012).

6.3.2 Impacts, Risks and Vulnerabilities

The potential impacts and risks faced by the emergency management sector over coming years were drawn from a review of existing literature and an emergency management sector workshop, attended by NAGA council officers. The full emergency management sector impact and risk assessment is contained in Volume II, Appendix B of the RCCAP. The following table (Table 20) describes the impacts identified as being of high-risk and the groups across the NAGA region considered most vulnerable based on those identified in Volume II, Appendix A. High-risk impacts have been identified primarily due to the risks to human life posed either directly from extreme weather events, or indirectly due to an over-stretched or under-resourced emergency management sector.

CLIMATE EXPOSURE EVENT/S	SCOPE	DESCRIPTION OF IMPACT	DIRECT OR INDIRECT	RISK	VULNERABLE GROUPS											
					Older people	Socioeconomically disadvantaged people	CaLD people	People with a disability	Children and young people	People with poor quality housing	Those with existing illnesses	Obese and overweight people	Indigenous communities	Rural, urban fringe and other fire-prone communities	Low lying communities	Obese and overweight poeple
Bushfire	Regional	More premature deaths	Direct	Extreme	•	•	•	•	•	•	•	•	•	•	•	
Bushfire	Regional	Increased "worst case" impact bushfire events	Direct	High	•	•	•	•	•	•	•	•		•		•

Table 20 - Emergency services sector: Impacts, risks and vulnerabilities in the NAGA region

Flood

An analysis of the number of houses at risk from flood, as determined by their presence within a flood overlay is provided in Table 15. The middle ring municipalities of City of Darebin and City of Moreland have the highest number of houses at risk, with City of Hume and the Shire of Nillumbik the lowest.

As discussed in the human services sector, it is often those with mobility challenges that are most vulnerable in a flood event. From a City of Moreland perspective, there are a number of vulnerable populations present within the municipality that may require assistance from emergency services in a flood event. In particular the relatively high proportion of the elderly as defined by those over 70 and over 80, those with a disability and infants and children. While the percentage of the population over 70 and over 80 respectively is lower in the City of Darebin, the percentage of the population with a disability and infants and children is commensurate with City of Moreland.

Fire

Rural, urban fringe and other fire-prone communities are predictably most common in the outer ring councils (measured as the number of houses at risk from bushfire). Nillumbik has the highest number of houses at risk, with almost 14,000, followed by Manningham and Whittlesea, with around 8,000. Hume and Banyule also have houses at risk of bushfire, with around 5,000 and 2,000, respectively.

As identified by *Department of Environment and Primary Industries: 2013* and *Department of Justice: 2014*, these occurrences can result in direct or indirect impacts on the community associated with overloading the emergency services. Of these events, bushfires pose the greatest risk to the emergency management sector of the NAGA region.

The high risk direct impacts associated with 'worst case' bush fire events are of particular relevance to those vulnerable communities identified in Table 20. These vulnerable groups largely reflect those previously described in the human services sector section.

The most vulnerable communities include those in rural, urban fringe and other fire prone areas that could be directly impacted, particularly municipalities such as Nillumbik, Whittlesea and Manningham where high proportions of the major health care facilities are at risk of bushfires. Other vulnerable groups that could be directly impacted include those who cannot cope well independently, those who have pre-existing conditions and those who have limited mobility and sensory awareness such as the elderly, children and young people, socio-economically disadvantaged people, people with multiple and complex needs and people with existing illnesses or alcohol and drug issues.

Indirectly bushfires and flooding represent a high risk to the emergency services as extreme events can increase the demand on ambulances and fire services. This is particularly challenging for the elderly and those with existing mental health issues and health conditions as they require frequent medical attention.

These vulnerable groups are distributed unevenly across the NAGA regions which can make the management of such risks difficult. Furthermore many of the municipalities with the highest proportion of vulnerable communities also have a high proportion of their infrastructure at risk from flooding and bushfire. This could result in negative cumulative impacts on the emergency management services, further perpetuating the need for a holistic strategic review to enhance resilience and account for these disparities.

6.3.3 Workshop Outcomes

A workshop focussed on emergency management involving relevant NAGA region council officers and external state agencies was held to assess the particular impacts and vulnerabilities faced by the region. The analysis and workshop consultation process identified the following major findings:

There is a need for continued emergency management research and review

From a regional perspective, it was found that further information is needed to identify and implement best practices for emergency management workers and the community in the general in response to extreme events. Such information could be gathered through increased engagement with MAV, the Bushfire and Natural Hazards Cooperative Research Centre, the North West Emergency Management Collaboration and Emergency Victoria. Gathered information should be organised into temporal scales to provide clarity on the decisions made by key stakeholders at different stages of an event (e.g. during, 6 weeks after, 1 year after, etc.).
Additionally, a review of international case studies on emergency management would allow improved understandings of risk reduction and minimisation of cross-sector duplication of efforts in response to extreme weather events.

Communication can be significantly improved to facilitate consistent and regular messaging

During extreme weather events, it was found that levels of communication increase significantly both from organisations and within the community. This creates potential confusion in messaging and therefore increases the risk of harm. A coordinated approach to messaging is crucial to the reduction of risk. Such an approach should be multi-channelled and address issues of translation for non-English speakers, issues of a lack of access to communication or general infrastructure in some areas, take advantage of existing networks within the community and strive to deliver a centralised message that remains relevant at local scales.

There is a need for an emergency management community education program

Spontaneous volunteering was identified as a significant issue in emergency response, particularly if volunteers are poorly informed of the council's actions. An education program centred on the community's role in preparing for and responding to extreme weather events would simultaneously reduce the risks presented from unregulated activities, and also take advantage of the additional resources they present. The program could additionally increase awareness of extreme weather risks and be modelled on existing programs such as Emergency Volunteering in Queensland, street wardens in Japan or the Community Emergency Response Team (San Francisco, USA) program.

6.3.4 Nominated Priority Actions

Based on sector workshops, a number of potential management actions were identified, with certain actions prioritised. The following emergency management actions represent the nominated actions for NAGA and alliance councils to implement. There are a number of additional potential actions that were identified to assist the emergency management sector address climate impacts, risks and vulnerabilities. These actions have been captured and collated as programs of potential works to be undertaken over coming years and are included in Volume II of the RCCAP.

OBJECTIVE/S	• **CLARIFY THE ROLES AND RESPONSIBILITIES FOR EMERGENCY MANAGEMENT ACROSS THE NAGA REGION.** • **ENHANCE THE RESILIENCE AND BREADTH OF COMMUNICATION MECHANISMS DURING SHOCKS AND STRESSES SO THAT THERE CONSISTENT AND SINGULAR SOURCES OF MESSAGING AND THOSE MOST IMPACTED ARE ABLE TO READILY ACCESS THE REQUIRED INFORMATION.**		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
B1	Develop research agenda to obtain a better understanding of issues identified in Emergency Management consultation, including: • stages of relief and recovery (i.e. after 6 weeks, 1 year etc) and understand what decisions needs to be made at each stage and by which key stakeholders to facilitate relief and recovery in a manner that increases community resilience to future emergency events; • a more granular understanding of the spatial vulnerability to lack of infrastructure (e.g. power outage, road blockage), and how this vulnerability might be decreased to ensure community copes better with failed infrastructure in emergency events; • definitions of recovery, as provided by state government; and	Advocate to key stakeholders, including the Municipal Association of Victoria, North West Metro Emergency Management Collaboration and Emergency Victoria on key issues identified for clarification or research within the emergency management sector, as outlined in research agenda.	NAGA

OBJECTIVE/S	• CLARIFY THE ROLES AND RESPONSIBILITIES FOR EMERGENCY MANAGEMENT ACROSS THE NAGA REGION. • ENHANCE THE RESILIENCE AND BREADTH OF COMMUNICATION MECHANISMS DURING SHOCKS AND STRESSES SO THAT THERE CONSISTENT AND SINGULAR SOURCES OF MESSAGING AND THOSE MOST IMPACTED ARE ABLE TO READILY ACCESS THE REQUIRED INFORMATION.		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
	• opportunities for improving emergency communication, including pros and cons of having one consistent voice, the roles and responsibilities of state and local responders in communicating, issues of translation and making better use of existing community relationships	Implement recommended improvements or additions to heatwave communications across the NAGA region.	NAGA
B2	Develop relationships with key sources of information about the impact of climate change upon the emergency management sector, including the Bushfire and Natural Hazards Cooperative Research Centre and the National Climate Change and Adaptation Forum.	Advocate for a research project to understand the implications for Councils in the delivery of services in the context of the projected climatic impacts, risks and vulnerabilities for the NAGA region.	NAGA
B3	Develop relationship with key stakeholders, including Volunteering Victoria, to explore community opportunities for volunteers during and after emergency events.		NAGA
B4	Develop a better understanding of how the vulnerable persons register can be improved, including the potential of an 'opt-in' vulnerability register and the needs of the community.		NAGA

Table 21- Nominated priority actions for the emergency management services sector

6.4 Infrastructure

6.4.1 Overview

The NAGA region is served by a variety of infrastructure that is vital to providing essential services to key businesses and the residents of the region. A detailed consideration of the current level of provision and the performance of all types of infrastructure for the majority of the NAGA region is contained in *Northern Horizons – 50 Year Infrastructure Strategy for Melbourne's North* (NORTH Link: 2014).

Transport infrastructure includes major roads, such as the M80 Ring Road, CityLink, Tullamarine Freeway, Hume Freeway and Highway, Bell Street, Cooper Street and Greensborough Highway. There is a broad mix of public transport assets within the region, including the Hurstbridge, Craigieburn, South Morang, Upfield and Sunbury heavy rail lines and various tram routes that hub into the city centre. Supporting these are a multitude of bus routes, including the SmartBus routes, 901, 902 and 903. The public transport network is shown in the figure below.

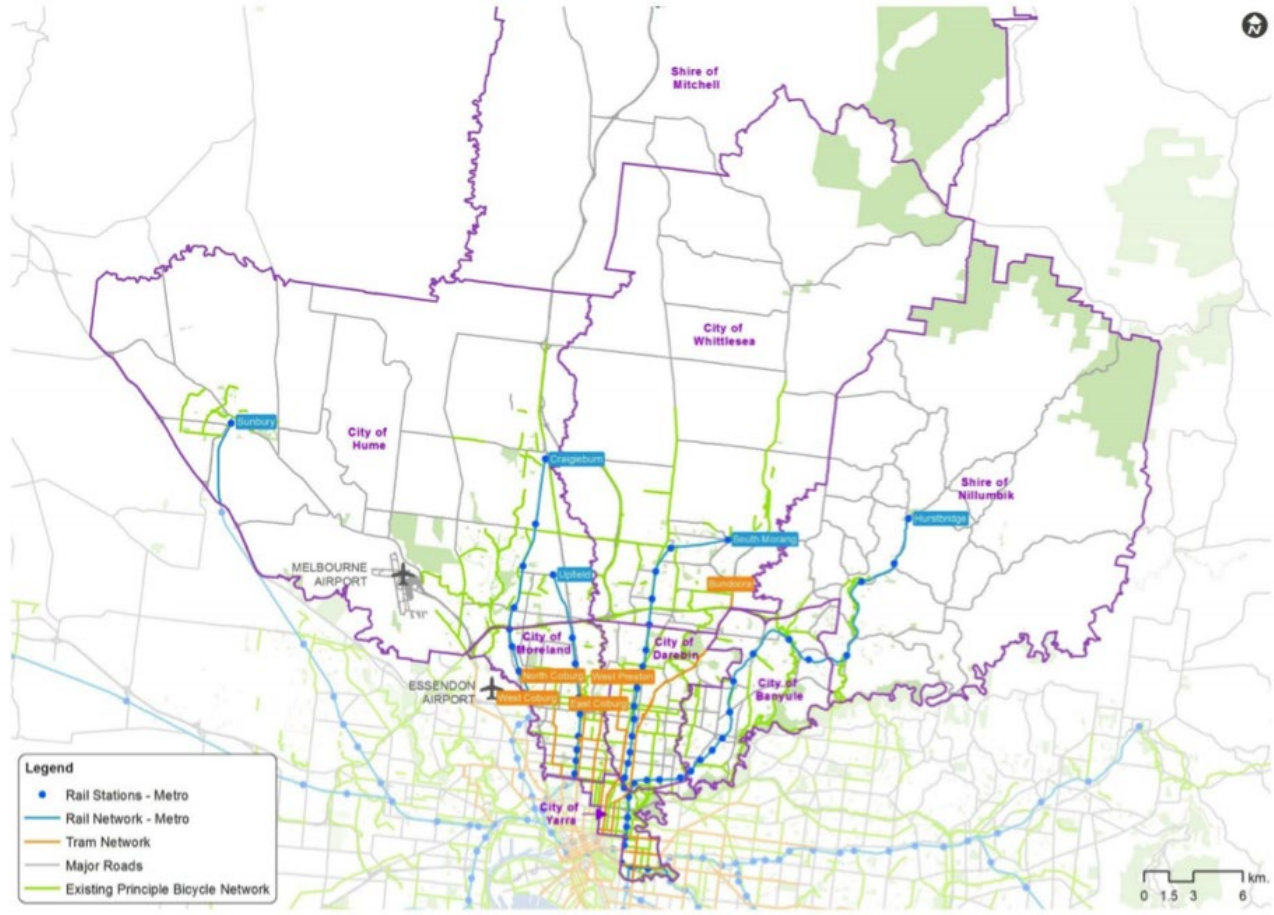

Figure 37 - Public transport network in Melbourne's North. (Source: NORTH Link: 2014)

Future transport links have also been planned for the region, and are listed in *Plan Melbourne* for the NAGA region include the Melbourne Rail Link, East West Link, a potential North East Link and a potential Outer Metropolitan Ring Road and Rail link (DTPLI: 2014).

Regarding utilities, the region is supplied by the following utilities:

- Water – wholesale services are provided by Melbourne Water, with Yarra Valley Water and City West Water as major retailers within the region (Western Water provides services to Hume). This includes the provision of water supply and sewerage services.
- Electricity – the region is delivered electricity through a transmission and distribution network. Electricity distribution businesses such as SP AusNet, Jemena and CitiPower maintain and operate crucial infrastructure, such as the poles and wires that supply electricity to residents and businesses.
- Gas – there are a range of gas pipelines located underground across the region, providing natural gas for heating, cooking and for business needs. Within the region, SP AusNet and Envestra are the gas distribution businesses that maintain and operate related infrastructure.

Both electricity and gas distribution businesses are regulated by the Australian Energy Regulator (AER). Distribution businesses report to the AER on future demands and capacity of the system. This assists in analysing associated capacity and infrastructure needs required in the future.

Included in this assessment are council-owned assets and infrastructure, including public open spaces, community infrastructure and council buildings, drainage and stormwater infrastructure and council owned and maintained roads. Some council infrastructure, such as community halls or civic centres are also vital for emergencies (acting as refuge centres), but also to ensure business continuity in servicing the community.

The following section provides a summary of the major impacts, risks and vulnerabilities to infrastructure within the NAGA region. This section also describes the key issues identified for infrastructure due to climate change impacts in the region, and nominated regional actions for adaptation.

6.4.2 Impacts, Risks and Vulnerabilities

The potential impacts and risks faced by the infrastructure sector over coming years were drawn from a review of existing literature and an infrastructure sector workshop, attended by NAGA council officers and relevant representatives from Victorian Government agencies. The full infrastructure sector impact and risk assessment is contained in Volume II, Appendix B of the RCCAP and the following table (Table 22) describes the impacts identified as being high-risk by infrastructure type.

Impacts on the transport infrastructure result from a range of climate events such as heatwaves, heavy precipitation, flooding and cold or hot days and nights. This may result in impacts such as stranded passengers and network disruptions. As an example, an extreme storm event on Christmas Day 2011, led to flash flooding that significantly disrupted transport in the affected neighbourhoods. This has economic implications (workers) and can impact particular vulnerable groups from access to care or refuge. Similar issues are associated with bushfires.

CLIMATE EXPOSURE EVENT/S	SCOPE	DESCRIPTION OF IMPACT	DIRECT OR INDIRECT	RISK	VULNERABLE GROUPS								
					Ground infrastructure (road, rail, bridge)	Public transport services	Power distribution and substations	Telecommunications infrastructure	Buildings	Stormwater, drainage and sewerage systems	Community infrastructure	Water reservoirs/ catchments	Airports/ ports/ jetties
TRANSPORT													
Hot days and nights Heatwaves	Regional	Passengers become stranded as trains to the City of Melbourne are delayed / cancelled in hot weather	Direct	High		•							
Heatwaves Heavy precipitation / floods Bushfire	Regional	Disruption to transport network operations	Direct	High		•							•
Heatwaves Heavy precipitation / floods Bushfire	Regional	Power outage impacts on road transport – traffic light, freeway management systems, Intelligent Transport Systems (ITS) and ongoing maintenance activities. Power outage impacts on rail transport – power and substation impacts	Direct	High	•	•							
Heatwaves Heavy precipitation / floods	Regional	Train and tram derailments / accidents result in injuries and major disruptions	Indirect	High	•	•							
Heatwaves	Regional	Increased reliance on the road network if there is a cessation or truncation of PT services in a particular area.	Indirect	High	•	•							
Heavy precipitation / floods	Regional	Mass stranding of people due to public transport stoppages, as a result of flooding or storm damage	Direct	High	•	•							•

CLIMATE EXPOSURE EVENT/S	SCOPE	DESCRIPTION OF IMPACT	DIRECT OR INDIRECT	RISK	VULNERABLE GROUPS								
					Ground infrastructure (road, rail, bridge)	Public transport services	Power distribution and substations	Telecommunications infrastructure	Buildings	Stormwater, drainage and sewerage systems	Community infrastructure	Water reservoirs/ catchments	Airports/ ports/ jetties
Heavy precipitation / floods	Regional	Access to emergency shelters, medical services, auto-mated teller machines (ATMs) impinged by impacts to the transport network.	Indirect	High	•	•							
WATER													
Heavy precipitation / floods Drought Extreme high sea level	Regional	Storm water drainage and flooding damage	Direct	High						•			
Heavy precipitation / floods	Regional	Damage to water supply infrastructure	Direct	High						•		•	
Bushfire Heavy precipitation / floods	Regional	Contamination of water supplies	Direct	High						•		•	
Heatwaves Drought	Regional	Reduced quality of green assets (e.g. street trees and active open space)	Direct	High							•		
Heatwaves	Regional	Increased urban heat island effect	Direct	High	•	•	•	•	•		•		•

CLIMATE EXPOSURE EVENT/S	SCOPE	DESCRIPTION OF IMPACT	DIRECT OR INDIRECT	RISK	VULNERABLE GROUPS								
					Ground infrastructure (road, rail, bridge)	Public transport services	Power distribution and substations	Telecommunications infrastructure	Buildings	Stormwater, drainage and sewerage systems	Community infrastructure	Water reservoirs/ catchments	Airports/ ports/ jetties
POWER													
Heatwaves Bushfire Heavy precipitation / floods	Regional	Damage to above ground electricity/gas/ telecommunications vital points of access (access to sub-transmission, substations, exchange points) and assets	Direct	High			•	•	•				
TELECOMMUNICATIONS													
Heatwaves Bushfire Heavy precipitation / floods	Regional	Damage to above ground electricity/gas/ telecommunications vital points of access (access to sub-transmission, substations, exchange points) and assets	Direct	High			•	•	•				
BUILDINGS													
Bushfire	Regional	Increased bushfire damage to buildings and structures	Direct	High	•			•	•		•		
Bushfire	Regional	Loss of buildings to fire	Direct	High				•	•		•		
COMMUNITY FACILITIES													
Bushfire Heavy precipitation / floods	Regional	Risk to life from damaged community infrastructure	Direct / Indirect	High					•	•	•		

Table 22 - Infrastructure sector: Impacts, risks and vulnerabilities in the NAGA region

Other impacts on transport infrastructure such as power outages on roads, train derailments and accidents, flooding on rail and restricted access to critical services (such as emergency shelters and ATMs) are also high risk and would be particularly problematic for ground infrastructure and public transport networks. These direct and indirect impacts may lead to economic, social and potential health and environmental impacts due to the restriction of travel and the movement of goods.

Impacts to the transport network associated with heatwave events can impact across the NAGA region, in particular in inner ring municipalities where the UHI is more pronounced and there is a concentration of public transport infrastructure and rolling stock.

The distribution of impacts associated with flooding and fire events is more closely aligned with the spatial location of these events, in conjunction with the presence of the infrastructure under consideration.

From a road infrastructure perspective, the City of Moreland and City of Darebin have the greatest length of all roads at risk of flood, while when just state declared roads are considered, the City of Melbourne and City of Yarra have the greatest length at risk. In relation to fire, the greatest length of all roads at risk is within the Shire of Nillumbik, and of state declared roads is the City of Hume, followed by the City of Whittlesea.

> **The shortcomings of like for like funding replacement needs to be recognised in the context of a changing climate and the potential to enhance the resilience of replaced assets considered as part of any recovery funding.**
>
> *Infrastructure Workshop Comment, 7 August 2014*

The extent of heavy rail infrastructure at risk of flood is generally low across the NAGA region, with no municipality, except for City of Melbourne, having more than two kilometres at risk of flooding. Melbourne, has just under 10 kilometres at risk. The nature of the rail network is such that impacts in the City of Melbourne will have significant impacts on the connecting rail network. In addition, while only a limited length of track may be at risk, an impact on one part of a rail line has the potential to suspend the operations on the entire line. Similarly, the greatest length of the tram network at risk of flood is located within the City of Melbourne, reflecting the density of the network in the Melbourne CBD, followed by the City of Yarra.

Conversely the greatest extent of rail at risk from bushfire is located in the outer ring municipalities of Hume, Whittlesea and Nillumbik, which have approximately 40, 30 and 10 kilometres at risk, respectively.

For water infrastructure, direct damage to drainage, catchments and storage can occur from extreme climate events such as storms and flooding. Water supply infrastructure and in particular reservoirs in the NAGA region are at particular risk from bushfire due to their locality in identified risk areas, Figure 29. Likewise, buildings may also be damaged directly. These impacts have direct economic costs (for repair and rebuilding), but also indirect costs to productivity.

For above ground infrastructure, such as electrical poles and transmission and distribution lines and telecommunications towers, there is a direct risk associated with fire and flood events impacting these assets. In relation to the electrical poles there is a specific risk associated with the historical use of wooden cross beams, that can pose a fire risk, in particular during extreme and very high fire risk days.

In certain areas across the NAGA region there is overlap between the existing residential and urban area and Bushfire Prone Area, representing areas of particular risk (Figure 21). These areas are evident in the City of Hume, Shire of Nillumbik and City of Banyule and City of Manningham, through the Yarra River corridor. Across the NAGA region, an analysis of the number of houses at risk within each municipality (Table 23) reinforces this assessment. The Shire of Nillumbik as having the greatest number of houses at risk from bushfire.

LGA	NUMBER OF HOUSES
City of Banyule	2,092
City of Darebin	-
City of Hume	5,267
City of Manningham	8,229
City of Melbourne	-
City of Moreland	-
Shire of Nillumbik	13,977
City of Whittlesea	7,831
City of Yarra	-

Table 23 - Number of houses at direct risk from bushfire across the NAGA region

An analysis of the number of houses at risk from flood, as determined by their presence within a flood overlay (Figure 22) is provided in Table 24. This illustrates the middle ring municipalities of City of Darebin and City of Moreland as having the highest number of houses at risk, with City of Hume and the Shire of Nillumbik having the lowest.

LGA	NUMBER OF HOUSES
City of Banyule	2,282
City of Darebin	4,755
City of Hume	1,051
City of Manningham	1,310
City of Melbourne	1,706
City of Moreland	3,816
Shire of Nillumbik	1,177
City of Whittlesea	2,200
City of Yarra	2,445

Table 24 - Number of houses at direct risk from flood across the NAGA region

In considering these potential impacts it is important to recognise the relationships and dependencies between infrastructure types. An example of these interactions, replicated from *A Roadmap for Victorian Critical Infrastructure Resilience: An All Hazards Resilience Framework* (Department of Premier and Cabinet: 2013) is illustrated in Figure 38 (Rindali S: 2001). The diagram highlights the critical role of electric power in maintaining the function of other infrastructure types. This criticality is equally applicable to the NAGA region given the electrified passenger heavy and light rail network and relationship to water infrastructure.

Through the infrastructure workshop, it was also identified that during extreme events, there is an interdependency between the transport network and, in the particular, the road network and electric power. Service vehicles seeking to access downed electric poles and wires can be delayed if there if there are significant blockages or traffic on the road network.

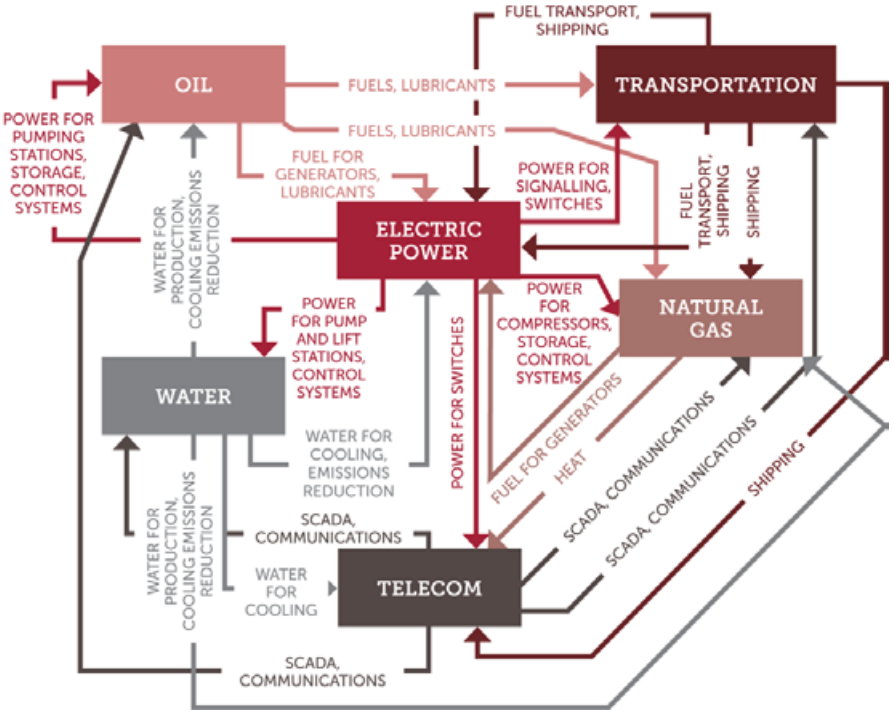

Figure 38 - Infrastructure interdependencies

In addition to the relationship to other infrastructure types, electric power provides a number of functions at an individual household and business level; failure of cooling, pumping and telecommunication systems during climate events can exacerbate the potential impacts on a range of vulnerable groups.

Processes of system /infrastructure innovation during post recovery should take into account improvements for specific equipment, buildings and entire systems. The planning design and consultation around these improvements should occur at the regional level."

Infrastructure Workshop Comment, 7 August 2014

6.3.3 Workshop Outcomes

An infrastructure-focussed workshop was undertaken to assess the particular impacts and vulnerabilities faced by the sector in the region. From a regional perspective, the infrastructure sector has a number of vulnerabilities which are exposed to reoccurring and exacerbated climate change events. As a result of the analysis and workshops, a series of major findings and issues were identified.

During period of climatic shocks and stresses there are potential impacts to each infrastructure type and these have been identified in Volume II, Appendix B.

A need for vulnerability assessments on council assets and community infrastructure

Councils own, maintain and operate a number of buildings and infrastructure across the region. These buildings and assets may be particularly vulnerable to a range of climate exposure events. Furthermore, these assets may be vital for vulnerable populations in the region (refer to human services and emergency management), such as homes for the elderly and council halls acting as designated refuge areas. NAGA may assist councils in undertaking a vulnerability assessment of council buildings, services, and community infrastructure.

Increased utilisation of data and research to enhance infrastructure resilience

Relevant and useful climatic data is a useful tool for building resilience for infrastructure, particularly in informing decision-making. Across the NAGA region, councils have varying degrees of access to quality data, such as those related to flooding risk data. Councils can use this information for vulnerability assessments on council-owned assets or it can be used to assist and engage community stakeholders, including residents or businesses.

Distributed energy systems can build infrastructure resilience

The region depends on the reliability of energy infrastructure and in Victoria, electricity generation is highly centralised. There is benefit in having distributed energy to supplement the system and build resilience to disruptions from the electricity grid. Distributed energy may be in the form of solar PV and battery storage systems. These systems often are compatible with the carbon mitigation strategies of councils within the region.

NAGA can act as a facilitator and information provider for the further development of distributed power generation in the region.

6.4.4 Nominated Priority Actions

Based on sector workshops, a number of potential management actions were identified, with certain actions prioritised. The following infrastructure actions represent the nominated actions for NAGA councils to implement (Table 25). There are a number of additional potential actions that were identified to assist the infrastructure sector address climate impacts, risks and vulnerabilities. These actions have been captured and collated as programs of potential works to be undertaken over coming years and are included in Volume II of *Adaptation in the North*.

OBJECTIVE/S	**ENHANCE THE RESILIENCE OF THE INFRASTRUCTURE NETWORK ACROSS THE NAGA REGION TO PROJECTED CLIMATIC CHANGES.**		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
C1	Research requirements and structure of a vulnerability assessment of key council building typologies (aquatic centres, libraries, administration buildings, community hubs, etc.).		NAGA
C2	Develop and pilot a vulnerability assessment of council buildings in a pilot project and implement the recommendations.		
C3	Advocate for any appropriate recommendations from the vulnerability assessment.		
C4	Develop templates for a vulnerability assessment of council buildings, to be used as a regional resource applicable to other NAGA Councils.	Investigate the viability of performing a vulnerability assessment of residential and commercial infrastructure.	
D1	Identify additional climate change data, such as flood overlays, that will support council decision making in responding to climate emergency events.		NAGA / NAGA councils

OBJECTIVE/S	ENHANCE THE RESILIENCE OF THE INFRASTRUCTURE NETWORK ACROSS THE NAGA REGION TO PROJECTED CLIMATIC CHANGES.		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
D2	Increase access to climate change data through ongoing engagement with relevant data stakeholders for incorporation into council decision making processes, in particular for flood data.		
D3	Identify relevant climate change triggers that will require additional capacity building and capital works projects to respond to the climatic changes identified in data sources.		
D4	Initiate appropriate capacity building and capital works projects to address the climatic changes identified in data sources in accordance with the relevant climate change triggers.		
E1	Develop programs to facilitate the further development of distributed power generation throughout the community (in particular solar PV) to contribute to the reduction of peak loads and risk of outages.		NAGA / NAGA councils

OBJECTIVE/S	ENHANCE THE RESILIENCE OF THE INFRASTRUCTURE NETWORK ACROSS THE NAGA REGION TO PROJECTED CLIMATIC CHANGES.		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
E2	Implement programs to facilitate the further development of distributed power generation throughout the community.		
E3	Investigate complementary peak load reduction strategies, in partnership with electricity distributors, to reduce the risk of outages.		
E4	Test identified complementary peak load reduction strategies, in partnership with electricity distributors.	Continue testing identified complementary peak load reduction strategies, in partnership with electricity distributors.	
E5	Increase the provision of on-site storage to provide a secondary source of power to key council infrastructure, in particular, community refuges and other sites of significance during heatwave, flood and bushfire events.		

Table 25 - Nominated priority actions for the infrastructure sector

6.5 Industry

6.5.1 Overview

The economy of the NAGA region is in a period of transition, moving from a traditional manufacturing past to a knowledge economy model that promotes health and education employment clusters, high-tech manufacturing and creative industries (National Institute of Economic and Industry Research: 2009). This trend is reflected in *Plan Melbourne*, which forecasts growth in employment in population services from 43 to 48 per cent and a decline in manufacturing employment from 11 to 6 per cent, over the period of 2011 to 2031 (DTPLI: 2014a).

The economy and key industries of the NAGA region are heavily influenced by the contribution of the City of Melbourne. As the centre of Victoria's knowledge economy, the City of Melbourne provides a significant contribution to the overall employment for the region, both in terms of the total number of jobs it provides and by the type of occupations present, specifically its contribution to the number of professional, scientific and technical services and finance and insurance persons employed (Figure 39).

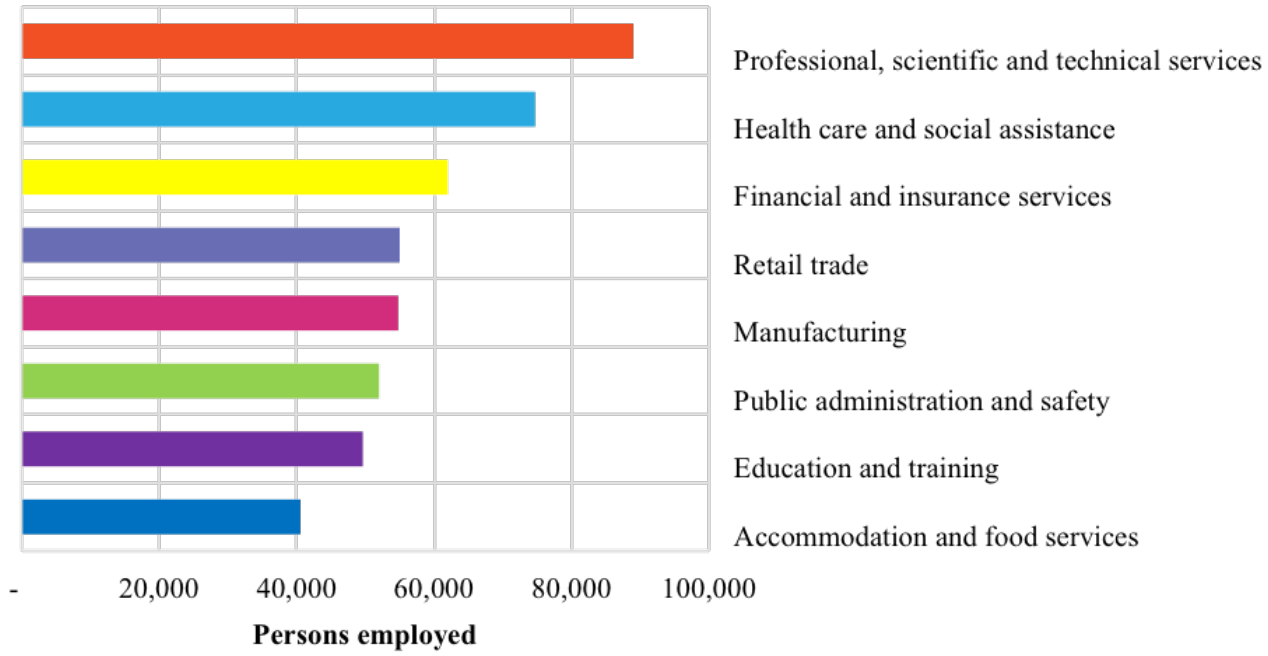

Figure 39 - Industries of Employment within the NAGA region 2011 (all municipalities)

If the City of Melbourne's data is excluded, the NAGA region shows a large proportion of employment occurring in the health, manufacturing and retail trade sectors (Figure 40).

The proportion of people employed in highly skilled occupations varies to a limited extent across the NAGA region, with most councils within 10 per cent of the Metropolitan Melbourne average. Hume has the lowest proportion at 46.8 per cent while Melbourne has the highest rate at 69.2 per cent. The unemployment rate varies significantly across the NAGA region. As of September 2014, Nillumbik has the lowest rate at 3.1 per cent while the City Hume has the highest rate at 10.1 per cent (Department of Employment: 2014).

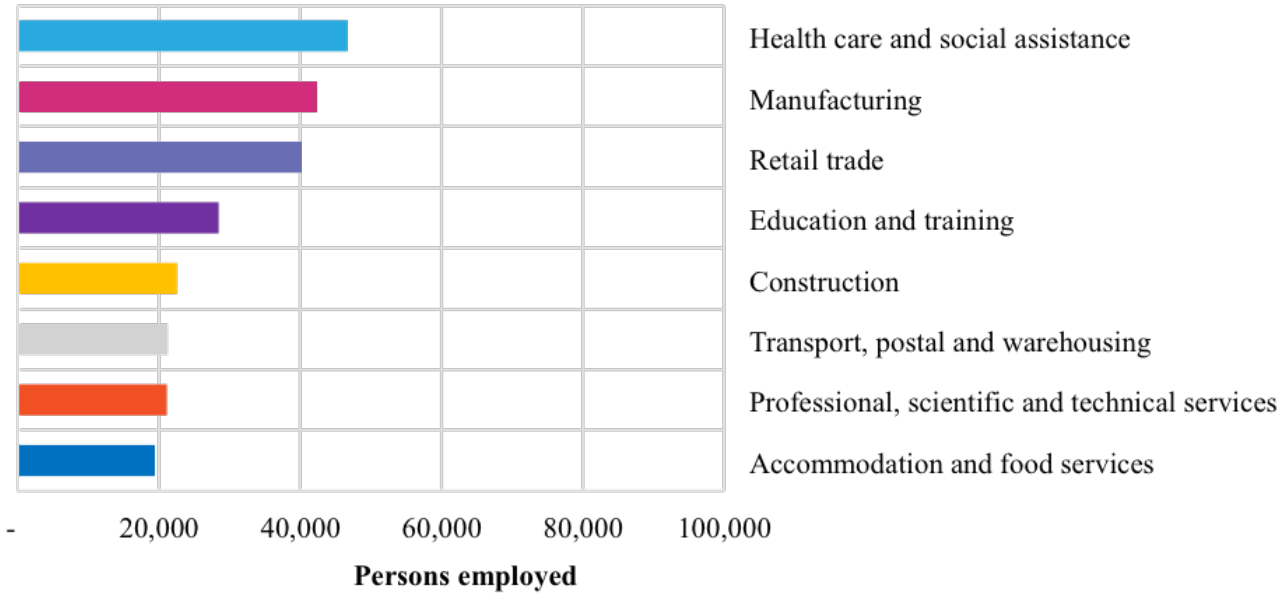

Figure 40 - Industries of Employment within the NAGA region 2011 (excluding City of Melbourne)

As the NAGA region transitions and grows over the coming years it will need to address a range of climate related impacts, risks and vulnerabilities. These are identified in the following section along with the nominated regional actions to build resilience within the sector. As the Economic Development units within council generally have the closest relationship to business and industry, a focus of the actions is providing these officers with sufficient knowledge and resources to build resilience in industry across the NAGA region.

Local government could strengthen their role in going out to small business during post-recovery to ensure they have the right resources and know what the 'next steps' are."

Industry Workshop Comment, 5 August 2014

6.5.2 Impacts, Risks and Vulnerabilities

The potential impacts and risks faced by the industrial sector over coming years were drawn from a review of existing literature, in particular from *The Economics of Climate Change (Committee for Economic Development of Australia* (CEDA): 2014) and *Foundation Paper One: Climate Change Victoria (Commissioner for Environmental Sustainability* (CES): 2012) and an industry sector workshop, attended by NAGA council officers, mainly from the economic development areas of council, and industry representatives. The full industry sector impact and risk assessment is contained in Volume II, Appendix B and the following table (Table 26) describes impacts identified as being high-risk and those industry sectors most vulnerable across the NAGA region.

For industry in the NAGA region, there were particular vulnerable groups identified as part of the consultation workshops. Each impact was assessed to determine the applicable vulnerable groups, and these are included in the following table (Table 26). These groups are particularly vulnerable to climate events related to increased hot days, heatwaves or increased maximum daily temperatures.

CLIMATE EXPOSURE EVENT/S	SCOPE	DESCRIPTION OF IMPACT	DIRECT OR INDIRECT	RISK	VULNERABLE GROUPS						
					Outdoor workers	Agriculture land	Small businesses	Health care and social assistance	Transport services	Postal and warehousing	Retail trade
TRANSPORT											
Heatwaves Heavy precipitation / floods Drought	Regional	Extreme weather leading to reduced primary production	Direct	High		•					
Heatwaves Heavy precipitation / floods Drought	Regional	Extreme weather leading to power, transport and communication disruption	Indirect	High			•	•	•	•	•
Heatwaves Heavy precipitation / floods Drought	Regional	Extreme weather leading to property damage	Direct	High		•	•	•	•	•	•

CLIMATE EXPOSURE EVENT/S	SCOPE	DESCRIPTION OF IMPACT	DIRECT OR INDIRECT	RISK	VULNERABLE GROUPS						
					Outdoor workers	Agriculture land	Small businesses	Health care and social assistance	Transport services	Postal and warehousing	Retail trade
Heatwaves Heavy precipitation / flooding Drought	Regional	Extreme weather leading to increasing insurance claims.	Indirect	High		•	•	•	•	•	•
Heavy precipitation / flooding	Regional	Business closure and job loss due to business interruption from storm damage and flooding	Direct	High		•	•	•	•	•	•
Hot days and nights Heatwaves	Regional	Increased heat stress in employees working outdoors, such as construction, heavy industry, defence, emergency services, postal services and couriers	Direct	High	•	•				•	
Bushfire	Regional	Bushfires leading to reduced primary production and property damage	Direct	High	•	•	•	•	•	•	•
Bushfire	Regional	Bushfires leading to increasing disruption of power, transport and communication	Indirect	High	•	•	•	•	•	•	•
Bushfire	Regional	Bushfires leading to increasing insurance claims.	Indirect	High		•	•	•	•	•	•

Table 25 - Industry sector: Impacts, risks and vulnerabilities in the NAGA region

The direct high-risk impacts are related to increased frequency of hot days or heatwaves, which particularly impact productivity, in particular in the north west of the NAGA region where there is variable rainfall (Figure 17). During such events, outdoor workers in particular, have reduced capacity to work and equipment and supporting infrastructure for the running of business. Given the considerable proportion of the population working outdoors in areas such as Nillumbik, Hume and Whittlesea this is a notable issue for the NAGA region.

There are a range of direct impacts on the industries of the NAGA region identified that could have economic impacts. There is a high risk of extreme weather influencing primary production, power disruptions and other resources such as property, transport and communication that could stop activities in all of the

vulnerable industries identified. This is also applicable to bushfires and these direct impacts may lead to a reduction in economic performance alongside a reduction in the provision of goods and services provided by such industries. One such example is food from the agricultural sector which is particularly important as virtually all of the agricultural land in four of the municipalities is at risk from bushfire.

It is also worth considering that the high risk of business closures due to storm events or flooding would also reduce economic performance and limit opportunities for local people to be engaged in work or training during climate change exposure events. This is a concerning trend for small business which is less resilient and able to cope and for health and social care services as this leads to further issues discussed in the human services and emergency management sections.

These impacts may lead to significant general reduction in economic performance relative to current forecasts. One of the major impacts to business is due to the reliance on electrical infrastructure, which may be impacted by increased heat leading to blackout or infrastructure failures. These impacts are described in the summary on the infrastructure sector.

Climate events such as bushfire and flood have a broad economic impact in terms of increasing insurance premiums for personal and commercial purposes. As an example, the Insurance Council of Australia which has calculated the cost, based on insured loss, of the Black Saturday fires as exceeding $1.2 billion (based on 2011 dollars) and the Christmas Day floods in 2011, as approximately $728 million (Insurance Council of Australia: 2015).

A number of these vulnerable groups represent a significant amount of employment within the region, such as health care, transport and warehousing, and the retail trade (refer to Figure 40). The impacts faced by these vulnerable groups have the potential to negatively affect the economic performance of major industries within the region when considered in the context of increased heatwave, flooding and bushfire events.

In terms of particular industries that are vulnerable, the transport, postal and warehousing industry is most significant in terms of employment for Hume, with over 10 per cent employed in this industry.

Retail trade is more evenly distributed, employing around 10 per cent of the population for each municipality. Manningham and Whittlesea are slightly higher, at around 12 per cent, while Melbourne and Yarra are slightly lower, at around 8 per cent.

Within the inner municipalities of the NAGA region, such as the City of Moreland and City of Darebin, retail trade is often associated with strip retail in locations such as Sydney Road and High Street Preston. In these locations retail trade is vulnerable due to the relative lack of protection from the climatic conditions.

In 2014, the City of Melbourne commissioned research into the impact on business of the January 2014 heatwaves, *2014 Heatwave Business Impacts – Social Research* (Sweeney Research: 2014). This identified the retail trade sector as being most affected as measured by demand, sales value and profitability. In the outer municipalities, such as the City of Manningham and the City of Whittlesea, retail trade tends to be located in larger complexes, such as Westfield Doncaster and Westfield Plenty Valley. During events such as a bushfire or heatwaves, these centres can become surrogate relief centres for the community, placing pressure on the operators of such facilities. Conversely, in the event that these facilities need to be evacuated due to a climate event, this can lead to a range of access issues and has the potential to hamper emergency services.

6.5.3 Workshop Outcomes

An industry focussed workshop was undertaken to assess the particular impacts and vulnerabilities faced by the sector. From a regional perspective, the industry sector has businesses and industry groups that are particularly vulnerable to more reoccurring and exacerbated climate change events.

As a result of the analysis and in consultation workshops, a series of major findings and issues were identified.

A regional-wide response for industry adaptation is required

To assist industry to adapt, a regional-wide response is required. This means that all existing groups and industry players in the region need to participate in building the resilience of the industry. NAGA can have a role in hosting forums to collaborate with industry or to disseminate useful climate change adaptation information to the industry.

A current lack of information from vulnerable groups to build capacity

Some industry groups that are particularly vulnerable, are the same groups who have limited resources or economic capacity to cope with climatic shocks and stresses. For example, small businesses have limited insurance cover or have not considered the specific conditions in their insurances in the event of particular extreme weather events. Many businesses also do not have information on how to improve resilience against climate events.

There are two areas of information that focus can be directed to:

- ***Risk prevention*** – information on modifying business processes, equipment or building upgrades to build resilience in times of extreme climate events.
- ***Post-recovery assistance*** – information on the relief or recovery assistance available from government and organisations.

Councils and its Economic Development officers can play a role in providing and disseminating independent and credible advice on building resilience against climate change, with a particular focus on vulnerable groups. NAGA can support by providing or sourcing this information or advice.

There is an opportunity for local businesses to support post-recovery activities

Often in post-recovery situations, there is an immediate need for supply products for the population that is severely impacted. Local businesses may have the immediate stock and supplies to provide support at this time. There is opportunity for NAGA to identify and establish a database of these local businesses for post-recovery scenarios.

6.5.4 Nominated Priority Actions

As a general comment, of all the sectors it was felt that the understanding of the climate change impacts, risks and specific vulnerabilities was least understood for the industrial sector and as such, relatively moderate action has the potential to have a significant benefit in increasing awareness and building capacity within the sector. The key objective of *Adaptation in the North* for the industry sector is to provide support in order to enhance the capacity of industry within the NAGA region to address the projected shocks and stresses associated with climatic change.

It is noted that the supporting actions for this objective predominantly rest with the Economic Development officers within NAGA councils and therefore the key role of NAGA in this context is one of advocacy. The following industry actions represent the nominated actions for NAGA and alliance councils to implement. There are a number of additional potential actions that were identified to assist the industry sector address climate impacts, risks and vulnerabilities. These actions have been captured and collated as programs of potential works to be undertaken over coming years and are included in Volume II of *Adaptation in the North*.

OBJECTIVE/S	SUPPORT THE CAPACITY OF INDUSTRY IN THE NAGA REGION TO ADDRESS SHOCKS AND STRESSES ASSOCIATED WITH PROJECTED CLIMATIC CHANGES		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
F1	Conduct research into information required by industries to build resilience to and recover from climactic weather events, including preparing for relevant events, assistance available from government organisations and opportunities to enhance business continuity.		NAGA
F2	Develop a package of information for Economic Development officers within council to provide to relevant industries to build resilience and enhance business continuity. Potential information includes flexible working hours and modified breaks (including working from home options), insurance requirements, bulk-buying of essential equipment, goods, the benefits of better building standards and design improvements to enable continued service during climate events.		

OBJECTIVE/S	SUPPORT THE CAPACITY OF INDUSTRY IN THE NAGA REGION TO ADDRESS SHOCKS AND STRESSES ASSOCIATED WITH PROJECTED CLIMATIC CHANGES		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
	Host a regional climate change industry forum to publicise the availability of the aforementioned information packages and gauge the level of interest in ongoing engagement.		
F3	Develop communications pack for council Economic Development Officers to promote to their own businesses. Communications need to be tailored to specific industry sectors and the climate threats they are likely to face.		
G1	Identify products and services required following a climate event.		NAGA
G2	Establish a regional database of local businesses that are able to supply products that are likely to required immediately following a climate event.		NAGA

Table 27 - Nominated priority actions for the industry sector

6.6 Natural ecosystem

6.6.1 Overview

Responsibility for natural ecosystems within council traditionally resides with the Environment and Sustainability teams. Increasingly, this responsibility is being shared, as the value of ecosystem services in augmenting infrastructure, parks and open space and health and wellbeing strategies is being realised. This broadening of interest and involvement in natural ecosystems is being formalised within council through the creation of urban forest strategies and integrated water management plans.

While the focus of climate change is often on the impacts associated with urban areas and the implications for individuals, populations and society, across the NAGA region there are significant areas of remnant vegetation, streams, conservation reserves, parks and areas of open space. The vast majority of remnant vegetation is associated with the outer ring municipalities of the City of Hume, City of Whittlesea and Shire of Nillumbik as well as the City of Manningham, a legacy of the Green Wedge Zones that were established in the 1960s to assist in the provision of environmental health objectives and today support a range of land uses that are either not compatible with urban development, or provide for the protection of natural attributes.

A number of extensions of the Urban Growth Boundary have placed pressure on biodiversity within the Green Wedge Zones and to manage the impact of future urban development on the ecological values of growth areas, the Victorian Government has proposed a network of small and medium sized conservation reserves, in particular along the Hume growth corridor within the City of Hume and City of Whittlesea.

The natural ecosystems within the NAGA region are varied, and include waterways and native vegetation. The native vegetation varies considerably, from the native grassland areas of the northern and western parts of the NAGA region to the forested areas of River Red Gum complexes of the north eastern parts of the region. Many of these ecosystems may be at risk to climate events such as bushfire and flooding as well as long term stresses associated with prolonged periods of drought, as identified in the *Port Phillip and Westernport Regional Catchment Strategy* (Port Phillip and Westernport Catchment Management Authority: 2013).

The area of protected land varies widely across the NAGA region, with the Metropolitan Melbourne average being 63.7 hectares protected per 1,000 hectares of land. Banyule, Melbourne, Moreland and Yarra have no conservation land or nature reserves. Darebin, Hume and Manningham have between 15 to 50 hectares protected per 1,000 hectares of land, while Nillumbik and Whittlesea both have around 175 hectares protected per 1,000 hectares of land.

Across the NAGA region, the municipalities with notable presence of unique species and habitats are the Shire of Nillumbik (290.8 square kilometres), the City of Whittlesea (169.7 square kilometres), the City of Hume (82.9 square kilometres), the City of Manningham (46.4 square kilometres) and the City of Banyule (7.7 square kilometres).

Knowledge base around environmental/ecological impacts of drought and heatwave is extremely poor.

Natural Ecosystems Workshop Comment, 13 August 2014

It is noted however that it is not just native biodiversity that is at risk from climate change. Part of the driver for development of the City of Melbourne urban forest strategy, *Melbourne's Urban Forest Strategy – making a great city greener 2012 – 2032* (City of Melbourne: 2012) was in response to the impact a decade of drought had on the approximately 70,000 council owned-trees and a realisation by council of the opportunity that their required renewal presented in shaping the future of the city.

To provide a more detailed understanding of the potential implications of climate change on natural ecosystems, PPWCMA commissioned the preparation of *NRM Planning for Climate Change – Victorian Climate Catchment Management Authorities, Final Project Report 1 – Impact and Vulnerability Assessment Process and Spatial Outputs (Spatial Vision: 2014)*. This has produced a significant level of information on the potential climate change impacts, sensitivities and vulnerabilities of natural assets within the catchment that includes the NAGA region.

Open space, as defined by passive and active open space makes up 11.9 per cent of area in Metropolitan Melbourne. All of the NAGA region municipalities are below the Melbourne metropolitan average of 26 per cent (VEAC: 2011), in terms of open space, with the Hume having approximately 6 per cent and Moreland, 9.4 per cent of area. The councils with the greatest proportion of open space are Nillumbik, Whittlesea and Manningham with 19.6, 16.5 and 17.7 per cent respectively. Most NAGA councils have a similar number of parks and gardens per 1,000 population to the Metropolitan Melbourne average of 2.3 per 1,000 people. The exceptions are Hume and Whittlesea at the higher end at around 4 per 1,000 population, and Darebin and Moreland at the lower end at 1.2 per 1,000 population.

As a general trend, the NAGA municipalities of Banyule, Darebin, Melbourne, Moreland and Yarra will have limited opportunities for the creation of new public open space due to population growth and the existing coverage of built up areas (VEAC: 2011). The remaining municipalities are less restricted in this sense.

6.5.2 Impacts, Risks and Vulnerabilities

This section provides a summary of the major impacts, risks and vulnerabilities to natural ecosystems within the NAGA region. The potential impacts and risks faced by the natural ecosystems sector over coming years were drawn from a review of existing literature and an infrastructure sector workshop, attended by NAGA council officers. The full natural ecosystems sector impact and risk assessment is contained in Volume II, Volume B of *Adaptation in the North*. The following table (Table 28) describes the impacts identified as being high or extreme risk and associated vulnerabilities.

High-risk impacts have been identified particularly from flooding, and this has direct impacts on local waterways, either through scouring, erosion of banks, sedimentation or even the eventual shifting of these waterways. As a result, this may lead to the destruction of habitats as well as having a direct impact on fauna within waterways.

More generally, changes in extreme hot and cold weather (and prolonged times of these) can lead to indirect impacts on fauna and flora that are sensitive to seasonal events. Bushfire can also have direct and indirect impacts on fauna, through short-term and long-term destruction of unique habitats.

There are a number of particular natural ecosystem vulnerabilities within the NAGA region. These vulnerable groups were identified during the consultation workshops. Each impact was assessed to determine the applicable vulnerable groups, and these are included in Table 28. Note that not all impacts directly impact the vulnerable groups. These groups are particularly vulnerable to climate events that push the ecosystem outside its normal range of conditions, due to elevated temperatures and extreme events including flooding and bushfire.

A number of potential issues have been identified for the natural terrestrial and aquatic ecosystems. Potential impacts have been identified such as habitat destruction from bushfire, increased fire risk and changes to the timing of seasonal events which may impact the natural environment of the NAGA region. Habitat destruction has been identified as an extreme risk to a number of vulnerable groups including species in unique habitats with limited capacity to migrate, fragmented ecosystems and stressed species, young habitats and wetland environments in the region. Furthermore given the vulnerability of the native vegetation and a high distribution of ecosystems susceptible to bushfire and flooding, habitat destruction and the decline of the quality of the natural environment presents a regional risk that could have devastating impact on the natural environment.

CLIMATE EXPOSURE EVENT/S	SCOPE	DESCRIPTION OF IMPACT	DIRECT OR INDIRECT	RISK	VULNERABLE GROUPS									
					Species unique habitat/ limited capacity to migrate	Fragmented and stressed species /ecosystems	Aquatic and riparian ecosystems	Ecosystems susceptible to frequent floods/bushfire	Large old trees	Floodplains and associated red river gums	Grasslands	Slow moving fauna	Young trees and revegetation areas	Wetland environments
TRANSPORT														
Heavy precipitation / floods	Regional	Destruction of habitat	Direct	Extreme	•	•	•	•		•	•		•	•
Heavy precipitation / floods	Regional	Erosion of banks in natural waterways (General)	Direct	High			•	•						•
Heavy precipitation / floods	Regional	Scouring of waterways / diversion	Direct	High			•	•						•
Heavy precipitation / floods	Regional	WSUD features damaged	Direct	High			•							•
Heavy precipitation / floods	Regional	Sedimentation (change of structure)	Direct	High			•	•						•
Heavy precipitation / floods	Regional	Reduced stream fauna, invertebrates and nursery and riparian habitats	Direct	High			•	•						•
Heavy precipitation / floods	Regional	Shifting of waterways over time	Direct	High			•	•						•
Heavy precipitation / floods	Regional	Reduced integration of environmental assets in urban planning due to changed community perception	Indirect	High	•	•	•	•	•	•	•	•	•	•

CLIMATE EXPOSURE EVENT/S	SCOPE	DESCRIPTION OF IMPACT	DIRECT OR INDIRECT	RISK	VULNERABLE GROUPS									
					Species unique habitat/ limited capacity to migrate	Fragmented and stressed species /ecosystems	Aquatic and riparian ecosystems	Ecosystems susceptible to frequent floods/bushfire	Large old trees	Floodplains and associated red river gums	Grasslands	Slow moving fauna	Young trees and revegetation areas	Wetland environments
Heavy precipitation / floods	Regional	Community impact of loss of environmental services: including wetlands (water treatment), and open space (recreation)	Indirect	High			•							•
Cold days and nights Heavy precipitation / floods Drought Bushfire	Regional	Increased threats to species with unique habitat and limited capacity to migrate	Direct	High	•	•								
Bushfire Heatwaves Drought	Regional	Increased fire risk	Direct / Indirect	High	•	•	•	•	•	•	•	•	•	•
Cold days and nights Hot days and nights	Regional	Change in timing of seasonal events, such as arrival of birds and butterflies, flowering of plants, impacting on the viability of certain species	Indirect	High	•	•								
Bushfire	Regional	Changes to ecosystems that are unable to recover from frequent bushfires	Direct	High	•	•		•	•		•	•		•

Table 28 - Natural ecosystems sector: Impacts, risks and vulnerabilities in the NAGA region

Climate change events resulting in flooding and heavy precipitation also represents a high risk and there are a number of associated potential impacts including the erosion of banks and scouring in natural waterways, sedimentation, reduced stream fauna and habitats, shifting of waterways and damage to WSUD features. Again, there is a considerable proportion of the land that is susceptible to flooding and the high risk of indirect impacts on flood levies further perpetuates the potential significant impacts on the natural environment.

Figure 41 describes the proportion of vegetation that is within bushfire or flooding overlays. The chart shows that four councils within the region are highly exposed to bushfire impacts, and these areas are located primarily in the outer parts (north and east) of the region. Regarding flooding, the region is less exposed, but three councils have more than 40 per cent of vegetation within flood overlays – these are located in more urbanised regions (Banyule, Moreland and Yarra).

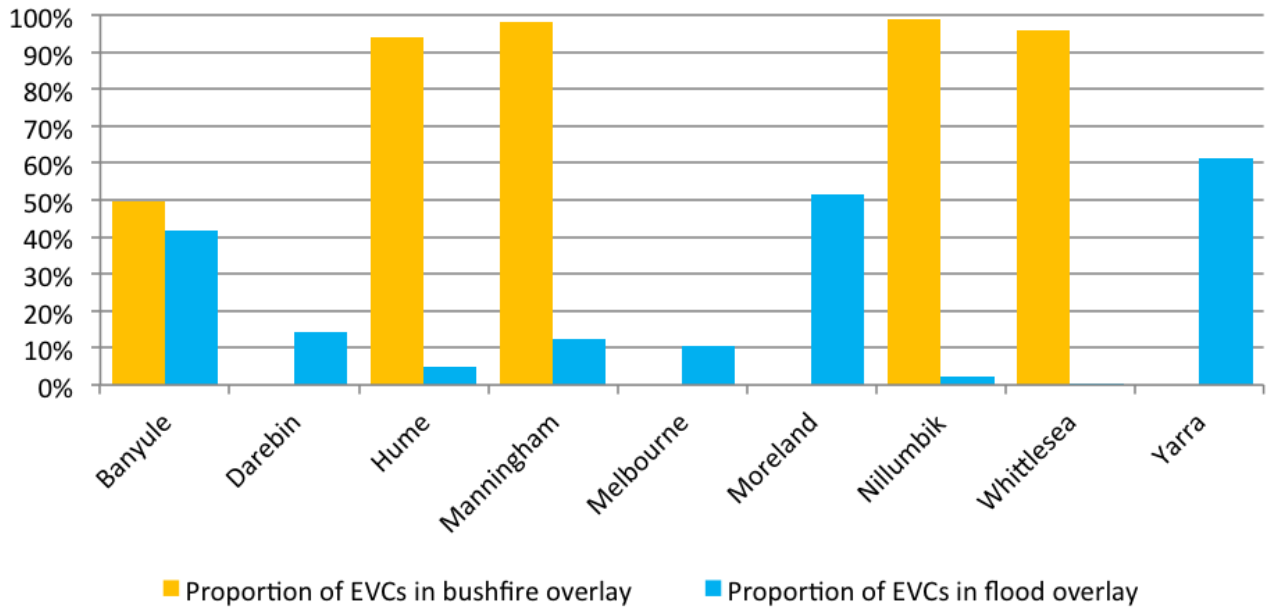

Figure 41 - Proportion of vegetation within bushfire and flood overlays

This data highlights some of the existing climate risks to natural ecosystems within the region, and are likely to be exacerbated in the future due to climate change. It is noted that damage to biodiversity from the species to ecosystem level is at risk from a variety of climate change exposure events that could present a number of environmental, social and potentially economic issues for the NAGA region. When the climate change projections to 2030 and 2070 are considered, the natural environment of the NAGA region is highly vulnerable and at risk from a range of climate change impacts.

6.6.3 Workshop Outcomes

A workshop focussed on natural ecosystems was undertaken to assess the particular impacts and vulnerabilities faced by the region. From a regional perspective, the exposure of biodiversity, habitats and waterways to flooding and bushfire is a particular concern. As a result of the analysis and consultation workshops, a series of major findings and issues were identified.

A need for a regional approach to biodiversity data, mapping and prioritisation

Although there is access to biodiversity data and mapping, there appears to be inconsistency across municipalities and councils. These inconsistencies can reduce the efficiency of work on areas that overlap councils. As such, there is a recognised need for a consistent approach for biodiversity data gathering, monitoring and mapping.

NAGA can facilitate this regional approach, drawing on experience and techniques being undertaken by individual councils, as well as by other regional organisations such as the Port Phillip and Westernport Catchment Management Authority and the Eastern Alliance for Greenhouse Action.

A need for regional knowledge sharing in response to climatic risks and vulnerabilities to biodiversity

As shown earlier in this section, the region has certain councils that are highly vulnerable to climate events (some to bushfire and others to flooding). However, most councils have some natural ecosystems that may be vulnerable to these events. In the event that bushfire or flooding occurs, there is benefit in sharing knowledge from councils that have greater (or more recent) experience in dealing with these events.

NAGA can act as a facilitator to help councils share knowledge in mitigating risks to biodiversity, or in developing resilience strategies.

6.5.4 Nominated Priority Actions

Based on sector workshops, a number of potential management actions were identified, with certain actions prioritised. The following natural ecosystems actions represent the nominated actions for NAGA and alliance councils. There are a number of additional potential actions that were identified to assist the natural ecosystems sector address climate impacts, risks and vulnerabilities. These actions have been captured and collated as programs of potential works to be undertaken over coming years and are included in Volume II of *Adaptation in the North*.

OBJECTIVE/S	**SUPPORT THE CAPACITY OF INDUSTRY IN THE NAGA REGION TO ADDRESS SHOCKS AND STRESSES ASSOCIATED WITH PROJECTED CLIMATIC CHANGES**		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
H1	Investigate current approaches to regional biodiversity mapping, being developed by individual councils, Port Phillip and Westernport Catchment Management Authority and other relevant stakeholders.	Implement knowledge sharing across the NAGA region.	NAGA / NAGA Councils
H2	Identify gaps in consistency between NAGA member councils as regards biodiversity mapping.		
H3	Develop a regional approach to biodiversity mapping for NAGA councils.	Implement regional approach to biodiversity mapping for NAGA councils.	NAGA / NAGA Councils
I1	Adapt the Eastern Alliance for Greenhouse Action's research to establish biodiversity data gathering protocols and a monitoring program of current natural assets to monitor change over time, for the NAGA region.	Implement biodiversity monitoring program in collaboration with relevant stakeholders.	NAGA / NAGA Councils

OBJECTIVE/S	SUPPORT THE CAPACITY OF INDUSTRY IN THE NAGA REGION TO ADDRESS SHOCKS AND STRESSES ASSOCIATED WITH PROJECTED CLIMATIC CHANGES		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
J1	Review existing NAGA council urban greening strategies to develop a regional strategy to increasing urban greening, especially within those councils without strategies.	Implement identified urban greening strategies.	NAGA
	Identify key elements of urban greening strategies, including mitigating urban heat island effect.	Develop and implement identified urban greening strategies.	
	Develop relationships with key stakeholders, such as academics on potential regional biodiversity climatic risks and vulnerabilities and the approach to mitigating these.		
	Facilitate knowledge sharing sessions on the potential regional biodiversity climatic risks and vulnerabilities.		
J2	Investigate management, education and resilience strategies, for public conservation land and privately owned land with conservation values, to prepare for climate risks.	Highlight best practice in management, education and resilience strategies, for public conservation land and privately owned land with conservation values, to prepare for climate risks.	NAGA

Table 29 - Nominated priority actions for the natural ecosystem sector

6.7 Planning

6.7.1 Overview

Careful consideration in planning can help councils address climate change impacts, risks and vulnerabilities for new developments or urban renewal projects. Planning can help to build resilience across a range of physical assets, including buildings, infrastructure, essential services and community facilities. This can lead to indirect benefits to the population, through improved social infrastructure, increased resilience of buildings (particularly those that support vulnerable populations), and the preservation of natural ecosystems and resources.

In Victoria, the *Planning and Environment Act 1987* is the principle framework that sets out how land can be used and developed in the state. This act provides an opportunity for individual councils to address climate change considerations through the incorporation of local content – these can be achieved through planning schemes, which are prepared and approved for every municipal district. Figure 42 describes the general structure of planning schemes in Victoria.

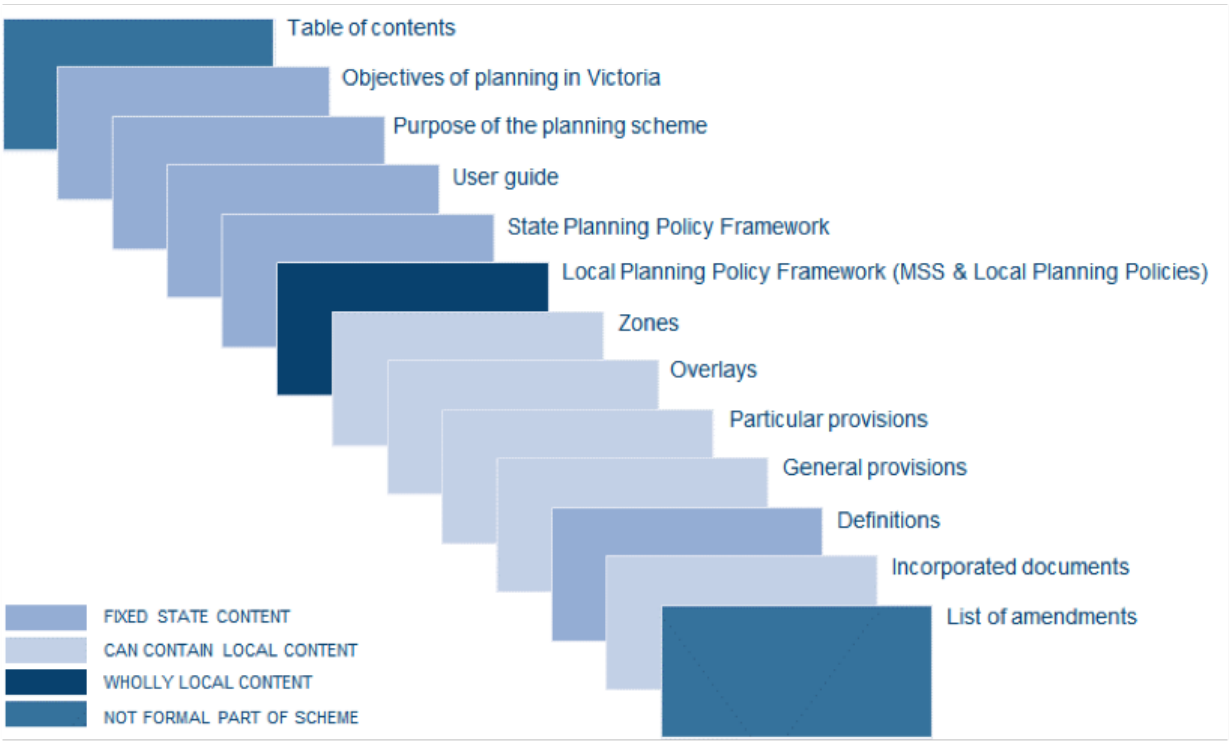

Figure 41 - Planning Scheme Structure [1]

It should be noted that there are a number of instruments within the planning scheme that can assist councils account for the impacts and risks of climate change in urban development. For example, bushfire and flood overlays have particular provisions regarding the inclusion of protection measures. These overlays for the region are presented in Figure 21 and Figure 22.

[1] Municipal Association of Victoria (2012) *Land Use Planning in Victoria: A Guide for Councillors* (Municipal Association of Victoria: Melbourne

Beyond overlays, planning scheme amendments can be pursued in order to change requirements or restrictions to development – these can be done with climate change risks in mind. As an example, the City of Melbourne worked to achieve approval of the *Melbourne Planning Scheme Amendment C187 – energy, water and waste efficiency*[2], which is applicable to particular new buildings. As a result, all new planning permit applications are assessed against the amendment, which requires:

- the achievement of high environmental performance standards at the design, construction and operation phases;
- the improvement of water efficiency of buildings and encouragement of the use of alternative water sources; and
- the minimisation of the amount of waste going to landfill and maximisation of the recycling and re-use of materials.

At a state government level, in 2014, the current *State Planning Policy Framework* (SPPF) is being revised to align with a number of state policies. Since May 2014, a draft *Planning Policy Framework* (PPF) is currently under review. As part of this draft PPF, it should be noted that climate change is explicitly recognised as a state policy under an environmental context , stating[3]:

"The Victorian climate is constantly changing, due to a wide range of human and natural factors. Over its history, Victoria has seen frequent bushfires, heatwaves, flooding and storms and these are projected to increase in intensity and frequency. Planning needs to take account of these changes."

It is clear that planning at various levels (state government, regional and municipal) can play a vital role in addressing issues related to climate change, particularly those impacts and risks that cause potential damage to infrastructure and assets.

[2] For further information, refer to http://www.melbourne.vic.gov.au/BuildingandPlanning/Planning/planningschemeamendments/Pages/AmendmentC187.aspx

[3] State Government of Victoria (2014) *Draft Planning policy Framework (PPF)*, Section 02.01-S-03

6.7.2 Impacts and Risks

While the planning scheme has significant potential to positively contribute to building resilience within the community to address climate change impacts, risks and vulnerabilities, conversely poor planning has the potential to exacerbate climate change impacts. Examples of this include:

- expansion of the Urban Growth Boundary in close proximity to areas identified as prone to bush or grass fires;
- master planning communities without the provision of sufficient access for Emergency Services in times of flood or bushfire;
- continued urban development increasing runoff from an expansion of impervious surface areas, contributing to flooding risk; and
- inadequate provision of open space enhancing the UHI.

In considering future approaches to planning across the NAGA region it is important that this risk of enhancing existing climate change impacts is explicitly recognised and addressed.

6.7.3 Workshop Outcomes

A workshop focussed on natural ecosystems was undertaken to assess the particular impacts and vulnerabilities faced by the region. From a regional perspective, the exposure of biodiversity, habitats and waterways to flooding and bushfire is a particular concern. As a result of the analysis and consultation workshops, a series of major findings and issues were identified.

Potential gaps may exist in the ability of the Victorian Planning Scheme and Building Code of Australia to adequately account for consider climatic changes and impacts for the region

It was recognised that the planning scheme does have some requirements that consider the impact of certain climate events, namely bushfire and flooding. However, other climate change impacts have not been taken into consideration. For the NAGA region, these include heatwaves, coastal impacts and soil degradation.

There is potential for these impacts or exposure events to be considered within planning schemes from a regional level, such as:

- addressing specific climatic issues for the NAGA region for urban renewal and growth areas;
- new overlays considering heatwaves or urban heat island effects; or
- regionally-consistent or extended local planning policies that require new developments to consider climate change (as exampled by City of Melbourne's C187 Planning Scheme Amendment).

NAGA may have a potential role in assisting a gap analysis on existing planning schemes and policies, and advocate or provide recommendations on behalf of the region. NAGA can also have a role in providing independent and regional information on best-practice planning approaches in climate change adaptation.

An opportunity for planning professionals within councils to build capacity and knowledge

in addressing climate change through planning instruments and practice

Recently, the NAGA region has experienced a number of extreme weather events that have caused widespread damage, and drawn attention to the potential increased impacts associated with climate change. The planning profession has also realised the need to consider climate change in its practices, particularly as it influences the way we develop our infrastructure.

As a result, there is a clear opportunity for planning professionals to build capacity and knowledge in climate change adaptation. This requires not only a working knowledge of climate change issues, but a practical understanding of how these can be addressed through the setting and application of planning policy and legislation.

NAGA recognises that this is a developing sphere of knowledge and practice for planning professionals. NAGA may have a role in hosting forums and providing networking and learning opportunities for council planning officers in the area of planning for climate change.

> **SPPF currently can mitigate heatwave impacts through the provision of open space, amenity and permeability. Potential for better passive design to reduce heatwave impacts... Potential to require canopy trees or mandate percentage shading through the LPP... Potential for design and development overlays that incorporate climate change consideration.**
>
> *Planning Workshop Comment, 24 July 2014*

6.7.4 Nominated Priority Actions

Based on sector workshops, a number of potential management actions were identified, with certain actions prioritised. The following planning actions represent the nominated actions for NAGA to implement.

OBJECTIVE/S	IMPROVE THE QUALITY AND DIRECTION OF PLANNING POLICY AND STRATEGY TO ADDRESS EXPECTED CLIMATIC IMPACTS, RISKS AND VULNERABILITIES ACROSS THE NAGA REGION.		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
K1	Collate best practice examples of how other planning approaches are addressing climatic changes and protecting areas required for future adaptation and review their applicability to the NAGA region.		
K2	Identify key stakeholders, such as the Municipal Association of Victoria (MAV), the Council Alliance for a Sustainable Built Environment (CASBE), Planning Institute of Australia (PIA), the Urban Development Institute of Australia (UDIA) and the Victorian Government, to identify roles and responsibilities in improving the ability of planning approaches to respond to climate change impacts.		
K3	Advocate to relevant stakeholders to undertake a comprehensive gap analysis of the current ability of the Victorian Planning Scheme and Building Code of Australia to address projected climatic changes and impacts for the NAGA region for both urban renewal and growth areas, and to protect areas required for adaptation now and in the future. For example, aligning with Urban Forest Strategies or Integrated Water Management Strategies.	Advocate for relevant changes to the Victorian Planning Scheme.	

OBJECTIVE/S	IMPROVE THE QUALITY AND DIRECTION OF PLANNING POLICY AND STRATEGY TO ADDRESS EXPECTED CLIMATIC IMPACTS, RISKS AND VULNERABILITIES ACROSS THE NAGA REGION.		
ACTION	**SHORT (2015-2018)**	**MEDIUM (2019-2030)**	**RESPONSIBILITY**
L1	Investigate opportunities for extending existing ESD policies / requirements to address projected climatic impacts, risks and vulnerabilities for the NAGA region, for: • council facilities; • public realm, infrastructure and streetscapes; and • commercial and residential buildings.		
M1	Engage planning officers across the NAGA region to build network capacity in relation to understanding the key climate change impacts, risks and vulnerability and the potential role planning practice, policy and legislation can play in reducing these.		NAGA

Table 30 - Nominated priority actions for the planning sector

7. SUMMARY OF MANAGEMENT ACTIONS

7.1 Overview

For each sector, priority actions for NAGA councils to implement have been defined to support the overall objective/s for the sector.

The following provides a summary of the key attributes of each short term action, from 2015 to 2018, in relation to the type of action, high and extreme risk climate impacts and vulnerabilities addressed. Further commentary is provided in relation to its applicability addressing climate impacts and vulnerabilities identified in other sectors, as well as the environmental, economic and social benefits of the action and barriers to its implementation. Successful implementation of the majority of actions will require close collaboration with a range of organisations across the region. These have been defined, as well as the area within council which will own the action.

7.1.1 Human Services

HUMAN SERVICES	
Primary Objectives	Design and deliver programs that facilitate strong, informed, capable, self-reliant, connected and willing communities responding to climate change across the NAGA region.
Action Type	Research and innovation, information and communications
Action Overview	A. Conduct review of best practice of community engagement to build resilience to climate change impacts, including programs to build social cohesion before events. B. Conduct review of best practice of heatwave communications for vulnerable communities. C. From best practice review and an analysis of current approaches, identify opportunities for improving or developing additional communication mechanisms. D. Advocate to existing heatwave committees within NAGA Councils for a research project to evaluate effectiveness of heatwave communications. E. Conduct a regional level gap analysis of coordination between NAGA Councils and community organisations with relationships with vulnerable populations and individuals, during periods of climatic shocks and stresses. F. Advocate for a research project to understand the implications for Councils in the delivery of human services in the context of the projected climatic impacts, risks and vulnerabilities for the NAGA region.

HUMAN SERVICES	
Cross Sector Applicability	Emergency Management Industry
High and Extreme Impact Risks Addressed	Increased effectiveness of communication strategies is likely to foster improved community resilience and address extreme and high risks. These include: • direct health risks, including injuries, exacerbation of existing health problems and premature deaths; and • indirect risks including the inability to contact vulnerable populations if communication services are impacted and council and essential services workers are unable to respond to events.
Vulnerabilities Addressed	• older people • children and young people • socioeconomically disadvantaged people • homeless people • CaLD people • people with a disability • people with mental health issues • people with alcohol and other drug issues • victims of family violence. • people with multiple and complex needs
Triple Bottom Line Effects	Economic and social sustainability will be supported by advances in general community health and networking relationships. Environmental sustainability is not addressed by these actions.
Barriers to Implementation	The effectiveness of communication strategies depends on the quality of relationships held with individual businesses and community groups, which may vary considerably between councils and indeed between individual staff members within councils.
Key Collaborators	Local businesses and, community organisations and community groups
Timing	Short – Medium
Owner	*Within Council* Human Services or similar

7.1.2 Emergency Management

EMERGENCY MANAGEMENT	
Primary Objectives	Clarify the roles and responsibilities for emergency management across the NAGA region. Enhance the resilience and breadth of communication mechanisms during shocks and stresses so that there is a consistent and singular source of messages, and so that those most impacted are able to readily access information.
Action Type	Research and innovation, capacity development, information and communications, education.
Action Overview	A. Develop research agenda to gain better understanding of issues identified in Emergency Management consultation, including: • Stages of relief and recovery (i.e. after 6 weeks, 1 year etc) and understand what decisions needs to be made at each stage and by which key stakeholders to facilitate relief and recovery in a manner that increases community resilience to future emergency events; • A more granular understanding of the spatial vulnerability to lack of infrastructure (e.g. power outage, road blockage), and how this vulnerability might be decreased to ensure community copes better with failed infrastructure in emergency events; • definitions of recovery, as provided by state government; and • opportunities for improving emergency communication, including pros and cons of having one consistent voice. B. Develop relationships with key sources of information about the impact of climate change upon the emergency management sector, including the Bushfire and Natural Hazards Cooperative Research Centre and the National Climate Change and Adaptation Forum. C. Develop relationship with key stakeholders, including Volunteering Victoria, to explore community opportunities for volunteers during and after emergency events. D. Develop a better understanding of how the vulnerable persons register can be improved, including the potential of an 'opt-in' vulnerability register and the needs of the community.
Cross Sector Applicability	Human Services and Industry (particularly local businesses) – for community engagement and education Infrastructure – for refuge development

EMERGENCY MANAGEMENT	
High and Extreme Impact Risks Addressed	Research into improvements in emergency communication, relief and recovery will improve the emergency response services, addressing the risks presented by increased bushfire events and the increased demand on emergency services agencies.
Vulnerabilities Addressed	Communication and education strategies should be developed with a view to directly engaging the vulnerable groups identified in this report. As such, it would be expected that all such vulnerable groups would benefit from the actions. These strategies address all vulnerable groups identified including: • older people • socioeconomically disadvantaged / homeless • CaLD communities • people with a disability • children and young people • Indigenous communities • people with mental health issues • people with multiple and complex needs • those with existing illnesses • rural, urban fringe and other fire-prone communities
Triple Bottom Line Effects	The direct result of reduced injury or death should be sustained levels of social and economic capital. Environmental sustainability is not directly addressed.
Barriers to Implementation	Potential unwillingness to engage in periods devoid of immediate threat, or potential lack of engagement from particular community or cultural groups lacking strong relationships with councils.
Key Collaborators	MAV, NW Metro Emergency Management Collaboration, Emergency Victoria, community and cultural leaders, communication/engagement specialists.
Timing	Short
Owner	*Within Council* Emergency Services

7.1.3 Infrastructure

INFRASTRUCTURE (I)	
Primary Objectives	Enhance the resilience of the infrastructure network across the NAGA region to projected climatic changes.
Action Type	Research and innovation, capital works and infrastructure
Action Overview	A. Research requirements and structure of a vulnerability assessment of key council building typologies (aquatic centres, libraries, administration buildings, community hubs, etc.). B. Develop and pilot a vulnerability assessment of council buildings in a pilot project and implement the recommendations. C. Advocate for any appropriate recommendations from the vulnerability assessment. D. Develop templates for a vulnerability assessment of council buildings, to be used as a regional resource applicable to other NAGA Councils.
Cross Sector Applicability	Human Services
High and Extreme Impact Risks Addressed	Increased urban heat island, reduced quality of green assets, damage to buildings from fire
Vulnerabilities Addressed	Community infrastructure, buildings, stormwater and drainage infrastructure
Triple Bottom Line Effects	Vulnerability assessments of council assets have the potential to provide a long term return on investment through addressing potential risks that may emerge over coming years and enable timely investment to address. Council assets are also critical during climate shocks and stresses to reducing the impacts on vulnerable populations.
Barriers to Implementation	Internal resourcing within council to undertake assessments
Key Collaborators	Within council.
Timing	Short - Medium
Owner	*Within Council* Infrastructure Services, Engineering Services or similar.

INFRASTRUCTURE (II)	
Primary Objectives	Enhance the resilience of the infrastructure network across the NAGA region to projected climatic changes.
Action Type	Information and communications
Action Overview	A. Identify additional climate change data, such as flood overlays, that will support council decision making in responding to climate emergency events. B. Increase access to climate change data through ongoing engagement with relevant data stakeholders for incorporation into council decision making processes, in particular for flood data. C. Identify relevant climate change triggers that will require additional capacity building and capital works projects to respond to the climatic changes identified in data sources. D. Initiate appropriate capacity building and capital works projects to addresses the climatic changes identified in data sources in accordance with the relevant climate change triggers.
Cross Sector Applicability	**Planning** May require engagement with other sectors in order to complete vulnerability assessments and deliver infrastructure that is appropriate to their needs.
High and Extreme Impact Risks Addressed	Incorporating climate change data and vulnerability assessments into capital works programs will increase the resilience of infrastructure to risks including: • direct impacts such as damage to buildings and infrastructure, and the risk to life presented by this damage; and • the economic cost of rebuilding after damage.
Vulnerabilities Addressed	Stormwater, drainage and sewerage systems, buildings, community infrastructure. ground infrastructure
Triple Bottom Line Effects	Infrastructure improvements are likely to promote sustainable communities and economic activity. Proposed actions could reduce costs related to extreme weather disruption, and improve the safety of communities. Environmental sustainability is addressed to the extent that parks, open space and street trees are covered by capital works program.
Barriers to Implementation	Existing decision making and asset management processes may be well ingrained and difficult to change. Vulnerability assessments are likely to require a deep understanding of the nature of council and community services as well as their structures. Such an understanding may take time, leaving the action at risk of losing momentum.
Key Collaborators	Asset managers within Council and external to Council
Timing	Short
Owner	*Within Council* Infrastructure Services, Engineering Services or similar

INFRASTRUCTURE (III)	
Primary Objectives	Enhance the resilience of the infrastructure network across the NAGA region to projected climatic changes.
Action Type	Governance, Information and communications, capital works and infrastructure
Action Overview	A. Develop programs to facilitate the further development of distributed power generation throughout the community (in particular solar PV) to contribute to the reduction of peak loads and risk of outages. B. Implement programs to facilitate the further development of distributed power generation throughout the community. C. Investigate complementary peak load reduction strategies, in partnership with electricity distributors. D. Test identified complementary peak load reduction strategies, in partnership with electricity distributors. E. Increase the provision of on-site storage to provide a secondary source of power to key council infrastructure, in particular, community refuges and other sites of significance during heatwave, flood and bushfire events.
Cross Sector Applicability	Industry Planning
High and Extreme Impact Risks Addressed	Distributed energy generation increases the resilience of the power system and addresses the risk of damage to power distribution infrastructure.
Vulnerabilities Addressed	Power distribution and substations, telecommunications infrastructure
Triple Bottom Line Effects	Increased energy independence within the community can contribute to social and economic sustainability through reduced long term costs of living. This action will make indirect contributions to environmental sustainability through a reduction in NAGA's carbon footprint.
Barriers to Implementation	Capital costs required for solar PV retrofits. The capacity of the distribution grid to accommodate large local energy generation systems.
Key Collaborators	Power distribution industry stakeholders, notably solar PV retailers and installers
Timing	Short - Medium
Owner	*Within Council* Infrastructure Services, Engineering Services or similar

7.1.4 Industry

INDUSTRY (I)	
Primary Objectives	Support the capacity of industry in the NAGA region to address shocks and stresses associated with projected climatic changes.
Action Type	Capacity development, information and communications
Action Overview	A. Conduct research into information required by industries to build resilience to and recover from climactic weather events, including preparing for relevant events, assistance available from government organisations and opportunities to enhance business continuity. B. Develop a package of information for Economic Development officers within council to provide to relevant industries to build resilience and enhance business continuity. Potential information includes: flexible working hours and modified breaks (including working from home options), insurance requirements, bulk-buying of essential equipment, goods, the benefits of better building standards and design improvements to enable continued service during climate events. C. Develop communications pack for council Economic Development Officers to promote to their own businesses. Communications need to be tailored to specific industry sectors and the climate threats they are likely to face.
Cross Sector Applicability	N/A
High and Extreme Impact Risks Addressed	These actions will create resilience within the business community in terms of access to resources and improved worker conditions, addressing the key risks of: • reduced primary production and property damage due to extreme weather or bushfire events; • business closure and job loss due to business interruption; and • heat stress in employees working outdoors.
Vulnerabilities Addressed	Small businesses, outdoor workers, transport services, postal and warehousing, retail trade.
Triple Bottom Line Effects	Improved business resilience will directly affect NAGA's social and economic bottom lines, particularly post-recovery. Environmental sustainability is likely to be unaffected by these actions.
Barriers to Implementation	• Information packages may be relatively simple to establish, although slow to be taken up due to a lack of urgency and/or difficulty in changing work hours or suppliers. • Access to business stock information may be difficult or unreliable in establishing the database.

INDUSTRY (I)	
Key Collaborators	Local businesses and community groups.
Timing	Short
Owner	*Within Council* - Economic Development

INDUSTRY (II)	
Primary Objectives	Support the capacity of industry in the NAGA region to address shocks and stresses associated with projected climatic changes.
Action Type	Information and communications
Action Overview	A. Identify products and services required following a climatic event. B. Establish a regional database of local businesses that are able to supply products that a likely to required immediately following a climate event.
Cross Sector Applicability	Emergency Management
High and Extreme Impact Risks Addressed	Bushfires leading to reduced primary production, property damage/increasing insurance claims, disruption of power, transport and communication; Business closure and job loss due to business interruption from storm damage and flooding
Vulnerabilities Addressed	Small businesses, outdoor workers, retail trade.
Triple Bottom Line Effects	Improved business resilience will directly affect NAGA's social and economic bottom lines, particularly during post-recovery. Environmental sustainability is likely to be unaffected by these actions.
Barriers to Implementation	No significant barriers. This action should be recognised as a barrier reducing exercise to be conducted once the information packages are developed.
Key Collaborators	Local businesses and community groups.
Timing	Short
Owner	*Within Council* - Economic Development

7.1.5 Natural Ecosystems

NATURAL ECOSYSTEMS (I)	
Primary Objectives	Enhance the resilience of biodiversity within the NAGA region to projected climatic changes.
Action Type	Governance, research and innovation, capacity development, information and communications
Action Overview	Projected climatic changes are likely to place significant stresses on natural assets in the NAGA region, of which biodiversity has been identified as key. To enhance the resilience of biodiversity, it is proposed that NAGA should: A. Investigate current approaches to regional biodiversity mapping, being developed by individual councils, Port Phillip and Westernport Catchment Management Authority and other relevant stakeholders. B. Identify gaps in consistency between NAGA member councils on biodiversity mapping. C. Develop a regional approach to biodiversity mapping for NAGA councils.
Cross Sector Applicability	Planning
High and Extreme Impact Risks Addressed	A systematic understanding of natural assets provides the basis for monitoring the impacts of all high and extreme risks. These include: • Direct impacts such as the destruction, degradation or alteration of habitats, particularly riparian zones and waterways. • Indirect impacts such as loss of planning protection due to changing community perception, loss of environmental services for the community, and species impact of changing seasonal patterns.
Vulnerabilities Addressed	This action covers all vulnerable groups identified including: • vulnerable species, such as those with limited ability to migrate, and which are already fragmented or stressed; • ecosystems that are biodiverse and threatened, such as riparian zones, grasslands, floodplains and bushfire zones; and • significant individuals, such as large old trees.
Triple Bottom Line Effects	These actions will create clear and direct improvements to the environmental sustainability of the NAGA region. Indirect improvements to social and economic sustainability are likely to arise through improved land value, tourism, recreation, and water and air quality.
Barriers to Implementation	Changes to funding and legislation required. Cross-sectoral collaboration is necessary, creating logistical complications.

NATURAL ECOSYSTEMS (I)	
Key Collaborators	Parks Victoria, Port Phillip and Westernport Catchment Management Authority
Timing	Short - Medium
Owner	*Within Council* – Environment, Parks or similar

NATURAL ECOSYSTEMS (II)	
Primary Objectives	Enhance the resilience of biodiversity within the NAGA region to projected climatic changes.
Action Type	Research and innovation
Action Overview	Adapt the Eastern Alliance for Greenhouse Action's research to establish biodiversity data gathering protocols and a monitoring program of current natural assets to monitor change over time, for the NAGA region.
Cross Sector Applicability	Planning
High and Extreme Impact Risks Addressed	Destruction of habitat; increased threats to species with unique habitat and limited capacity to migrate; change in timing of seasonal events, such as arrival of birds and butterflies, flowering of plants, impacting on the viability of certain species
Vulnerabilities Addressed	This action covers all vulnerable groups identified including: • vulnerable species, such as those with limited ability to migrate, and which are already fragmented or stressed; • ecosystems that are biodiverse and threatened, such as riparian zones, grasslands, floodplains and bushfire zones; and • significant individuals, such as large old trees.
Triple Bottom Line Effects	These actions will create clear and direct improvements to the environmental sustainability of the NAGA region. Indirect improvements to social and economic sustainability are likely to arise through improved land value, tourism, recreation, and water and air quality.
Barriers to Implementation	Internal resourcing
Key Collaborators	Eastern Alliance for Greenhouse Action
Timing	Short - Medium
Owner	*Within Council* – Environment, Parks or similar

NATURAL ECOSYSTEMS (III)	
Primary Objectives	Enhance the resilience of biodiversity within the NAGA region to projected climatic changes.
Action Type	Education, governance, research and innovation, capacity development, information and communications
Action Overview	A. Review existing NAGA council urban greening strategies to develop a regional strategy to increasing urban greening, especially within those councils without strategies: • Identify key elements of urban greening strategies, including mitigating urban heat island effect. • Develop relationships with key stakeholders, such as academics on potential regional biodiversity climatic risks and vulnerabilities and the approach to mitigating these. • Facilitate knowledge sharing sessions on the potential regional biodiversity climatic risks and vulnerabilities. B. Investigate management, education and resilience strategies, for public conservation land and privately owned land with conservation values, to prepare for climate risks.
Cross Sector Applicability	Planning
High and Extreme Impact Risks Addressed	Increased threats to species with unique habitat and limited capacity to migrate; reduced integration of environmental assets in urban planning due to changed community perception; destruction of habitat
Vulnerabilities Addressed	This action covers all vulnerable groups identified including: • vulnerable species, such as those with limited ability to migrate, and which are already fragmented or stressed; • ecosystems that are biodiverse and threatened, such as riparian zones, grasslands, floodplains and bushfire zones; • significant individuals, such as large old trees; • grasslands; and • young trees and revegetation areas.
Triple Bottom Line Effects	There is increasing literature supporting the economic and social benefits associated with urban greening. From an economic perspective, urban forest strategies have the potential to address UHI and the associated loading on buildings and infrastructure. Increased greening in urban areas has the potential to enhance a range of health benefits associated with increased recreation and use of external areas.

NATURAL ECOSYSTEMS (III)	
Barriers to Implementation	Potential conflicts between other requirements for urban space, such as infrastructure easements.
Key Collaborators	Parks Victoria, Universities
Timing	Short - Medium
Owner	*Within Council* – Environment, Parks or similar

7.1.6 Planning

PLANNING (I)	
Primary Objective	Improve the quality and direction of planning policy and strategy to address expected climatic impacts, risks and vulnerabilities across the NAGA region.
Action Type	Legislation and regulation
Action Overview	The Victorian Planning Scheme has the potential to either address or exacerbate the projected climatic impacts, risks and vulnerabilities across the NAGA region. To improve the quality and direction and planning policy in the context of the projected climatic changes, NAGA will: A. Collate best practice examples of how other planning approaches are addressing climatic changes and protecting areas required for future adaptation and review their applicability to the NAGA region; B. Identify key stakeholders, such as the Municipal Association of Victoria (MAV), the Council Alliance for a Sustainable Built Environment (CASBE), Planning Institute of Australia (PIA), the Urban Development Institute of Australia (UDIA) and the state government, to identify roles and responsibilities in improving the ability of planning approaches to respond to climate change impacts; and C. Advocate to relevant stakeholders to undertake a comprehensive gap analysis of the current ability of the Victorian Planning Scheme and Building Code of Australia to address projected climatic changes and impacts for the NAGA region for both urban renewal and growth areas, and to protect areas required for adaptation now and in the future. For example, aligning with Urban Forest Strategies or Integrated Water Management Strategies.
Cross Sector Applicability	Infrastructure Natural Ecosystems
High and Extreme Impact Risks Addressed	The planning sector is unique in that it impacts or addresses climate change impacts and risks across all sectors, whether directly or indirectly. Refer to the high and extreme risks in each sector.
Vulnerabilities Addressed	The breadth of this sector's influence makes the classification of relevant specific vulnerabilities difficult. It is likely that all actions presented under the banner of planning will have direct or indirect impacts on the vulnerabilities within the sectors listed under 'Cross Sector Applicability'.
Triple Bottom Line Effects	Specific effects on triple bottom line sustainability are indeterminable until the details of changes to the planning scheme as revealed. However based on the findings of the management actions prioritisation workshop, it was identified that planning strategies present considerable opportunity for progression in social and environmental sustainability.
Barriers to Implementation	Practices employed under the current planning scheme too embedded to facilitate meaningful changes.

PLANNING (I)	
Key Collaborators	The *Planning and Environment Act* provides the legislative basis for amendments to the Victorian Planning Scheme. Councils can collaborate on a common methodology to make any amendments to zones and overlays. There is precedent for councils to pool resources to undertake local policy amendments that cover multiple municipalities. Stakeholders and collaborators include potentially affected land owners, developers, neighbours (residents and businesses), authorities (e.g. Melbourne Water) and non-NAGA councils.
Timing	Short term
Owner	*Within Council – Strategic and Statutory Planning*

PLANNING (II)	
Primary Objectives	Improve quality and direction of planning policy and strategy to address expected climatic impacts, risks and vulnerabilities across the NAGA region.
Action Type	Legislation and regulation, governance
Action Overview	Investigate opportunities for extending existing ESD policies / requirements to address projected climatic impacts, risks and vulnerabilities for the NAGA region, for: • Council facilities • Public realm, infrastructure and streetscapes; and • Commercial and residential buildings
Cross Sector Applicability	Infrastructure Natural Ecosystems
High and Extreme Impact Risks Addressed	The focus of this action is on addressing cross-sector impacts associated with primarily council facilities and then community residential and community developments
Vulnerabilities Addressed	The breadth of this sector's influence makes the classification of relevant specific vulnerabilities difficult. There is a particular focus on community infrastructure impacts, as identified in the Infrastructure sector
Triple Bottom Line Effects	Infrastructure improvements are likely to promote sustainable communities and economic activity. Proposed actions could reduce costs related to extreme weather disruption, and improve the safety of communities. Environmental sustainability is addressed to the extent that parks, open space and street trees are covered by capital works program.
Barriers to Implementation	Internal resourcing

PLANNING (II)	
Key Collaborators	CASBE
Timing	Short term
Owner	*Within Council* – Sustainable Design, Planning and Infrastructure

PLANNING (II)	
Primary Objectives	Improve quality and direction of planning policy and strategy to address expected climatic impacts, risks and vulnerabilities across the NAGA region.
Action Type	Capacity development, information and communications
Action Overview	Engage council planning officers across the NAGA region to build network capacity in relation to understanding the key climate change impacts, risks and vulnerability and the potential role planning practice, policy and legislation can play in reducing these.
Cross Sector Applicability	The planning sector is unique in that it impacts or addresses climate change impacts and risks across all sectors, whether directly or indirectly. Refer to the high and extreme risks in each sector.
High and Extreme Impact Risks Addressed	The breadth of this sector's influence makes the classification of relevant specific vulnerabilities difficult. It is likely that all actions presented under the banner of planning will have direct or indirect impacts on the vulnerabilities within the sectors listed under 'Cross Sector Applicability'.
Vulnerabilities Addressed	Specific effects to triple bottom line sustainability are indeterminable until the details of changes to the planning scheme as revealed, however based on the findings of the management actions prioritisation workshop, it was identified that planning strategies present considerable opportunity for progression in social and environmental sustainability.
Triple Bottom Line Effects	Infrastructure improvements are likely to promote sustainable communities and economic activity. Proposed actions could reduce costs related to extreme weather disruption, and improve the safety of communities. Environmental sustainability is addressed to the extent that parks, open space and street trees are covered by capital works program.
Barriers to Implementation	No specific barriers.
Key Collaborators	Planning Institute of Australia, Victorian Planning and Environmental Law Association.
Timing	Short term
Owner	*Within Council* – Strategic and Statutory Planning

8. CROSS SECTOR INTEGRATION

8.1 Overview

Adaptation in the North was developed using an IRVA approach that considered the NAGA region through the lens of six sectors. This has enabled a structured approach in considering the key aspects of the social, economic and environmental attributes of the region most likely to be impacted by projected climate change. Furthermore, the assessment has identified those populations, individuals, environments and objects in the region most likely to be vulnerable.

However, history has demonstrated that impacts associated with climatic events often simultaneously occur across a number of sectors. One common theme, for consideration at a regional level, is the type of climate exposure that drives impacts and vulnerabilities faced by the region.

The common climate exposures (particularly for high and extreme impacts) faced by the NAGA region are:

- ***Heatwaves*** – of particular concern in the region are the inner and middle ring municipalities, as highlighted by the locations of high-intensity UHI (Figure 35);
- ***Fire*** – it is the outer municipalities of Hume, Whittlesea Nillumbik, Manningham and to a lesser extent, Banyule that face the greatest threat from impacts associated with grassland and bushfires (Figure 21); and
- ***Flooding*** – while flash flooding can occur across the NAGA region, it is the middle ring and to a lesser extent, the inner areas, with the large expanses of impervious areas and proximity to the waterways of the Yarra Catchment, that are at greatest risk from flooding impacts (Figure 22).

8.2 Opportunity for addressing cross sector impacts and vulnerabilities

At a regional level, there are opportunities for addressing cross sector impacts and vulnerabilities through coordinated action based on commonalities in climate exposures. These opportunities are:

Cross-sector strategies that focus on minimising the extent or magnitude of an exposure event

For example, an urban forest strategy that reduces the urban heat island effect for a particular area can also address the impacts across the sectors of infrastructure, human services, industry and emergency management. The implementation of this strategy helps to reduce the magnitude of surface and air warming associated with a heatwave event. Therefore, actions based around particular climate exposures should be primarily focused, where practicable, on minimising the extent or magnitude of the exposure event.

Actions related to infrastructure have multiple benefits to other sectors

The promotion of actions that may not specifically address a climate exposure event, but build resilience in aspects of the region are integral to the region's response during climatic shocks and stresses. Actions that perform this role will often have benefits in addressing multiple impacts beyond one specific sector and often stem from where there are dependencies between the sectors.

From the workshop process it was evident that actions associated with the infrastructure sector provides a key opportunity for having multiple benefits to other sectors during climate events. For example, the role of essential services infrastructure is particularly important. An uninterrupted power supply is critical for minimising impacts under a range of during climatic shocks and stresses.

Actions focussed on addressing the vulnerabilities of individuals or human populations

Another opportunity for cross sector integration is through coordination action at a regional level on the key vulnerabilities within the NAGA region. Across the sectors, it is those who are least able to cope who are most likely to be affected by climatic change. With the exception of the natural ecosystems sector, these vulnerabilities are directly or indirectly focused on people who have the least capacity to respond to the impacts and risks of climate change.

There is an opportunity at a regional level to have an integrated approach focused on specific individual or population vulnerabilities; in particular those identified in the VCOSS report *Disaster and disadvantage: Social vulnerability in emergency*.

9. CAPACITY BUILDING AND GOVERNANCE

Development of *Adaptation in the North* has involved officers from across all areas of NAGA councils and MEFL. For many participants, this process has been the first opportunity to actively consider the climate change implications on the services they provide to the community and to the region more broadly. It has also been identified that there is a significant body of work and activity already occurring in addressing impacts, risks and vulnerabilities across the region.

This collaborative and regional process has been a strength of the development of *Adaptation in the North*. It has provided a cause for reflection on the role of NAGA and its future role in implementing actions across six sectors, through this reflection it has been recognised that each sector has its own networks and challenges, regardless of the additional considerations that climate change provides. The key role NAGA can play in implementing the plan is to:

- **Manage the implementation and further development** of *Adaptation in the North* including the investigation of using an adaptation pathways approach;
- Be the **central advocacy voice for action** to address regional impacts, risks and vulnerabilities;
- Provide a **primary mechanism for coordinating cross sector actions** across common climate exposure, vulnerability or action themes;
- Convene **regional engagement** for NAGA councils on the implications and response to climate change for each sector;
- Investigate the **development of indicators** to evaluate the success of *Adaptation in the North*;
- **Build capacity within the region** for addressing the identified climatic impacts, risks and vulnerabilities; and
- Initiate and participate in **further investigations and research** with relevant collaborators into the climatic impacts, risks and vulnerabilities and appropriate responses, including development of the adaptation pathways approach.

In order to fulfil the above responsibilities and implement *Adaptation in the North*, NAGA will develop a work plan setting out its key activities for the identified management actions as well as supportive work to ensure the successful delivery of the plan. This will provide further granularity in relation to the timing of the actions identified in the short terms and its approach to advocacy and communications.

In developing this plan it is recognised that NAGA member councils are all at different stages considering and implementing appropriate responses to the potential shocks and stresses associated with climate change. Councils can be broadly grouped into one of three categories:

- A council specific climate change adaptation strategy has been developed and council is in the process of implementing;
- Council is in the process of developing its climate change adaptation strategy; or
- Council is yet to develop a climate change adaptation strategy.

For those councils that are yet to develop or are developing a climate change adaptation strategy, *Adaptation in the North* is intended to provide a key resource from which to guide and inform the development of a council specific document. For those councils already with their own plan, the intention is that they will be able to use the actions and direction within the *Adaptation in the North* to both assist in the implementation of their plan and provide a mechanism by which they can share their experiences and learnings across the NAGA region.

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