Towards a Resilient Sydney Adaptation Review Paper

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1 Introduction

This adaptation review paper was compiled as part of the Towards a Resilient Sydney Project. It was completed in February 2012 and reviewed in August 2014 to reflect administrative changes and update case study information where appropriate.

Towards a Resilient Sydney is a cross-government initiative to assess Sydney's climate change vulnerability and the expected impacts of climate change on key government service sectors, and make recommendations for a coordinated approach to increase Sydney's resilience to climate change. It was led by the Office of Environment and Heritage (OEH) in partnership with the NSW Department of Planning and Infrastructure (DP&I), the NSW Environment Protection Authority (EPA), the Sydney Coastal Councils Group (SCCG); and the Western Sydney Regional Organisation of Councils (WSROC).

1.1 Climate change adaptation

According to the Intergovernmental Panel on Climate Change (IPCC 2001), climate change adaptation refers to adjustment in natural or human systems in response to actual or expected climatic conditions in order to minimise harm or enhance beneficial opportunities. It is becoming widely accepted that a certain amount of climate change is now inevitable, and that adaptation is needed in order to cope with the changes this will bring (IPCC 2007). It is important to note that adaptation is an ongoing process with no set end point, and it will take time to quantify both the risks of climate change impacts and to build the capacity to minimise costs (DCCEE 2007).

Some key terms relating to climate change adaptation are:

- adaptive capacity: the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC 2001)
- resilience: the amount of change a system can undergo without changing state (IPCC 2001)
- 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 2014)
- risk: the potential for consequences where something of value is at stake and where the outcome is uncertain, recognising the diversity of values (IPCC 2014).

2 Purpose of the review paper

The purpose of this review paper is to provide an overview of existing work on climate change adaptation which is relevant to the Sydney Metropolitan Area. The review paper is the first deliverable of the Towards a Resilient Sydney Project, providing an overview of global examples of city adaptation planning. Specifically the paper's purpose is to:

- determine current understanding of best practice for adaptation planning and implementation
- provide reference material and guidance during the development of Towards a Resilient Sydney.

Section 3 provides an overview of climate change and cities and the relevant theme areas for city adaptation planning

Section 4 gives an overview of government frameworks and context for adaptation planning, which are relevant to Sydney.

Section 5 undertakes a brief review of adaptation strategies and plans at a country, city and local government scale, which may be relevant to Sydney.

Section 6 reviews the current status of adaptation planning activities in Sydney and provides an overview of adaptation planning frameworks.

Section 7 outlines best practice for adaptation planning and implementation.

3 Climate change and cities

As areas of highly concentrated populations and complex infrastructure systems, cities face significant challenges from a changing climate (Matthews 2011). Cities are most vulnerable to the impacts of extreme weather events (IPCC 2007), however, they are also vulnerable to impacts of gradual climate change, especially as changes approach thresholds beyond which the change is unmanageable (WRI 2011, IPCC 2007). Cities also face additional challenges due to high rates of population increase, putting pressure on existing infrastructure and services even in the absence of climate change impacts (Matthews 2011).

The vulnerability of cities to climate change depends significantly on geographic, social and individual sector contexts. The interaction of a changing climate with non-climate drivers must be considered in assessing the vulnerability and potential responses to climate change (IPCC 2007). Another aspect of cities which must be considered is that they rely to a large extent on inputs from outside the city itself, for example food, water and energy (Hammer et al. 2011). This means that to truly estimate the impacts of climate change on a given city, impacts outside the city boundary must be considered.

The IPCC (2014) identifies key risks to cities from climate change impacts:

1 risk of severe ill-health and disrupted livelihoods for large urban populations due to inland flooding

2 risk of mortality and morbidity during periods of extreme heat, particularly for vulnerable urban populations and those working outdoors

3 systemic risk of extreme events leading to a breakdown of infrastructure networks and critical services like water, electricity, health and emergency services

4 risk of food insecurity and breakdown of food systems (while most food production is in rural areas this will affect cities that rely on these areas for food)

5 increased migration by rural populations affected by extreme weather, scarce resources, health status, or changed economic conditions.

The extent to which a city is affected by climate change depends on a wide range of variables. The IPCC (2007) has identified that some cities are more vulnerable than others, for example cities in high-risk locations, such as coastal or riverine cities, or cities that have economies highly dependent upon climate-sensitive resources such as agriculture, forestry, water-intensive industries or tourism. However, the IPCC (2014) has identified that settlements often have high potential for adaptation if given access to financial and other resources, as well as the competence and capacity of a range of individuals and organisations. The IPCC (2007) also noted the importance of supporting locally specific adaptation measures through linkages with national and global systems.

More detailed information about the potential impacts of climate change on cities, and on Sydney in particular, is given in Appendix 1. This appendix provides an overview of the five themes identified in Towards a Resilient Sydney:

- built environment and infrastructure
- natural and cultural assets
- economy and industry
- human health and emergency management
- settlements and communities.

It should be noted that there are synergies between these themes, and action in one area often affects some or all of the others.

4 Adaptation context in Sydney

Sydney is subject to a range of governance mechanisms, including national, state and local government. In addition, there are existing policies and programs in place which could be used to leverage adaptation action. In Sydney, climate change adaptation work will be affected by Australian Government policies and legislation, NSW Government policies, legislation and programs and local government policies and actions. The key initiatives and policies at the national and state levels of government are outlined in detail in Appendix 2. Adaptation work undertaken by local government in Sydney, and the enabling mechanisms in place are outlined in Appendix 3. This multi-layered context will be considered in the course of the Towards a Resilient Sydney Project.

5 Review of existing adaptation strategies and plans

This section provides an overview of adaptation plans developed for different levels of government as well as applying to particular organisations, or specific sectors, both within Australia and internationally. Plans of similar scope have been grouped together in order to extract common themes, common action types, key characteristics and to highlight leading practice.

5.1 Adaptation at a range of scales and focus areas

It is not possible for government (at any level) to step in and 'solve' the problem of climate change. The range, scale and uncertainty of climate change impacts require a flexible and dynamic response by both government and private parties. The constitutional principle of subsidiarity in Australia's federal system of government ensures that decision-making remains responsive to the needs of its community; those responsible for managing their own risks will usually be best placed to do so.

In 2012 the Council of Australian Governments agreed roles and responsibilities for each tier of government in relation to climate change adaptation.

The Australian Government is responsible for responding to impacts that may affect national prosperity or security. In some cases this will require targeted action, for example in managing natural assets such as Kakadu National Park or the Great Barrier Reef. State governments are responsible for assessing local science and impact information, managing their own assets and services appropriately, creating a regulatory and policy space that promotes private adaptation, and supporting communities and businesses in adaptation. Local governments are responsible for ensuring policies and regulations under their jurisdiction incorporate climate change considerations consistent with other government approaches, managing impacts to their assets and services, and building resilience and adaptive capacity in the local community (COAG 2012).

Governments are not the only organisations preparing and implementing adaptation plans. Private sector industry groups and non-government organisations (NGOs) are also involved. This section of the paper outlines the key findings from plans prepared by different types of organisations, both government and non-government based, and discusses the challenges and opportunities for different parties to work together on adaptation implementation.

City scale

A variety of plans have been developed for implementation at a city level. This review examined cities which have developed climate change adaptation plans with the aim of finding examples analogous to Sydney. Table 1 outlines the various city plans which were examined. More detail on the content of these plans is available in Appendix 4.

Table 1: City-level climate change adaptation plans

City	Country	Plan name	Developed
Boston	US	A Climate of Progress – City of Boston Climate Action Plan Update 2011	April 2011
Cape Town	South Africa	Framework for Adaptation to Climate Change in the City of Cape Town	August 2006
Copenhagen	Denmark	Copenhagen Climate Adaptation Plan	October 2011
London	UK	Managing Risks and Increasing Resilience – the Mayor's Climate Change Adaptation Strategy (The London Climate Change Adaptation Strategy)	October 2011
New York	US	PlaNYC* (updated version)	April 2011
Toronto	Canada	Ahead of the Storm … Preparing Toronto for Climate Change – Development of a Climate Change Adaptation Strategy	April 2008

*This is not solely a climate change adaptation plan, but a holistic city plan containing adaptation actions.

Throughout this research it has become evident that Towards a Resilient Sydney will be unique in that it covers a city which is comprised of multiple municipalities. This presents challenges and opportunities for the development and implementation of an adaptation strategy. London operates in a similar way with a variety of boroughs operating within the city (ICLEI 2011). Sydney's planners could benefit from the experiences of the developers of the London strategy.

States and regional scale

Adaptation plans have also been developed at a state or regional level. These plans are of relevance to the development of Towards a Resilient Sydney because they incorporate a number of jurisdictions, and examine broader impacts and influences on climate change effects and adaptive capacities.

Table 2 lists the adaptation plans for states and regions that were examined in this review.

Table 2: Climate change adaptation plans at a state or regional scale

State/region	Country	Plan name	Developed
Queensland	Australia	Climate Change: Adaptation for Queensland – Issues Paper	2011
California	US	2009 California Climate Adaptation Strategy	2009
Massachusetts	US	Massachusetts Climate Change Adaptation Report	2011
South Australia	Australia	Prospering in a Changing Climate: a Draft Climate Change Adaptation Framework for South Australia. Draft for Community Consultation.	2010

South East Queensland	Australia	South East Queensland Climate Change Management Plan: Draft for Public Consultation	2009

Local government scale

A number of local or municipal governments have developed or are in the process of developing adaptation plans. Local governments have a clear role to play in climate change adaptation, both as the authority responsible for local planning approvals and zoning regulations, as well as the level of government with the closest ties to its constituents. Local government plans tend to comprise more specific, 'on-the-ground' actions in conjunction with education and engagement actions. Appendix 3 provides more detail on local government plans in Sydney.

Table 3 lists the plans from local governments in Australia that were examined to inform this paper.

Table 3: Local government climate change adaptation plans

Council	Plan name	Developed	In Sydney?
Melbourne City Council	City of Melbourne Climate Change Adaptation Strategy	June 2009	No, in Victoria
Byron Shire Council	Byron Shire Council Policy No. 14/006: Climate Change Strategic Planning Policy	November 2009	No, northern NSW
Hornsby Shire Council	Climate Change Adaptation Strategic Plan – Hornsby Shire Council	May 2009	Yes
Ku-ring-gai Council	Draft Climate Change Adaptation Strategy – Ku-ring-gai Council	Not specified	Yes
Manly Council	Climate Change Actions for Manly LGA: 2008–2038	April 2008	Yes
Parramatta City Council	Parramatta City Council – Climate Extremes Risk Assessment and Adaptation Plan	November 2010	Yes
Sydney City Council	Sydney 2030	June 2008	Yes

Organisation- and theme-specific plans and strategies

This section outlines a range of plans or suggested policy frameworks specific to a given theme, organisation or area.

Infrastructure

- Sydney Water and Water Services Association of Australia (WSAA) have developed the 'Adapt Water' decision support tool which can provide sophisticated cost-benefit analyses of adaptive responses across its asset base. The tool can quantify and project the probability of damage and failure of assets by existing and future hazards, and assess and compare adaptation options.

- UK Department for Environment, Food and Rural Affairs (DEFRA) has developed an infrastructure report outlining the challenges to information and communications technology (ICT), transport, energy and water sectors in adapting to climate change. It outlines the actions which are needed from the many players in the infrastructure sector, including owners and operators, regulators, insurers and government agencies (DEFRA 2011).
- New York City's Department of Environmental Protection released an assessment of climate change impacts and an action plan focused on water infrastructure. The plan covers water supply, water drainage and wastewater infrastructure.

Settlements and communities

- The National Climate Change Adaptation Research Facility (NCCARF) released a position paper about framing national climate change adaptation policy for the built environment.

Economy and industry

- A national climate change framework has been developed for the tourism industry, called Tourism and Climate Change – A Framework for Action (Department of Resources, Energy and Tourism 2008). This framework highlights the impacts of climate change on tourism, and suggests high-level actions to improve resilience, such as improving knowledge of potential impacts and increasing effectiveness of communication and public engagement strategies.

Government

- In the US, Federal agencies were required to prepare agency-specific climate change adaptation plans by June 2012 to be implemented in financial year 2013. This was the substance of an Executive Order aimed at providing federal leadership in environmental, energy and economic performance (Executive Order 13514).

Coastal zone

- In 2010 the Hunter and Central Coast Regional Environmental Management Strategy (HCCREMS) commissioned an adaptation plan for coastal councils. This plan examines the risks to coastal councils in this area as a consequence of climate change, and suggests a series of actions in response.
- Mandurah Council in Western Australia has developed a climate change adaptation plan specific to the coastal zone.

5.2 Common characteristics in adaptation plans

Key characteristics emerge throughout the development and implementation of adaptation strategies across all focus levels and jurisdictions. These characteristics are listed in Table 4.

Table 4: Key characteristics common to adaptation strategies

Key characteristic
Incorporates a climate change impact assessment
Adopts a risk management approach
Based on a firm scientific foundation
Adopts a flexible pathways approach to avoid maladaptation
Includes criteria/principles for prioritising actions
Has strong governance structures including expert panels
Incorporates a stakeholder engagement plan
Includes tools and guidelines for capacity building
Outlines a monitoring and evaluation methodology
Establishes ongoing responsibilities and funding to ensure long term commitment
Combines a long-term list of broad actions with shorter timeframe goals which are reviewed regularly

Common climate change impacts in plans

There are many climate change impacts outlined in adaptation plans. Although the most pressing impacts vary geographically, a large number of impacts are mentioned in most plans. Climate change impacts are often intertwined, with one impact causing or exacerbating other impacts. The impacts of climate change are further complicated because they are not happening in isolation, and can be mitigated or exacerbated by other non-climate trends, for example ageing infrastructure, population growth or increasing urbanisation of previously green spaces.

As well as common types of impacts appearing in plans, there are common themes which are repeated across plans to address these impacts. These have the potential to provide a valuable foundation when preparing the adaptation plan for Sydney. Some of the key impacts and common responses are outlined in Table 5.

A major problem across adaptation plans is the lack of clarity in the language used. Because climate change impacts and their flow-on effects are often cross-sectoral, and affected by a variety of drivers, it is challenging to summarise them effectively and clearly without being repetitive. Clarity of language should be an area of focus for Towards a Resilient Sydney.

Table 5: Climate change impacts identified in various adaptation plans

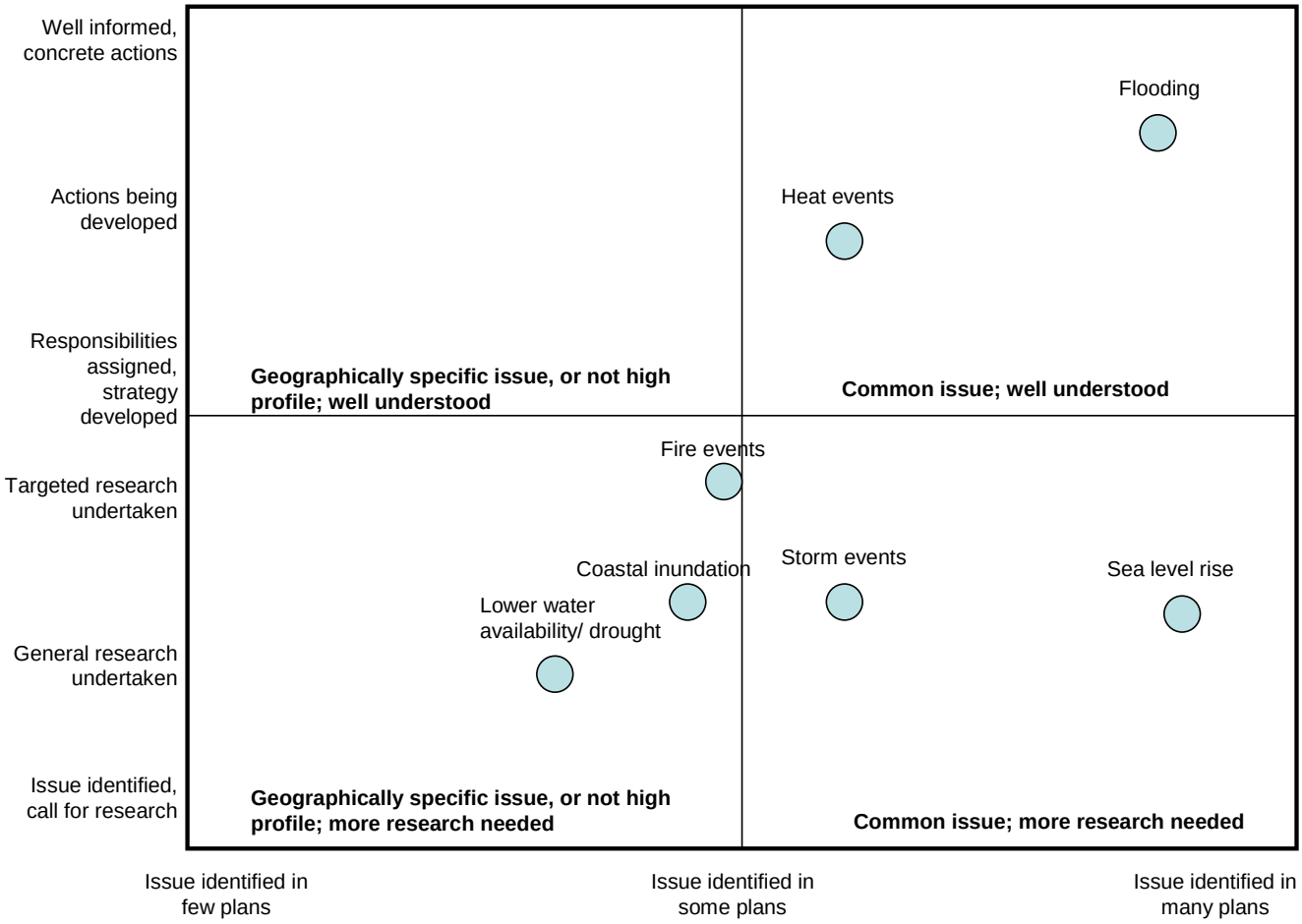
Drivers (climate and non-climate)	Direct impact	Indirect impacts	Key adaptation responses from plans
Increased extreme rainfall events; increased impermeable surfaces as a result of urbanisation; ageing/inadequate infrastructure	**Flooding**	Transport disruptions; injuries/deaths; property damage; contamination of waterways; ecosystem pressures	• Improve understanding of current and future flood risk • Reduce flood risk to the most vulnerable communities and most critical assets • Raise public awareness of flooding and capacity of both individuals and communities to respond
Increased extreme rainfall and storm events; removal of natural coastal buffer systems	**Coastal inundation**	Loss of property; injuries/death	• Identify risk areas, emphasising key infrastructure • Improve planning processes for future developments in risk areas • Create an early warning system and evacuation procedure • Integrate emergency responses • Improve resilience and protection of exposed infrastructure and low-lying developments
Increased temperatures; altered rainfall regime	**Increased bushfire frequency and intensity**	Changing ecology; injuries/death; property damage	• Identify high-risk areas • Create an early warning system and evacuation procedures • Integrate emergency responses • Educate and engage with the community • Research the impacts of altered fire management
Increased global temperatures resulting in oceanic expansion and melting of ice caps	**Sea level rise**	Loss of property; loss of estuarine and coastal ecology; displacement of people	• Improve planning processes, incorporating contingencies or restricting development in high-risk areas • Improve protection for existing low-lying developments
Increased temperatures; increased number of hot days; urban heat island effect	**Heat waves**	Human health impacts, both physical and mental; disruption of transport systems; impacts to infrastructure, especially energy supply	• Identify high-risk areas and community groups • Increase passive cooling through design and infrastructure changes, and increase public green space • Improve public understanding and encourage safe behaviours • Develop early warning systems for heat events • Develop strong response plans

Drivers (climate and non-climate)	Direct impact	Indirect impacts	Key adaptation responses from plans
Altered rainfall regime; increased average temperature	**Lower water availability/ drought**	Human health impacts; impacts on industry; impacts on agriculture and food security; lower water quality; ecological impacts	• Reduce water demand / increase water efficiency • Take a strategic view on water resources / diversify water supply • Improve responses to drought events
Altered rainfall regime; changing wind patterns; increased average temperature	**Increased storm events**	Injuries/death; loss of property; damage to infrastructure	• Improve drainage and stormwater capture • Develop early warning systems • Integrate emergency responses • Improve public knowledge and safe behaviour • Minimise debris potential • Improve infrastructure standards
Increased temperatures; atmospheric inversions; emissions of particulates and other pollutants	**Poorer air quality**	Health impacts; amenity and comfort	• Improve tracking and monitoring of climate change and air quality indicators • Address non-climate stressors • Encourage safe behaviours during poor air quality periods • Identify and locate vulnerable populations • Develop targeted preparedness and response plans • Maximise green space and green design options

The review of existing plans also revealed there are certain climate change impacts which are taking prominence in adaptation plans. These tend to be the areas in which the science is better understood, and in which governments have previously played a role. For example, many plans address the issue of flooding quite comprehensively because this is an area in which governments have a great deal of expertise, and the mechanics of flooding are well understood.

Figure 1 outlines the extent to which potential climate change impacts are mentioned in adaptation plans and strategies, as well as the level of action being taken.

Figure 1: Summary of key impacts outlined in adaptation plans, and level of action taken to address impacts



Action types

Adaptation plans and strategies also contain a wide range of actions. These actions are often grouped together to increase understanding, but the methods for doing this are inconsistent. For example, the City of Melbourne Climate Change Adaptation Strategy groups actions into loss prevention, loss sharing, behaviour modification and relocation (City of Melbourne 2009) while Smith et al. (2008a) use the categories ‘know your enemy’, ‘plan for change’, ‘get smart’, ‘act, watch and learn’, ‘put the house in order’, and ‘money talks’.

In this paper, the adaptation actions have been grouped into six categories: capacity building, engagement, knowledge, procedure, regulation, behavioural change, strategy and structure. Definitions and examples of these categories are outlined in Table 6.

Table 6: Common actions in adaptation plans by category

Action category	Description	Examples
Capacity building	Action aimed at increasing the ability of others to adapt to climate change impacts	Funding of adaptation measures, education programs, financing of risk assessments, dissemination of research

Action category	Description	Examples
Engagement	Active building of relationships and networks to provide better adaptation solutions	Cross-jurisdictional government groups, engagement with industry associations, use of technical experts in development of plans
Knowledge	Research into both the impacts of climate change and the best ways to minimise adverse effects	Climate change risk assessments, research into tipping points, research into the social impacts of proposed adaptation measures, sector-specific impacts
Procedure	Changes to existing procedures to enhance adaptation	Changes to impact monitoring procedures, early warning systems, training protocols
Regulation	Developing new regulations, or altering existing regulations in order to adapt to climate change	Revisions to building codes, changes to planning instruments
Behavioural change	Actions aimed at providing or encouraging alternatives to traditional behaviours or activities	Relocating activities to new areas, promoting alternatives to current behaviours which will be less subject to climate change impacts
Strategy	Actions aimed at improving strategic functions and good governance	Prioritising key actions or sectors, appointment of expert panels to provide input, creation of steering committees, monitoring and evaluation protocols (at a whole-of-strategy level)
Structure	Actions where something is physically changed	Engineering solutions, physical structures, landscaping programs, new infrastructure

More detail about adaptation actions is given in Appendix 4.

High-value adaptation actions

Many plans also identify ‘high-value’ adaptation actions: those actions which have broader positive co-benefits. These actions can be:

- actions which address more than one type of climate impact; for example, increased stormwater harvesting and re-use results in a diversified water supply, increasing drought resilience and decreasing dependence on large water infrastructure, and reduces the likelihood of flash flooding in major rainfall events.
- actions which have outcomes for mitigation as well as adaptation; for example, passive cooling technologies reduce the effects of heat waves on human health and amenity, while simultaneously reducing the energy demand of buildings, and therefore the greenhouse gas emissions associated with energy production. These types of high value actions are particularly emphasised throughout the Adaptation Report for Massachusetts (Massachusetts Executive Office of Energy and Environmental Affairs 2011).
- actions which address other, non-climate related problems; for example, an increase in tree cover in urban areas reduces the urban heat island effect which exacerbates the

impacts of climate change, and simultaneously improves the amenity and beauty of a city. Similarly, actions which enhance the ability of emergency services agencies to predict and respond to emergencies will have benefits for non-climate related emergencies as well.

- actions which can be undertaken immediately; these can allow for work to begin and momentum to build while the necessary long-term planning is taking place. For example, the City of Toronto began by identifying actions which could be implemented in the short term, which did not require lengthy research, and which were possible to implement under existing city activities. A budget was assigned to these actions immediately, and implementation began while long-term planning and research into more comprehensive actions was started (Toronto Environment Office 2008).

6 Adaptation planning

This section reviews existing guidelines and toolkits for climate change adaptation, as well as examining research into adaptation decision-making. It explores methodologies and frameworks for decision-making around climate change adaptation, and identifies some key challenges generally, in particular for local government.

Because climate change adaptation is a relatively new area, the decision-making processes are not yet well entrenched and best practice is still being established. Due to the fact that the impacts of climate change will affect so many issues, the decision-making framework needs to take an integrated, holistic view and provide clear and transparent outputs.

Research into decision-making in an adaptation context has been undertaken before. Globally, although adaptation decision-making frameworks have different details, they all have some methods in common – namely three broad actions: initial risk screening, detailed risk assessment and assessment of risk management options (UNDP 2011). The Australian Government funded several studies into adaptation decision-making in coastal areas under the Coastal Adaptation Decision Pathways project, which concluded in June 2012.

6.1 Review of existing guidelines and toolkits

There are a range of toolkits and guidelines on how to develop adaptation plans and strategies. These documents have been developed by various organisations, including governments and non-governmental organisations. Table 7 lists some of the existing toolkits and guidelines examined in this review.

Table 7: Existing adaptation toolkits and guidelines

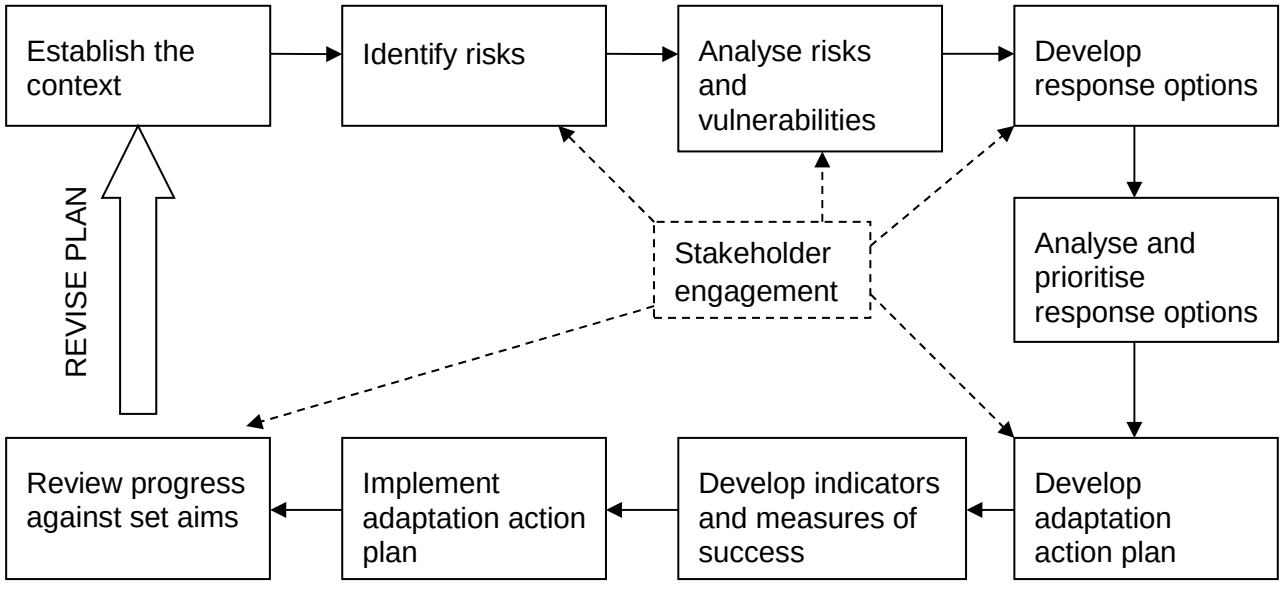
Organisation	Name of guideline/toolkit	Intended audience	Year published
ICLEI	Local Government Climate Change Adaptation Toolkit	Local government	2008
Australian Government	Climate Change Adaptation Actions for Local Government	Local government	2010
New York City Panel on Climate Change	Adaptation Assessment Guidebook	Various stakeholders	2010

Organisation	Name of guideline/toolkit	Intended audience	Year published
UK	Climate Change Adaptation by Design: a Guide for Sustainable Communities	Planners, designers and developers	2007
ICLEI	Adapting Urban Water Systems to Climate Change – a handbook for decision makers at the local level	Local water system authorities	2011
LGSA	Planning for Climate Change – A Local Government Workshop Package	Local government	2007
Australian Government	National Climate Change Adaptation Framework	Various stakeholders	2007
OEH NSW	Guide to Climate Change Risk Assessment for NSW Local Government	Local government	2011
Australian Institute of Landscape Architects (AILA)	Climate Adaptation Tools for Sustainable Settlements	Various stakeholders	2010

6.2 Methodologies and frameworks

A common framework recommended in guidelines is an adaptive management framework, where the emphasis is on using a risk management approach combined with a strong monitoring and review protocol, with the success of implemented actions informing future actions. It must be remembered that adaptation is not an end point, but is an ongoing process responding both to changes in scientific information and to the success of actions undertaken. The following diagram summarises this approach:

Figure 2: Adaptive management framework for adaptation planning



An effective framework will be supplemented by protocols for different steps, for example a defined risk assessment process, a defined means of prioritising response options, and a clear review process. Adaptation planning should also encompass a strong stakeholder engagement plan to ensure the needs and values of stakeholders are captured in the planning process. More detail about each of these requirements is given in Appendix 5.

6.3 Challenges to effective adaptation planning and implementation

The toolkits and guidelines note common challenges to effective planning and implementation of city adaptation planning, including:

- the difficulties in choosing an appropriate climate scenario
- the timescales and inherent uncertainties in the process
- the time and challenges involved in effective stakeholder engagement
- cooperating across disciplines, scales and functional area responsibilities
- the long-term perspective of management, inconsistent with political cycles.

The International Council for Local Environmental Initiatives (ICLEI – Local Governments for Sustainability) states that a key challenge for decision-makers is choosing an appropriate climate change impact scenario to develop climate change projections (ICLEI 2008). This is a challenge that can be extended to decision-makers at all levels of government and in non-government sectors. This can be remedied by a recognised authority promoting the use of a given scenario for adaptation planning purposes (ICLEI 2008). For example, OEH is producing high-resolution climate change projections which can be shared with multiple agencies and local governments.

Adaptation is a long-term process with significant uncertainties involved, making it difficult to identify and point out successes, especially early in the process (ICLEI 2011). This means that adaptation planning and implementation processes can lose momentum, or fail to make clear the urgency of action. This can potentially be avoided by focusing on short-term ‘easy’ wins, while simultaneously developing and implementing long-term actions.

Due to the interdisciplinary nature of both climate change impacts and adaptation actions, a wide range of stakeholders need to be consulted in the planning and implementation process (Gardner et al. 2009). However, it is often difficult to identify all relevant stakeholders, and achieve real and productive engagement with them (ICLEI 2011). This difficulty should be acknowledged, and best practice stakeholder engagement should be examined and used to inform adaptation planning processes. If practical, there should also be a role for stakeholders to play in the monitoring and review process, potentially allowing for input from stakeholders who were not involved in the initial planning stages (NYPCC 2010).

Because climate change adaptation requires interdisciplinary and cross-jurisdictional expertise and actions, a number of organisations need to be involved. This can prove challenging (ICLEI 2011), particularly when certain organisations are obstructionist, or have a complex relationship with historical disputes. In order to enhance cooperation in this area, comprehensive mapping of responsibilities and accountabilities is recommended, along with open and frequent communication between project partners in order to identify any problems early in the process (ALIA 2010).

Sydney is a complex metropolitan area which currently lacks a city-wide body for coordinating the response to climate change (Miranda et al. 2011), and challenges are exacerbated by having 41 local councils within the metro area all at different stages of understanding and implementing climate change mitigation and adaptation. In addition, some infrastructure in Sydney is the responsibility of the NSW Government, some is managed through State-owned corporations, and the Australian Government also has some jurisdiction in terms of legislation. Miranda et al. (2011) state that collaboration is needed between all stakeholders, including all levels of government, businesses, academics, education providers and the community in order to devise a suite of metropolitan and local strategies.

The impacts of climate change and the adaptation actions needed to moderate them are long-term phenomena, requiring long-term thought, planning and action. However, due to political cycles, government and communities have tended to favour short-term and responsive approaches, which can make adaptation more difficult to initiate (Stanley et al. 2013D)An adaptation plan needs to be able to combine short-term results with a long-term vision in order to be effective.

The international and national economic conditions may also impact on governments responding to climate change. During economic downturns resources are potentially less available for adaptation actions than they might previously have been. More broadly, when viewed as 'environmental', climate change issues receive less priority than economic concerns. It is possible that framing climate change adaptation in a risk management, economic framework could overcome these obstacles.

7 Best practice for adaptation planning and implementation

This section is a summary of best practice points extracted from the adaptation plans, guidelines and toolkits discussed above. This selection of common approaches from leading urban adaptation initiatives has been compiled into a checklist for best practice adaptation planning, available at www.climatechange.environment.nsw.gov.au/Adapting-to-climate-change/Local-government

7.1 Governance

Political support

An effective adaptation planning and implementation program requires strong political support. This is a relatively new area which requires strong leadership and long-term commitment to the end goal. Political support is needed at a local government, State government and national level in order for the best possible climate change adaptation to be undertaken.

An internal coordination unit

Due to the cross-sectoral nature of climate change adaptation planning and implementation, a wide variety of stakeholders need to be involved from the public, private and community spheres. In order to get the best possible outcomes from this range of stakeholders, an internal coordination unit is necessary to spearhead the project. This will allow for

comprehensive project planning, a coherent approach across sectors, a reduced chance of maladaptation, and a 'one-stop shop' for adaptation information and input.

Mapping of responsibility and defined areas of existing action

Much of the action required to adapt effectively to the impacts of climate change comprises actions already undertaken by different levels of government and private sector and community organisations, but it needs to be based on new inputs of climate parameters. For example, engineers already plan for flood events; they will need to reassess the regularity and magnitude of these events. Consequently the most effective adaptation planning will benefit from mapping existing activities and responsibilities and leveraging existing expertise to design and implement adaptation actions. Mapping areas of responsibility will also provide clarity about organisational structures and assist in responding to climate change-related events rapidly and effectively. Defined responsibilities will also aid the creation of focused working groups which can share knowledge and avoid duplication of work and funding.

Allocated funds, responsibilities and time frames

Climate change adaptation is a long-term process requiring long-term commitment. In order to ensure that adaptation actions can be planned and carried out over these time frames it is essential to have designated resources, both financial and human, allocated to adaptation. Allocated resources also build momentum and show commitment to the process. In addition to ongoing funding, a discretionary fund is recommended for securing necessary information, for example for undertaking research into impacts or the effectiveness of given actions.

Due to the interdisciplinary nature of both climate change impacts and the required adaptation actions, the responsibility for each aspect of an adaptation plan needs to be formally and clearly allocated. This avoids issues being neglected and also avoids duplication where more than one organisation has responsibility for a given issue. It is essential to assign lead organisations for each action in the plan, as well as providing potential for other organisations to provide input.

7.2 Adaptation planning

Scientific foundation

For any climate change adaptation plan to be credible it must be based on a solid scientific foundation. The expected impacts of climate change must be derived scientifically, and the methodology should be made public in order to ensure rigour and validity. Adaptation actions should similarly be based on scientific research, and where possible have proven effectiveness. Where actions are innovative they should be implemented in a scientific manner to assess their effectiveness, for example a pilot project with the potential to be scaled up should it prove effective.

Accepting, working with and communicating uncertainty

Uncertainties are an inherent part of climate change modelling and impact assessments, so will not be fully resolved in time for effective adaptation (ICLEI 2008). Organisations working in the adaptation arena need to be prepared to act with an unacceptable amount of uncertainty about the impacts of climate change. Organisations also need to be able to

implement a structured process in which they can act with some uncertainty about the impacts of their actions (ICLEI 2008). A strong and transparent risk management framework can assist with this, but organisations also need to become proficient at communicating issues related to uncertainty.

Clearly articulated aims

To be effective, an adaptation plan must outline its purpose and aims. Climate change adaptation is an emerging field so understanding of the desired outcomes of an adaptation plan may not be comprehensive. Without having clear aims it is not possible to create actions to achieve them, nor to measure progress and success.

Balancing immediate and long-term needs

Climate change presents both immediate and long-term challenges. There is a pressing need to be able to address immediate challenges without compromising the ability to address long-term challenges. It is often difficult in a political framework to examine issues arising in the long term. Funding cycles and decision-making frameworks are generally seen as focused on the immediate future, making it difficult to prioritise long-term considerations. However, climate change presents problems which are occurring now, but the impacts of which will not be truly felt until a way into the future. Good adaptation practice strives to address both the immediate and the long-term needs.

Clear risk management approach to assessing impacts

Using a risk management approach allows decision-makers to create a transparent framework for assessing the importance and probability of climate change impacts resulting from the scientific projections. This allows for decisions to be made in a methodical and somewhat objective manner, and provides a means for justifying decisions after the fact. A risk management approach also allows for flexibility, being able to be revised in response to new information or changes in risk level following effective implementation of adaptation actions.

Clear methodology for prioritising actions

Given the magnitude of issues involved in climate change adaptation planning it is likely that a large number of actions will be formulated and suggested for implementation. However, it is not possible to implement all actions so a methodology for prioritising actions is essential. This methodology should be created at the beginning of the planning process, and should be used to justify decisions. One consideration for inclusion in the methodology could be a risk assessment of the climate change impact; another could be the prioritisation of high-value adaptation actions (as outlined in Section 5.2).

Ongoing monitoring and review process

Adaptation is not an end point; it is a constant process of planning, implementation, monitoring and revision. A good adaptation plan is accompanied by a strong monitoring and review process. This requires clear measures of success and methods for assessing the effectiveness of implemented actions, including quantitative indicators where possible. There must also be a formal process for incorporating new information and results of monitoring into revised plans and future actions.

7.3 Implementation

Early adaptation

A key message about climate change adaptation which has arisen throughout the research is that the earlier it is started the better. Early adaptation reduces costs, reduces risk, increases resilience and builds capacity and the knowledge base. Early adaptation also allows for the identification of key issues requiring further research.

Implementing win-win adaptation actions

There is a high potential for 'win-win' adaptation actions, that is, actions which address more than one adverse effect, or which address a non-climate change issue while simultaneously building resilience to climate change. For example, when green space is added in order to limit the urban heat island effect, it can also have a beneficial effect on natural assets and human health and recreation opportunities. Similarly, when new transport infrastructure is planned it can build people's capacity to adapt to climate change as well as improving their day-to-day life through enabling social cohesion and increasing employment opportunities. These win-win actions have the potential to create momentum in the initial stages of an adaptation strategy and should be one of the immediate focus areas of adaptation plans.

Supplementing engagement and consensus with real action

The complexity and pervasiveness of climate change impacts means that many stakeholders will need to act. ICLEI (2008) warns about the tendency to postpone action while focusing on consensus and engagement with other stakeholders. Although organisations do need to build partnerships with important stakeholders, they should also identify actions which fall entirely within their jurisdiction which they can implement immediately without waiting for stakeholder buy-in.

7.4 Engagement and communication

High levels of stakeholder engagement

Climate change adaptation will only be effective if the stakeholders involved feel their interests have been represented, their concerns addressed and that the plan is based on the best information available. Effective engagement results in stakeholders adopting the goals and actions of the adaptation plan, and assisting rather than resisting the implementation. It is important that stakeholder engagement occurs at a variety of stages throughout the development of an adaptation plan, as well as once the plan is being implemented. Targeted stakeholder engagement is an effective way to streamline the engagement process while ensuring that the available expertise is incorporated.

Working closely with the research community

As well as being based on a solid scientific foundation, a good adaptation plan must involve ongoing and regular communication and consultation with the research community. Adaptation is an ongoing process which requires regular revision of aims, progress and new information. The group responsible for implementing an effective adaptation plan needs to

maintain a close relationship with the research community in order to ensure the best possible inputs into adaptation practice.

Building capacity

Climate change adaptation is a large and multi-faceted challenge, which will need to be addressed across sectors. Rather than imposing a top-down approach where a group of climate change experts apply their expertise to a range of sectors, it is better to build capacity among people already working in each sector. This allows people to combine their existing expertise with new ideas and parameters in a changing climate. It is important to recognise that much of the expertise required to design and implement effective adaptation action already exists. For example, there are already experts who oversee planning regulations to ensure unsafe development does not occur. In adapting to a changing climate these professionals would be doing the same work, however, the definition of 'unsafe development' might expand to formerly safe areas.

Capacity building is also important because it strengthens the commitment people have to the adaptation process. People are generally more committed to, and more satisfied by working on projects they have been involved in developing (Gardner et al. 2009).

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Appendix 1: Cities and the impacts of climate change

As discussed in Section 3, there are expected impacts from climate change which will be particular to cities. This appendix outlines the key climate change impacts across the five themes in Towards a Resilient Sydney: infrastructure; natural and cultural assets; economy and industry; human health and emergency management; and settlements and communities.

Impacts on infrastructure

One of the key aspects to a well-functioning city is good quality infrastructure. Sydney's ports, airports, rail and bus networks, freight infrastructure, road networks, water and sewer, energy and telecommunications contribute to its productivity and economic competitiveness, as well as its liveability and functioning for its citizens. A challenge for Sydney is maintaining existing infrastructure as well as developing new infrastructure to support growth and underpin Sydney's national and international importance (NSW Government 2011).

Traditionally in Australia, infrastructure has been planned, designed and built based on historical records of weather patterns, however, within a changing climate this is no longer an appropriate methodology (AGIC 2010). Climate change impacts need to be taken into consideration both when designing and constructing new infrastructure, and when planning upgrades to existing infrastructure networks.

Water infrastructure

Water infrastructure, including supply, stormwater and wastewater networks, may be affected by climate change impacts in a number of ways. Changing rainfall patterns will alter the availability of fresh water supplies, as well as changing the necessary capacity of stormwater networks (Hunter 2011). In addition, water infrastructure will need to be able to cope with the predicted increase in frequency and magnitude of extreme rainfall events (Hunter 2011). Infrastructure located in coastal or estuarine areas will need to be assessed for the impacts of sea level rise and inundation, and availability of water during heat events will need to be ensured (Thom et al. 2010).

Energy infrastructure

Energy infrastructure is also likely to be impacted by climate change, both in terms of supply and distribution. During heat events, energy demand grows through higher use of cooling appliances, placing pressure on the energy supply (Howden & Crimp 2001). Heat events also affect the efficiency of the distribution network. Despite this, few cities to date have studied the impacts on their energy systems from climate change (Hammer et al. 2011). Sydney already experiences stress on the energy system during heat events due to increased peak demand (Howden & Crimp 2001). With a changing climate these peak demand events may become more frequent and extreme, potentially requiring a review of Sydney's peak energy requirements.

Transport infrastructure

Transport infrastructure is likely to be impacted by climate change both in terms of the effectiveness of transport, and the demand for transport during extreme events.

The most obvious threats to transport infrastructure from climate change result from increased physical damage during extreme events and floods. However, the more gradual

impacts of climate change also cause vulnerability in transport networks, for example Austroads (2004) found the cost of maintaining road networks is likely to increase under a changing climate as a result of rainfall impacting on the rate of pavement deterioration, and temperature ageing road surfaces. Rail systems are at risk of increasing buckling and rail degradation due to an increase in heat events (DCCEE 2012).

Communications infrastructure is also vulnerable to the impacts of climate change, mostly in terms of physical damage (DCCEE 2012). Increases in storm events, high winds, flooding and coastal inundation will pose a threat to communication towers and cables, potentially causing system failure in certain areas. This results in people being unable to communicate for a period of time, the impacts of which are magnified if this occurs during an extreme event when people need to communicate with emergency services or relatives.

Impacts on natural and cultural assets

Cities are often sites of great cultural significance, both in terms of the current built and natural environment, and of past built and natural environments. In Sydney there are important indigenous sites which have the potential be affected by climate change, for example in coastal or exposed areas. Considering the important role some of these sites play in the culture of indigenous Australians, the impact on the community could be significant. Many of these sites listed under the *National Parks and Wildlife Act 1974* have existing management plans, which could potentially be altered to include expected impacts of climate change.

There are also non-indigenous cultural sites in Sydney which may be impacted by climate change, such as heritage-listed buildings, or cultural icons. A report by the Australian National University (ANU 2009) examined the expected impacts of climate change on World Heritage-listed sites in Australia, including the Sydney Opera House and the Greater Blue Mountains Area. It found that the Greater Blue Mountains Area will likely experience threats to the existing ecosystems through changed fire regimes and rainfall patterns, and that the largest threat facing the Sydney Opera House is due to sea level rise and increased risk of coastal inundation (ANU 2009).

Sydney as a city has a large number of natural assets, such as Sydney Harbour, national parks and parklands which are likely to be affected by climate change impacts. These types of green spaces have significant value in that they are important habitat, provide recreational opportunities and a sense of place, regulate the hydrological cycle and provide economic benefits, as well as having an intrinsic value (GLA 2009).

It is likely that climate change impacts will interact with existing stresses, such as increasing urban encroachment, to place even greater pressure on urban natural systems and species. Although natural assets will be affected by climate change in all regions of Australia, cities face particular challenges due to the urban nature of the landscape. The high proportion of land which is built-up means there is limited connectivity between green spaces, making it difficult or impossible for species to adapt by relocating to a more suitable range. This is similar to the idea of ‘coastal squeeze’ in which coastal habitats such as saltmarsh and mangroves cannot adjust their ranges in response to changes in sea level, because of restrictive coastal development (Department of Climate Change 2009). In addition, the urban heat island effect may have an increased effect on the natural systems (GLA 2009).

The iconic national parks of Sydney, including Ku-ring-gai Chase, Blue Mountains and Garigal national parks; estuaries and coastal lakes such as Narrabeen Lakes and the Hawkesbury estuary, represent significant ecological value to Sydney. There is the potential

for climate change impacts to have significant effects on these areas, affecting not just the ecosystem functions, but also the recreational amenity for Sydneysiders.

Sydney is also home to a variety of threatened species and threatened ecological communities (OEH 2011). These species and communities have existing management plans, some of which include an assessment of threats including climate change as a key threatening process.

Impacts on economy and industry

Sydney is home to Australia's largest economy, accounting for an estimated quarter of national gross domestic product. It also accounts for 70 per cent of the NSW economy. Sydney is a global city – its economic activity has a metropolitan, State, national and international catchment and its performance is crucial to Australia's economic performance.

The OECD report entitled *Climate Change, Employment and Local Development, Sydney, Australia* (Miranda et al. 2011) highlighted some of the strengths of the Sydney economy as having:

- dense networks of globally competitive firms with strong links to the Asia-Pacific region particularly in finance and business services
- supportive policy frameworks at national and state levels
- a strong awareness about the threat of global warming and the need for concerted action
- an advanced economy with strong research and technological capabilities and skills base
- a globally recognised higher education and vocational education and training system
- well-developed infrastructure, high-quality amenities and a living environment that is attractive to mobile knowledge workers.

Miranda et al. (2011) also highlight the significant non-climate drivers expected to have an impact on Sydney's economy, namely:

- strong economic growth in China, India and other Asia-Pacific countries
- demographic changes, including an ageing and increasing population and dependence on high immigration rates
- the global financial crisis and economic uncertainty
- intensification of global competition in service-based industries
- increasing evidence of climate change
- real energy price increases due to climate change and peak oil
- a shift to the knowledge economy
- increased demand for fresh food and food stability causing renewed interest in Sydney's agricultural fringe.

Climate change mitigation and adaptation will create both opportunities and challenges for Sydney's economy and main industry sectors. Opportunities exist for businesses specialising in consulting, carbon markets, scientific research, engineering and technology.

The impacts from a changing climate on industry sectors will vary depending on the nature of the industry and location. For example, manufacturing and retail industries will be affected by the availability and price of water and energy, potential disruptions in their supply and

distribution chains, health impacts on their employees, and a potentially unstable international market. Primary industries will be more directly affected, for example agriculture will be significantly affected by changing rainfall patterns and increased extreme events such as droughts and flooding, as well as potentially increased health issues among workers. Tourism is another industry that will be directly affected by climate change impacts, with significant sites potentially losing their appeal through a loss of ecosystems, physical damage to assets and potential reluctance to travel in areas with increased risk from extreme events.

In addition there are high economic and social costs of extreme events (IPCC 2007). An Insurance Australia Group report (Delloitte 2013) has indicated that the costs of extreme events in material terms has been increasing, and is expected to increase more as climate continues to change. This has a direct and indirect economic impact such as housing damage and the increase in insurance costs and tighter insurance requirements.

Impacts on human health and emergency management

Climate change is expected to have serious implications for human health, which may be exacerbated in cities, such as Sydney, due to the large number of people living in an urban area. Conversely, the proximity to health and support services is greater in cities, so assistance may be easier to receive.

The major health impacts expected from climate change are impacts related to an increase in the frequency and severity of natural disasters; heat wave health impacts; an increase in the frequency and range of vector-borne diseases and environmental pathogens and mental health impacts (McMichael et al. 2009).

With an expected increase in the frequency and magnitude of extreme weather events, bushfires, heat waves and flooding, emergency management is a key area that will need to be prepared for the impacts of climate change.

Impacts on settlements and communities

Significant impacts on Sydney's existing settlements and communities are expected as a result of a changing climate. The current built environment was designed based on historic climate and weather patterns, and the appropriateness and comfort of existing buildings and settlements will decline as the climate changes.

Other impacts on the built environment as a result of climate change could include a more rapid rate of deterioration of building materials and foundations, making building and maintenance more expensive, and reducing the safety of built structures. Settlements in coastal areas and floodplains will experience an increased level of risk of inundation and flooding, and coastal settlements will also face challenges as a result of incremental increases in sea level. An increase in the frequency and intensity of bushfires will also cause increased safety risk to communities in bushfire-prone areas, and settlements which were previously not high risk areas may become at risk from fires (DCCEE 2010).

Communities across Sydney may have more or less vulnerability or adaptive capacity depending on a number of factors including housing type, location, socio-economic profile, social isolation, accessibility to community services and public transport. Social cohesion is particularly important in relation to health and emergency management. Cities are often home to significant populations of non-English speaking residents, making community

engagement and education programs more difficult to administer (Melbourne City Council 2009).

Summary of key points

- Climate change is expected to have significant impacts across a range of sectors.
- Some impacts will cause challenges specific to urban areas.
- Climate change impacts need to be addressed in a comprehensive and integrated manner.
- The effects of climate change impacts on Sydney and the potential responses will be a result of the city's specific characteristics such as geography, economy, population and demographics and infrastructure.

Appendix 2: Adaptation context in Sydney

Australian Government

Despite the Council of Australian Governments (COAG) agreeing to roles and responsibilities in 2012, since that time climate policy in Australia has shifted substantially.

While the Australian Government still has primary responsibility for setting the national policy agenda on emissions reduction and brokering international agreements, the price on carbon emissions was removed in July 2014, the renewable energy target is under review and there is uncertainty around future emissions trading, other climate change policies and administration.

State and territory governments continue to take primary responsibility for climate change adaptation due to the regional impacts of climate change and the need for local adaptation responses. Recommendations for a more collaborative approach across government, made by the Productivity Commission in 2013, have yet to be acted upon.

National Climate Change Research Facility and Networks

The Australian Government established the National Climate Change Adaptation Research Facility (NCCARF) in 2007. NCCARF's objective is to generate information and research that decision-makers require to manage the risks of climate change impacts.

NCCARF has developed a number of National Adaptation Research Plans which identify critical gaps in the information needed by decision-makers, set research priorities based on these gaps, and identified the science capacity that could be harnessed to conduct this priority research.

NCCARF has also established eight research networks aimed at facilitating collaborative climate change adaptation research, openly exchanging information and sharing climate change adaptation resources. The focus of the eight networks are (1) terrestrial biodiversity; (2) primary industries; (3) water resources and freshwater biodiversity; (4) marine biodiversity and resources; (5) human health; (6) settlements and infrastructure; (7) emergency management and (8) social, economic and institutional dimensions.

NSW Government

NSW Government's *NSW 2021*

The NSW Government's ten-year plan for New South Wales was released in September 2011. *NSW 2021* is a strategic plan which outlines priority goals and targets relating to the economy, services, infrastructure, government accountability, and local environment and communities.

A key target of *NSW 2021* was to 'minimise impacts of climate change in local communities'. As outlined in the plan, the target involves helping 'local government, business and the community to build resilience to future extreme events and hazards by helping them to understand and minimise the impacts of climate change'. Actions outlined in the plan to achieve this were completed in 2014:

- complete fine-scale climate change projections for New South Wales and make them available to local councils and the public by 2014

- work with government agencies and universities to deliver improved climate projections for New South Wales and the ACT.

NSW Government programs

OEH is undertaking a wide range of programs and activities to help local government and the community build resilience to future extreme events, including:

- completing fine-scale climate projections for New South Wales for local government and the public in 2014
- developing guidance for local government to undertake climate change risk assessments
- assessing the vulnerability of communities in the south-east, Riverina–Murray, Sydney metropolitan and north coast regions of New South Wales to climate change
- developing green cover design options for reducing the impact of heat in the urban environment.

Metropolitan Strategy for Sydney

The first *Metropolitan Plan for Sydney 2036* (Metro Plan) was released in December 2010, and is the integrated land use and transport plan for the city. It aims to address each of the national criteria for capital city planning set by COAG, one of which is climate change adaptation. The revised metropolitan plan "A Plan for Growing Sydney", released in 2014 includes a commitment to use the recommendations of the *Towards a Resilient Sydney* project to contribute to strategic land use planning (see Action 4.2.1 Provide local councils and communities with tools and information to shape local responses to natural hazards).

NSW State Heatwave Sub Plan

New South Wales has a *State Heatwave Sub Plan* which exists under the *NSW State Disaster Plan*. The Sub Plan details the arrangements for the control and coordination of, the preparation for, response to and immediate recovery from heatwave events within New South Wales to reduce the risk or counter the effects on the community. The State Heatwave Sub Plan was endorsed by the State Emergency Management Committee in November 2011.

NSW floodplain guidelines

The NSW Government published the NSW *Floodplain Development Manual* in 2005. This manual incorporates the NSW Flood Prone Land Policy, and is intended to help councils balance the conflicting objectives of floodplain use through a risk management process. The manual requires the consideration of the impacts of climate change in floodplain planning and risk assessment. Supporting information is available on www.environment.nsw.gov.au

Metropolitan Water Plan

The *2010 Metropolitan Water Plan* sets out the NSW Government's role for water agencies to ensure secure water supply for Sydney. The plan was developed with input from complex modelling to deliver future water security, taking in a range of factors including climate change research. A commitment in the 2010 plan is to ensure continued research into potential impacts of climate change in greater Sydney's water supply.

Legislation

The NSW Government is currently undertaking a number of legislative reviews that will influence the climate change resilience of those respective areas. These include a review of coastal management arrangements, biodiversity legislation and local government effectiveness.

NSW threatened species legislation

The Scientific Committee, established by the Threatened Species Conservation Act, has made a final determination to list anthropogenic climate change as a key threatening process in Schedule 3 of the Act. Listing of key threatening processes is provided for by Part 2 of the Act.

Appendix 3: Local government adaptation in Sydney

Council progress on adaptation

There are 41 local government areas within the area to be covered by Towards a Resilient Sydney. The geographic scope of this area is illustrated in Figure 3. Encouraging and facilitating adaptation planning and actions within these local councils is a key output of the Towards a Resilient Sydney Project.

Figure 3: Map of local government areas to be covered by Towards a Resilient Sydney

Councils within the Sydney Metropolitan Area have made varying levels of progress on addressing climate change adaptation. In the administration of clause 46B of the Protection of the Environment Operations (Waste) Regulation 2005 all councils in the Sydney Metropolitan Area were required to complete risk assessments. Through this program, and

through other supporting programs many have developed and adopted adaptation plans,: such as Bankstown City, Blue Mountains City, Hornsby Shire, Kogarah City, Ku-ring-gai, Manly, Mosman, Parramatta City and Randwick City councils, although not all are publicly available.

Even in the absence of an adaptation plan or strategy some councils are addressing specific aspects of adaptation through existing planning instruments. For example, Manly and Warringah councils are incorporating climate change impacts into the flood management studies of the Narrabeen Lagoon area, and Fairfield City Council has revised the freeboard level in the floodplain management plan to allow for climate impacts. Other council planning and policy instruments which may be used to address climate change issues include local environmental plans (LEPs), bushfire zoning regulations and coastal management plans.

There are also some instances of councils developing climate change adaptation actions in the context of other corporate planning instruments, rather than discreet climate change adaptation plans. For example Fairfield City Council has several action items in regard to 'build up the resilience of the community to adapt to climate change' in its *Fairfield City Plan 2010–2020 – Community Strategic Plan*.

Challenges to adaptation by councils in Sydney

In addition to the general barriers to climate change adaptation outlined in Section 6.3, there are specific challenges faced by councils in Sydney. Smith et al. (2008b) examined the barriers to climate change adaptation in a variety of Sydney councils, finding the following barriers most pressing:

- Councils are resource-constrained, resulting in a trade-off between climate change spending and spending on services.
- Councils do not yet have the necessary knowledge and expertise to adequately address climate change adaptation.
- Some residents are hostile to climate change work due to public scepticism about climate change and its impacts.
- Knowledge silos within councils prevent the interdisciplinary response required for effective adaptation.
- There are perceived risks and liabilities for 'trailblazers' i.e. councils which act ahead of a formal requirement to do so.
- There is a lack of clarity in responsibilities and accountabilities for climate change risks and adaptation actions.

Mechanisms enabling adaptation by councils in Sydney

Regional organisations of councils

Some regional organisations of councils (ROCs) have undertaken work in Sydney, most notably Sydney Coastal Councils Group (SCCG). Both SCCG and the Western Sydney Regional Organisation of Councils (WSROC) are project partners for the development of Towards a Resilient Sydney. There is potential for these ROCs and others to function as information hubs and facilitate knowledge sharing both between councils in their area and between ROCs.

Building Resilience to Climate Change grants

This is a $1-million contestable grants program that will address identified climate change risks and vulnerabilities by supporting climate change adaptation projects and programs. Grants of $15,000 to $80,000 are open to NSW local government organisations including councils, ROCs and county councils. NSW government agencies, Aboriginal land councils, businesses and research and community organisations are encouraged to collaborate on grant proposals.

To be eligible, the grant proposal must be responding to a previously identified climate change risk or vulnerability.

Local Adaptation Pathways (LAP) Program

LAP is an Australian Government program providing funding aimed at helping local governments define the risks from climate change and develop appropriate responses. To date four councils within the Sydney Metropolitan Area have received funding through the LAP Program: Randwick City, Rockdale City, Manly and Blue Mountains City councils. This funding has been for climate risk assessments and adaptation plans.

ICLEI – Local Governments for Sustainability

International Council for Local Environmental Initiatives (ICLEI) is an association of over 1200 councils around the world who are committed to sustainable development. Many councils developed their climate change mitigation plans through participation in ICLEI's Cities for Climate Protection Program, which provides expertise and support. ICLEI has now developed and piloted a climate change adaptation stream, consisting of several modules to assist councils working on adaptation planning. Ashfield, Burwood, Sydney City, Hunters Hill, Leichhardt, North Sydney and Parramatta City councils are all current members of ICLEI.

Appendix 4: Detailed city-level adaptation actions

City	Climate driver	Direct impact	Indirect impact	Action type	Specific action
London	Altered rainfall regime; sea level rise	Flooding	Human health; property damage; infrastructure damage	Engagement and knowledge	The Mayor will work with the Environment Agency, boroughs and other partners to improve the mapping of who and what is at flood risk from all sources of flooding today, and to predict future flood risk for all flood sources.
London	Altered rainfall regime	Flooding (surface level)	Human health; property damage; infrastructure damage	Strategy	The Drain London Forum will develop a surface water management plan for London which identifies and prioritises areas at risk and develops more detailed plans for priority areas.
London	Altered rainfall regime	Flooding	Human health; property damage; infrastructure damage	Procedure and knowledge	The Drain London Forum will create an online data portal to allow flood risk management partners to more effectively share information
London	Altered rainfall regime; sea level rise	Flooding	Human health; property damage; infrastructure damage	Procedure	The Drain London Forum will create a flood incident reporting system and encourage its adoption across London.
London	Altered rainfall regime; sea level rise	Flooding	Human health; property damage; infrastructure damage	Capacity building	The Mayor will encourage each borough to form a cross-departmental flood group.
London	Altered rainfall regime; sea level rise	Flooding	Human health; property damage; infrastructure damage		The Mayor will work with Thames Water, the Environment Agency and the boroughs to trial an intensive urban greening retrofitting pilot project to manage surface water flood risk.
London	Altered rainfall regime; sea level rise	Flooding	Human health; property damage; infrastructure damage	Strategy	The Mayor will work with the London Resilience Partnership and the London Climate Change Partnership to identify and prioritise critical infrastructure and vulnerable communities at flood risk.
London	Altered rainfall regime; sea level rise	Flooding	Human health; property damage; infrastructure damage	Engagement and procedure	The Mayor will maintain the Drain London Forum as a mechanism to facilitate information exchange, project identification and development.

City	Climate driver	Direct impact	Indirect impact	Action type	Specific action
London	Altered rainfall regime	Flooding (surface level)	Human health; property damage; infrastructure damage	Procedure	To reduce the risk of local surface water flooding, the Mayor will work with Transport for London, the London boroughs and Thames Water to review their drain and gully maintenance programme, particularly in high risk areas.
London	Altered rainfall regime	Flooding	Human health; property damage; infrastructure damage	Capacity building	The Mayor will work with the Environment Agency to increase the number of Londoners signing up to the Floodline Warning Direct scheme and to raise awareness of the measures that individuals and communities can undertake to reduce the risks and manage the consequences of flooding.
London	Altered rainfall regime	Flooding	Human health; property damage; infrastructure damage	Capacity building	The Drain London Forum will identify two communities at significant flood risk and work with them to develop bespoke community flood plans to build their capacity to manage flood risk. The Mayor will then encourage the boroughs and communities to roll this approach out to areas at high flood risk.
London	Altered rainfall regime	Lower water availability	Economy; human health; ecology; amenity	Strategy	The Mayor will work with partners to implement a six-point plan to improve water efficiency: • Improve the water efficiency of existing buildings. • Ensure all new development is super water efficient. • Raise Londoners awareness of the financial benefits of increased water efficiency. • Increase the number of homes with a water meter. • Change the way Londoners pay for their water. • Continue to tackle leakage.

City	Climate driver	Direct impact	Indirect impact	Action type	Specific action
London	Altered rainfall regime	Lower water availability	Economy; ecology; amenity	Structure and knowledge	The Mayor will work with London Sustainable Schools Forum to promote rainwater harvesting, including delivering at least two demonstration projects to retrofit schools with rainwater harvesting systems and developing a business model to enable their widespread uptake.
London	Altered rainfall regime	Lower water availability	Economy; water infrastructure; amenity	Structure and capacity building	The Mayor will lobby government to integrate water efficiency into housing retrofitting programmes.
London	Altered rainfall regime	Lower water availability	Economy; ecology; amenity; infrastructure	Strategy	The Mayor recommends that the London Resilience Partnership should review the need for a London-specific Drought Plan.
London	Altered temperatures	Heat waves; increased average temperature	Human health; amenity; energy and water infrastructure	Strategy	The London Climate Change Partnership will work with partners to undertake a feasibility study into creating and maintaining a network of weather stations across London to improve our understanding of London's microclimate and the impact of urban greening measures on managing temperatures.
London	Altered temperatures	Heat waves; increased average temperature	Human health; amenity; energy and water infrastructure	Knowledge	The Mayor will work with partners to improve our understanding of how climate change will affect summer temperatures in the future, and to identify and prioritise areas of overheating risk and risk management options.
London	Cross-cutting	Heat waves; flooding	Human health; amenity; ecology; property; infrastructure	Structure	The Mayor will work with partners to enhance 1000ha of green space by 2012 to offset the urban heat island effect, manage flood risk and provide biodiversity corridors through the city.
London	Altered temperatures	Heat waves; increased average temperature	Human health; amenity; ecology; infrastructure	Structure	The Mayor will work with partners to increase green cover in central London by 5 percent by 2030 and a further 5 percent by 2050 to manage temperatures in the hottest part of London.
London	Altered temperatures	Heat waves; increased average temperature	Human health; amenity; ecology	Structure	The Mayor will work with partners to increase tree cover across London by 5 percent (from 20 to 25 percent) by 2025.

City	Climate driver	Direct impact	Indirect impact	Action type	Specific action
London	Altered temperatures	Heat waves; increased average temperature	Human health; amenity	Structure	The Mayor will work with partners to enable the delivery of 100,000 m^2 of new green roofs by 2012 (from 08/09 baseline).
London	Altered temperatures	Heat waves; increased average temperature	Human health; amenity	Capacity building	The Mayor and the Chartered Institution of Building Services Engineers will publish design guidance for architects and developers to reduce the risk of overheating, and encourage its use through the revised London Plan.
London	Altered temperatures	Heat waves; increased average temperature	Human health; amenity	Regulation	The Mayor will work with social housing providers to encourage the use of passive measures to manage overheating and test the relative benefits of cavity wall insulation in managing overheating.
London	Altered temperatures	Heat waves; increased average temperature	Infrastructure	Knowledge	The Mayor will continue to work with the boroughs to map opportunities for decentralised energy. This will identify opportunities for combined cooling, heat and power and other forms of low-carbon cooling.
London	Altered temperatures	Heat waves; increased average temperature	Human health; amenity; energy infrastructure	Engagement	The Mayor will work with partners to assess and promote 'cool roof technology' (highly reflective, well insulated roofs) in London to reduce demand for mechanical cooling.
London	Cross-cutting	Cross-cutting	Human health	Strategy	The Mayor will work with the London Climate Change Partnership (LCCP), GP and other commissioners, London boroughs, London Councils and Public Health England to ensure that climate risks are addressed in the commissioning and provision of health and social care services; and the refurbishment programmes of the health and social care estates.
London	Cross-cutting	Cross-cutting	Human health	Knowledge	The Mayor will work with the shadow London Health Improvement Board to facilitate the provision of climate risk information to borough health and wellbeing boards.

City	Climate driver	Direct impact	Indirect impact	Action type	Specific action
London	Cross-cutting	Cross-cutting	Human health	Procedure	The LCCP will work with local healthcare providers and communities to provide scalable examples of practical adaptation measures. This will include supporting a bid to the Technology Strategy Board for funding to retrofit a health building to improve its resilience to the impacts of extreme weather and climate change.
London	Cross-cutting	Cross-cutting	Ecology; flooding; amenity; human health; property damage	Structure	The Mayor will work with the Environment Agency and other partners to restore 15kms of London's rivers by 2015 through the London Rivers Action Plan.
London	Cross-cutting	Cross-cutting	Economy	Engagement	The LCCP will work with London's business improvement districts (BIDs) to identify climate risks to the districts and develop appropriate communication and risk management measures.
London	Cross-cutting	Cross-cutting	Economy	Engagement	The Mayor will work with the insurance sector in calling for the government to amend building regulations to require buildings being rebuilt or renovated to be climate resilient.
London	Cross-cutting	Cross-cutting	Infrastructure	Strategy	Transport for London should regularly review and revise the risk assessments of their assets and operations and develop prioritised action plans for key climate risks.
London	Cross-cutting	Cross-cutting	Infrastructure	Engagement	The Mayor will work with the London Resilience Partnership to assess the resilience of London's critical infrastructure to climate risks, including interdependencies between infrastructure.
Copenhagen	Altered rainfall regime	Flooding	Property damage; human health; infrastructure	Structure	Larger sewers, underground basins and pumping stations.
Copenhagen	Altered rainfall regime	Flooding	Property damage; human health; infrastructure	Structure	Manage rainwater locally instead of guiding it into the sewers.
Copenhagen	Altered rainfall regime	Flooding	Property damage; human health; infrastructure	Strategy	Develop a Stormwater Plan to ensure that flooding takes place only where it causes least damage.

City	Climate driver	Direct impact	Indirect impact	Action type	Specific action
Copenhagen	Sea level rise	Flooding; coastal inundation	Property damage; human health; infrastructure	Structure	Building dykes, raising coastline, building structures to protect individual installations.
Copenhagen	Altered temperatures	Heat waves	Human health; amenity	Structure	Use of passive cooling measures when renewing the city's physical framework.
Copenhagen	Altered temperatures	Heat waves	Human health; amenity	Knowledge	Track changes in temperature and "level of greenness" in order to better understand effects of heat.
Copenhagen	Sea level rise	Flooding; groundwater changes	Infrastructure; built environment	Structure and regulation	New buildings and new urban development must be geared to future groundwater levels. Sewer pipes and other underground infrastructure must also be secured.
Copenhagen	Cross-cutting	Cross-cutting		Structure	Preserve and care for the city's existing green areas; supplement the city with more green and blue surfaces; create coherent green networks in the city.
Boston	Cross-cutting	Cross-cutting	Cross-cutting	Strategy	Establish a scientific advisory group.
Boston	Cross-cutting	Cross-cutting	Cross-cutting	Knowledge	Undertake a review of the most recent data and a new vulnerability analysis in conjunction with the next updating of the climate action plan.
Boston	Sea level rise	Coastal inundation	Ecosystems; property damage	Capacity building; regulation	Boston Conservation Committee is to work with the State Office of Coastal Zone Management to develop a tool box for addressing sea level rise in the coastal zone.
Boston	Sea level rise	Coastal inundation	Ecosystems	Knowledge; regulation	Boston Conservation Committee to work with Harvard Law School's Environmental Law and Policy Clinic to examine how new ordinance and other legal instruments might enhance the BCC's ability to protect wetlands.
Boston	Sea level rise	Coastal inundation	Built environment	Regulation	Boston Conservation Committee has developed an approach which strongly encourages developers to integrate sea level rise into their project development.

City	Climate driver	Direct impact	Indirect impact	Action type	Specific action
Boston	Sea level rise	Coastal inundation	Built environment; infrastructure	Strategy	Boston Redevelopment Authority is modifying its Development Review Guidelines to provide more explicit direction where the effects of climate change - and possible preparations for - should be included in the analysis and design of new projects.
Boston	Sea level rise	Coastal inundation	Built environment; infrastructure	Regulation	Develop more comprehensive responses to climate change, especially any necessary zoning changes.
Boston	Altered rainfall regime	Flooding	Built environment; infrastructure	Knowledge; strategy	The Boston Water and Sewer Commission is developing a 25 year asset management plan for the waste water and storm drain system of Boston. The project will look at implications for the sewer system of changes in rain intensity and volume, storm frequency, sea-level rise, and coastal flooding. It will also examine the need to make structural changes in order to ensure the system can cope with the changes.
Boston	Cross-cutting	Cross-cutting	Built environment; human health; infrastructure	Strategy	The Office of Emergency Management and the Boston Emergency Management Team are working to overhaul Boston's Emergency Management Plan, which includes Boston's preparations for extreme weather, such as flooding, severe storms and heat waves. This plan will consider the effects of climate change on emergency management requirements.
Boston	Cross-cutting	Cross-cutting	Built environment; human health; infrastructure	Strategy	Include the effects of climate change in the 2013 Hazard Identification and Risk Assessment (subject to FEMA guidelines).
Boston	Altered temperatures	Heat waves	Human health	Knowledge	Conduct a study in conjunction with the School of Environmental Policy and Planning at Tufts University into heat waves and climate change in Boston.
Boston	Altered temperatures	Heat waves	Human health	Structure	Acquire portable emergency generators which can be used to power air conditioning equipment at cooling centres in the event of power outages.

City	Climate driver	Direct impact	Indirect impact	Action type	Specific action
Boston	Cross-cutting	Cross-cutting	Infrastructure	Strategy	The Office of Emergency Management is undertaking an assessment of the reliability and resilience of energy networks during emergency conditions. This will incorporate sea level rise, heat waves and extreme storms into the vulnerability analysis.
Boston	Cross-cutting	Cross-cutting	Human health; amenity	Structure	Plant 100,000 new trees by 2020 and increase the number of trees by 20%.
Boston	Cross-cutting	Cross-cutting	Human health; amenity	Strategy	Incorporate explicit analysis of climate change risks and appropriate responses into the next iteration of the Open Space Plan for the city.
Boston	Cross-cutting	Heat waves; storm events	Infrastructure	Knowledge	Boston Public Works Dept has started to evaluate the effect of heat waves and more extreme storms on the durability of streets and its implications for design, choice of materials and allocation of resources.
Boston	Cross-cutting	Cross-cutting	Human health; amenity; infrastructure	Strategy	Continue to develop Complete Street Guidelines, which incorporate climate adaptation measures such as more trees for shade and the use of permeable pavements and rain gardens for stormwater management.
Boston	Cross-cutting	Cross-cutting	Ecosystems	Knowledge	Boston Harbour Islands National Park to carry out a range of studies tracking climate change indicators, and examining the impacts of climate change on different ecosystems and resources in the park.
Toronto	Cross-cutting	Cross-cutting	Various	Engagement	Engage directly with communities in greening projects as part of Live Green Toronto.
Toronto	Cross-cutting	Cross-cutting	Various	Capacity building	Develop Climate Change Preparedness Information Kits for citizens and small businesses.
Toronto	Cross-cutting	Cross-cutting	Emergency management	Capacity building	Conduct focus groups to seek input on 72 hour emergency and business continuity planning for households and businesses.

City	Climate driver	Direct impact	Indirect impact	Action type	Specific action
Toronto	Cross-cutting	Cross-cutting	Various	Knowledge	Improve information on expected climate extremes and gradual changes to permit better decision making on adaptation planning. Models will be used for next generation watershed planning.
Toronto	Cross-cutting	Cross-cutting	Various	Knowledge	Climate change vulnerability and risk assessment of city operations to improve understanding of where vulnerabilities are and ranking of risks will help prioritize needs for adaptation actions.
Toronto	Cross-cutting	Cross-cutting	Emergency management	Engagement	Participate in the Greater Toronto Incident Management Exchange to help plan for recovery from wide scale business disruptions or disastrous events including severe weather.
Toronto	Altered rainfall regime	Flooding	Water quality; infrastructure	Knowledge	Combined Sewer Overflow Control Strategy Project to assess effects of extreme weather on performance of drinking water and wastewater facilities, and attainment of water quality goals.
Toronto	Altered rainfall regime	Flooding	Infrastructure	Capacity building	Develop regional extreme precipitation intensity, duration and frequency curves to improve ability to design storm drainage infrastructure for extreme runoff events.
Toronto	Altered rainfall regime	Flooding	Infrastructure	Knowledge	Review urban flooding issues to identify future policy and program requirements for flood protection.
Toronto	Altered temperatures	Heat waves	Human health	Knowledge	Scan methods used in other jurisdictions for assessing vulnerability to heat, in order to develop heat-related vulnerability assessment tool to provide strategic direction for the City's Hot Weather Response Plan.
Toronto	Altered temperatures	Heat waves	Human health	Knowledge	Evaluate the Air Quality Health Index (AQHI) Pilot to help identify behaviour changes that citizens are making as a result of the AQHI and identify improvements in education initiatives that can help maximise health benefits when air quality is poor.

Appendix 5: Detailed requirements for adaptation planning

As discussed in Section 6.2, good adaptation planning and implementation follows a transparent and reiterative framework (Figure 2). This appendix gives additional detail around the steps involved in implementing this framework.

Risk assessment

A defined risk assessment process would comprise an assessment of the likelihood of an impact occurring, and the consequences of the impact. This is a common assessment framework used in risk assessment both within and outside the climate change sphere. The following example was taken from the New York City Panel on Climate Change's Adaptation Assessment Guidebook (2010), and defines the different inputs and outputs from risk assessment in regard to infrastructure.

Table 8: New York City infrastructure risk assessment

Factor	Description	Definitions
Likelihood of impacts	The likelihood that a given climate hazard (e.g. temperature rise) will result in infrastructure vulnerability (e.g. buckling of rail lines)	Virtually certain High likelihood Moderate likelihood Low likelihood
Magnitude of consequence	The overall consequence, should an impact occur	Internal operations (to the stakeholder) Capital and operating costs (for the stakeholder) Number of people affected (to the city) Public health and worker safety (to the stakeholder and city) Economy (to the city) Environment (to the city)

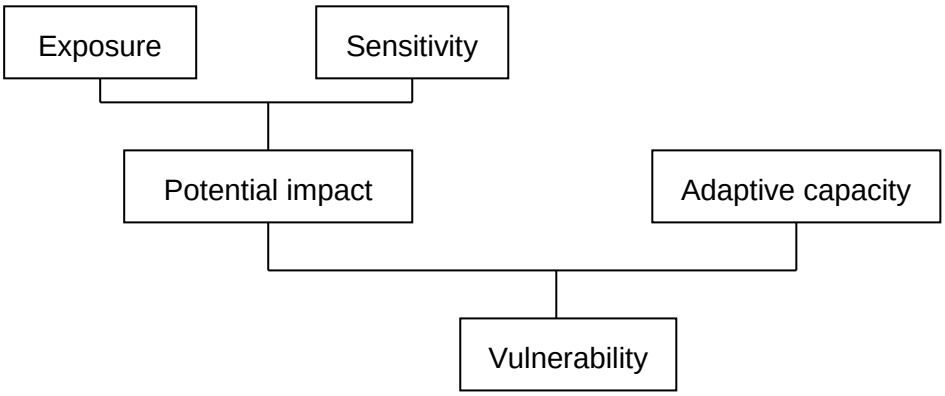
Source: NPCC (2010). Adaptation Assessment Guidebook, p. 251.

This risk assessment methodology is not limited to assessing risk to infrastructure, and can be applied more widely to assist with planning climate change adaptation actions and strategies.

Vulnerability assessment

In order to understand risk in the context in which it occurs, climate change adaptation planners use the concept of vulnerability. Vulnerability considers not only the risk of an impact occurring and its magnitude, but also the ability of the system to adapt to the impact (IPCC 2014). For example, an assessment of the vulnerability of a coastal community to sea level rise will consider both the likelihood and magnitude of the rise, as well as the community's capacity to respond, for example by relocating or building physical structures to protect their properties. Figure 4 illustrates the interactions between different factors in a vulnerability assessment.

Figure 4: Components of vulnerability



Source: Allen Consulting Group (2005).

Using vulnerability assessments allows the climate change adaptation planner to move beyond standard considerations of risk into a deeper consideration of the community or system being affected.

Prioritising actions

Many adaptation guidelines suggest that the methodology used for prioritising actions will depend to a large extent on the context in which the adaptation planning is occurring. For example, for some organisations expedience will be a key consideration, for others it may be the achievement of co-benefits, or adaptation actions which can occur under existing budgets. High-risk impacts will need to be prioritised in any context.

Questions which could inform the prioritisation process could be:

- What is the risk level of the impact?
- Could the adaptation project proceed under existing budget and governance arrangements?
- Could the action be completed in a short timeframe?
- Does the action have additional benefits?
- Does the expertise currently exist to implement this action?
- Has this action been trialled elsewhere? Was it successful?
- Is the cost-benefit analysis of this action favourable?
- Will the action limit future adaptation choices?
- Are there any perceived adverse effects of the action?

It is also important to consider the phenomenon of thresholds. Not all expected climate change impacts are steady through time. Incremental changes may be able to be absorbed by the current systems without much difficulty, however, there may be thresholds beyond which the change is unmanageable (WRI 2011). Identifying these thresholds will help to prioritise adaptation actions, placing less stress on annual resources.

Indicators and measures of success

In order to assess the effectiveness of an adaptation plan, the outcomes must be able to be measured. Indicators are important to any adaptation strategy because they can:

- create a mechanism for alerting stakeholders to emerging climate change data and related risk information
- warn of certain thresholds, some of which may lead to tipping points that may alter elements in a risk assessment process
- provide decision triggers for altering a certain adaptation path
- initiate course corrections in adaptation policies, or changes in timing of their implementation, if and when necessary.

(Jacob & Blake 2010.)

During the preparation of the New York City Adaptation Plan the need for good indicators and measurements was identified. Good indicators and measurements must be both regionally applicable while simultaneously being based on verifiable and easily accessible data (Jacob & Blake 2010). In order to use these indicators, it is important to identify and continue current data tracking programs, or to develop new ones, and to identify which organisations can be responsible for public access and tracking (Jacob & Blake 2010).

In order to provide value to adaptation work, indicators must be carefully selected. Box 1 provides a set of criteria for selecting appropriate indicators, taken from Jacob & Blake (2010). However, indicators will not necessarily meet all of these criteria given that adaptation is a new and emerging field.

BOX 1: Criteria for selecting adaptation indicators

Ideally, adaptation indicators should fulfil the following criteria:

Policy relevance

- provide a representative picture of climate conditions
- measure stakeholder-relevant climate change hazards and society's responses
- be simple, easy to interpret, and able to show trends over time
- be responsive to changes in climate and related human activities
- provide a basis for intra- and intercity comparisons
- have a scope applicable to critical regional climate change issues
- have a baseline, threshold, or reference value or range of values against which to compare, so that users can assess the significance of the values associated with it through time

Analytical soundness

- be theoretically well-founded in technical and scientific terms
- based on local, national or international standards, with consensus about their validity
- readily linked to economic models, scenario projections and information systems

Measurability

- based on readily available data or data available at a reasonable cost-benefit ratio
- be adequately documented and of known quality
- updated at regular intervals, in accordance with reliable procedures
- of sufficient length in time and numbers to allow a quantitative statistical evaluation of the uncertainties associated with the data.

Review process and plan revision

It is vital to have an established review and revision process in any adaptation planning. This process must take into account the results from the monitoring program, and must reconsider or reprioritise actions based on past success levels. The review process must also consider new information from emerging research, especially about climate change impacts. The process should review the risk assessment and make the necessary changes based on new information. The results of both the revised risk assessment and the changes to the prioritisation of actions should be used to revise the adaptation plan.

Stakeholder engagement

Stakeholder engagement is any process which involves using the collaborative input from a group of stakeholders to inform a decision. Stakeholders are considered to be anyone who could potentially influence the decision, or who could be affected by its outcome (Gardner et al. 2009). Stakeholder engagement is desirable because it improves the outcomes of a decision-making process (Gardner et al. 2009). It is also necessary on principle to involve the wider community in government decision-making processes in order to ensure community values and priorities are represented.

Some of the benefits of stakeholder engagement are outlined by Gardner et al. (2009), namely that the parties involved provide a wider range of perspectives and potential solutions, capacity is built among participants through increased understanding of the issues, and the sustainability of initiatives is improved due to stakeholder acceptance of the decision outcomes.

Gardner et al. (2009) recommend the identification of major stakeholders in terms of vulnerabilities. Namely they recommend engaging with:

- specific communities or regions which are vulnerable on the basis of their location or because of the principal industry that supports them
- federal, state and local governments and associated groups (e.g. local government associations, various government departments and advisory groups)
- infrastructure management agencies (responsible for management of ports, air and land transport, water, energy and property)
- industry groups and particular industries, including parks management and natural resource management; construction; health; tourism; agribusiness, forestry and fisheries; insurance and finance; mining and emergency management
- associations and non-government organisations, including those responsible for the built environment, the natural environment, and those involved with indigenous issues.