

Systems Approach to Regional Climate Change Adaptation Strategies in Metropolises



Regional Workshops Synthesis Report: Sydney Coastal Councils' Vulnerability to Climate Change *PART 1*



National Research
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Climate Adaptation



 University of the
Sunshine Coast
Queensland, Australia

Regional Workshops Synthesis Report: Sydney Coastal Councils' Vulnerability to Climate Change Part 1

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CONTENTS

LIST OF FIGURES	VI
LIST OF TABLES	VI
LIST OF BOXES	VI
EXECUTIVE SUMMARY	1
1 INTRODUCTION	3
1.1 Project Aim and Objectives	3
1.2 Workshop Objectives	3
1.3 Workshop Participants	4
1.4 Report Structure	4
METHODS	5
1.5 Research Design	5
1.6 Methods	6
1.6.1 Relative Vulnerability Assessment and Mapping	6
1.6.1.a <i>Defining vulnerability</i>	6
1.6.1.b <i>Scope of assessment</i>	7
1.6.1.c <i>Selecting and combining indicators</i>	8
1.6.2 Systems Conceptualisation	11
1.6.2.a <i>Developing a systems diagram or “horrendogram”</i>	11
1.6.2.b <i>Analysis of systems diagrams using Influence</i>	13
1.6.3 Identification of Priority Issues	15
1.6.3.a <i>Identification of Barriers and Opportunities to Manage Priority Issues</i> .	16
1.6.3.b <i>Analysis of Barriers and Opportunities to Manage Priority Issues</i>	16
2 FINDINGS	17
2.1 Relative Vulnerability Assessment and Mapping	17
2.1.1 Extreme Heat and Human Health Effects	17
2.1.2 Sea-Level Rise and Coastal Hazards	17
2.1.3 Extreme Rainfall and Stormwater Management	17
2.1.4 Bushfire	18
2.1.5 Ecosystems and Natural Assets	18
2.1.6 Net Relative Climate Change Vulnerability Map	19
2.1.7 Stakeholder Responses to Vulnerability Mapping	22
2.1.8 Stakeholder Survey of Vulnerability	22
2.1.9 Conclusions	26
2.2 System conceptualisation	26

2.2.1	Interpretation and Limitations of Analysis	27
2.2.2	Biophysical Drivers, Relays and Outcomes Related to Climate Change	27
2.2.3	Social Drivers, Relays and Outcomes Related to Climate Change ...29	
2.2.4	Government Drivers, Relays and Outcomes Related to Climate Change	30
2.2.5	Variation in Priority Issues across Councils	31
2.2.6	Discussion	33
2.3	Priority Issues	33
2.4	Barriers to managing climate change	35
2.4.1	Community	36
2.4.1.a	<i>Human capital</i>	36
2.4.1.b	<i>Diversity of perceptions</i>	36
2.4.1.c	<i>Unsustainable mindsets</i>	37
2.4.1.d	<i>Disconnect between attitudes and behaviours</i>	37
2.4.1.e	<i>Magnification of climate risk</i>	37
2.4.1.f	<i>Community education</i>	37
2.4.2	Council and other Tiers of Government	38
2.4.2.a	<i>Multi-jurisdictional issues</i>	38
2.4.2.b	<i>Divergent goals</i>	38
2.4.2.c	<i>State Government</i>	39
2.4.2.d	<i>Council corporate culture</i>	39
2.4.2.e	<i>Intra-Council integration and communication</i>	40
2.4.3	Planning and Development	40
2.4.3.a	<i>Jurisdictions and inconsistencies</i>	40
2.4.3.b	<i>Council planning</i>	41
2.4.3.c	<i>Development incentives</i>	41
2.4.3.d	<i>Legacies and tradeoffs</i>	42
2.4.4	Resources	42
2.4.4.a	<i>Council capacity</i>	42
2.4.4.b	<i>Impacts of lack of funding</i>	43
2.4.4.c	<i>Factors affecting Local Government financial capacity</i>	43
2.4.5	Knowledge	44
2.4.5.a	<i>Data and information</i>	44
2.4.5.b	<i>Human capital</i>	44
2.4.5.c	<i>Dealing with uncertainty</i>	45
2.4.5.d	<i>Scientific communication</i>	45
2.4.6	Infrastructure	45
2.4.6.a	<i>Current under capacity</i>	45
2.4.6.b	<i>Aging infrastructure</i>	46
2.4.6.c	<i>Existing vulnerabilities</i>	46
2.4.6.d	<i>Lack of alternatives</i>	46
2.4.6.e	<i>Lack of Council control</i>	46
2.4.6.f	<i>Community expectations</i>	47
2.4.7	Water	47
2.4.7.a	<i>Interlinkages</i>	47
2.4.7.b	<i>Liability and perceptions</i>	47
2.4.7.c	<i>Flood management</i>	48
2.5	Opportunities for Managing Climate Change	50
2.5.1	Community	51
2.5.1.a	<i>Nature of community</i>	51
2.5.1.b	<i>Ideas for engagement</i>	51

2.5.2	Education	51
2.5.2.a	<i>Education needs</i>	52
2.5.2.b	<i>Tools and methods</i>	52
2.5.3	Capacity and Leadership	52
2.5.4	Knowledge	53
2.5.4.a	<i>New knowledge</i>	53
2.5.4.b	<i>Communication</i>	53
2.5.5	Policy	54
2.5.5.a	<i>Economic incentives</i>	54
2.5.5.b	<i>Lobbying</i>	54
2.5.5.c	<i>Funding</i>	54
2.5.5.d	<i>Council strategies</i>	54
2.5.6	Planning	54
2.5.6.a	<i>Vulnerability reduction</i>	55
2.5.6.b	<i>Capacity building</i>	55
2.5.6.c	<i>Risk management</i>	55
2.5.7	Development	55
2.5.8	Water	56
2.5.9	Transport	56
3	DISCUSSION	58
4	RECOMMENDATIONS	59
5	CONCLUSIONS	61
	REFERENCES	62
	APPENDICES	63

**Regional Workshops Synthesis Report:
Sydney Coastal Councils' Vulnerability to Climate Change
PART 2**

APPENDIX I: SUMMARY OF WORKSHOPS FEEDBACK

APPENDIX II: INDIVIDUAL SCCG MEMBER COUNCIL WORKSHOP REPORTS

LIST OF FIGURES

<i>Figure 1:</i> Flow chart of activities and anticipated outcomes.....	5
<i>Figure 2:</i> Components of vulnerability.....	7
<i>Figure 3:</i> Example of a conceptual model for the vulnerability	9
<i>Figure 4:</i> Conceptual model of the approach for assembling vulnerability maps	10
<i>Figure 5:</i> Outputs from systems conceptualisation exercise an “Horrendogram”.....	12
<i>Figure 6:</i> A Systems diagram as recorded in “Vensim”.....	12
<i>Figure 7:</i> Multiple indirect and direct drivers of an issue.....	13
<i>Figure 8:</i> Multiple direct and indirect consequences of an issue.....	13
<i>Figure 9:</i> Classification matrix for system variables.....	15
<i>Figure 10:</i> Comparison of assessment of bushfire vulnerability.....	18
<i>Figure 11:</i> Results of vulnerability assessments for the five impacts areas and net regional vulnerability	19
<i>Figure 12:</i> Stakeholder perceptions of vulnerability to different impacts.....	22
<i>Figure 13:</i> Mapping stakeholder perceptions of vulnerability to different impacts.....	23
<i>Figure 14:</i> Stakeholder perceptions of management capacity of different impacts.....	23
<i>Figure 15:</i> Stakeholder perceptions of vulnerability (ratios) to different impacts.....	24
<i>Figure 16:</i> Local Government emphasis on system components.....	32
<i>Figure 17:</i> Synthesis of barriers to managing climate change impacts (all groups).....	35
<i>Figure 18:</i> Synthesis of opportunities for managing climate change impacts (all groups).....	50

LIST OF TABLES

<i>Table 1:</i> Example indicators used in vulnerability assessment.....	9
<i>Table 2:</i> Mean vulnerability scores for the 15 SCCG Councils.....	20
<i>Table 3:</i> Summary of benefits and challenges arising from communicating vulnerability Assessment Results to SCCG Member Council Stakeholders.....	21
<i>Table 4:</i> Comparison between Council vulnerability scores and Council self-reported Perceptions of Vulnerability.....	25
<i>Table 5:</i> Biophysical variables related to climate change	27
<i>Table 6:</i> Social variables related to climate change.....	29
<i>Table 7:</i> Government variables related to climate change	30
<i>Table 8:</i> Priority issue/s chosen by workshop participants.....	34
<i>Table 9:</i> Regional barriers.....	35
<i>Table 10:</i> Summary of main barriers to adaptation.....	49
<i>Table 11:</i> Regional opportunities.....	50
<i>Table 12:</i> Summary of suggested opportunities.....	57

LIST OF BOXES

<i>Box 1.</i> Comparison of objective and subjective Council vulnerability scores.....	25
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EXECUTIVE SUMMARY

As part of the second phase of the ‘Systems Approach to Regional Climate Change Adaptation Strategies in Metropolises’ project, the research team conducted climate change adaptation workshops with 15 Sydney coastal Local Councils from August to December 2007. The workshops represent the first attempt of local governments in the Sydney region to address climate change adaptation. The purpose of this report is to synthesize the results of the 15 workshops in order to identify and discuss the key barriers and opportunities to managing climate change vulnerability in the Sydney coastal region, as well as recommending key actions to improve Local Government adaptive capacity to managing those vulnerabilities.

The 257 workshop participants consisted of both Council staff and Councillors from most Council sections and departments. The workshops were informed by a relative vulnerability assessment of: (i) extreme heat and human health effects; (ii) sea-level rise and coastal hazards; (iii) extreme rainfall and stormwater management; (iv) bushfire; and (v) natural ecosystems and assets, which found that there is significant spatial variability throughout the Sydney coastal region with respect to climate change vulnerability (see Preston et al., 2008).

Based on the stimulus from the relative vulnerability assessment, workshop participants created systems diagrams of key climate change drivers, impacts, and management responses – and identified the relationships between those concepts. The systems diagrams were used to assist Councils to identify their priority climate issues, which were then discussed in small groups in terms of the barriers and opportunities to managing them. A notable feature from the workshop analysis of the implications for climate change for the Sydney coastal councils region is the breadth of social, environmental and economic issues acknowledged by Council staff as being directly and indirectly related to climate change.

Many workshop participants were concerned about potential liabilities as a result of climate change; they commented that current council plans did not take climate change into account. Additionally, many participants were unclear as to the extent of Local Government statutory responsibilities in relation to climate change. Based on the relative vulnerability assessment and regional workshops, key issues affecting Local Councils’ capacity to adaptively manage climate change included:

- Communities – specifically in relation to human capital, diversity of perceptions, unsustainable mindsets, disconnection between attitudes and behaviours, magnification of climate risk, and community education;
- Infrastructure – specifically in relation to current under capacity of existing infrastructure, aging infrastructure, existing non-climate related vulnerabilities, lack of alternatives, lack of Council control over infrastructure, and community expectations regarding infrastructure;
- Planning and decision-making – specifically in relation to jurisdictional overlaps, planning inconsistencies, political pressures, resources for planning, and legacies and tradeoffs.

Other barriers to Local Government managing climate change included issues related to water management, funding, development, State Government, Councils’ own management approaches, politics, transport management, Australian Government, knowledge, and flooding management. Some opportunities for Local Government to manage climate change were also identified by workshop participants and related to potential improvements in development assessments, policy, education, capacity, leadership, knowledge, and community action. As initial steps to building the adaptive capacity of Local Governments, it is recommended that:

- Local Governments play an active role in directing, participating in, and validating climate change adaptation research – thereby ensuring that climate change assessments have maximum benefit for decision-making;

- There is increased cross-Council dialogue regarding climate change adaptation strategies and interventions;
- Councils embed climate change considerations across all sections of Council operations;
- Councils and other tiers of government review and amend policies, planning controls, planning standards, development regulations, and legislation to facilitate climate change adaptation;
- That the State and Australian Governments articulate responsibilities for climate change adaptation and adequately resource adaptation responses;
- Government investments into research on climate change ‘exposure’ be expanded to also include ‘sensitivity’ and ‘adaptive capacity’ in order to comprehensively understand climate change vulnerability;
- Resourcing to enable Local Governments to implement adaptation strategies;
- Resourcing to enable Local Councils to work with researchers to develop and test monitoring and evaluation frameworks to determine the reasons for success or failure of climate change adaptation interventions and their potential transferability to other regions;
- More research be undertaken to understand the key cross-cutting regional barriers to managing climate change – this is the focus of the third stage of the ‘Systems Approach to Regional Climate Change Adaptation Strategies in Metropolises’ project.

1 INTRODUCTION

As part of the Australian Government Department of Climate Change¹ (DCC) National Climate Change Adaptation Program, the Sydney Coastal Councils Group (SCCG) have partnered with the CSIRO Climate Adaptation Flagship and are working in collaboration with the University of the Sunshine Coast (USC), to undertake research on regional systems approaches to managing climate vulnerability in the Sydney region. This 18-month project is funded through the Australian Government Department of Climate Change (DCC) National Climate Change Adaptation Program as one of five national projects. An earlier report from this project (Preston et al., 2008) described the vulnerability assessment methodology and findings for the Sydney coastal council region.

The purpose of this report is to synthesize the findings of workshops held with 15 SCCG Member Councils. The workshops adopted a systems approach in order to identify and discuss the key barriers and opportunities to managing climate change vulnerability in the Sydney coastal region, as well as recommending key actions to improve Local Government adaptive capacity to managing those vulnerabilities. In addition, this “Regional Workshops Synthesis Report” identifies three cross cutting issues that will be the focus of future work.

1.1 Project Aim and Objectives

The aim of the project is to develop and trial a method for a systems approach to regional climate change adaptation strategies in large urban areas, through:

- Developing and testing an integrated (systems) method to generate information about the likely impacts of climate change and feasible adaptation strategies in the Sydney region;
- Deepening the understanding of the likely impacts of climate change and resulting adaptation options in the Sydney region through integration of existing models, vulnerability mapping, and an analysis of adaptive capacity;
- Assessing the transferability of the integrated (systems) method to other large urban areas, with transfer to be facilitated through the project’s National Reference Group.

The workshops addressed the first two objectives of the study through applying a systems approach to work with each of the 15 local councils that comprise the Sydney Coastal Councils Group in order to both deepen the understanding of likely impacts of climate change and to generate information about the barriers and opportunities to managing those impacts.

1.2 Workshop Objectives

The workshop objectives were:

- To communicate the outputs of the vulnerability modelling undertaken across the region;
- To assist Sydney Coastal Councils to identify climate issues and the linkages between issues;
- To assist Sydney Coastal Councils to identify and understand the direct and indirect drivers and consequences of climate change impacts;
- To assist Sydney Coastal Councils to prioritise issues and;
- To assist Sydney Coastal Councils to identify their perceived vulnerability to issues and their capacity to manage them.

¹ The Australian Government Department of Climate Change was established under the Rudd Government and was formerly known as the Australian Greenhouse Office (AGO).

1.3 Workshop Participants

A total of 257 participants attended the 15 Local Government climate change adaptation workshops, an average of 17 participants per workshop.

The participants were from the following Council sections / departments:

- Infrastructure, engineering, assets (29%)
- Planning, strategic planning, risk (24.5%)
- Environmental, sustainability, health (24.5%)
- Governance, administration, communication, compliance (16%)
- Community, social (6%)

The workshops were held within each of the 15 Local Councils, including: Botany, City of Sydney, Hornsby, Leichhardt, Manly, Mosman, North Sydney, Pittwater, Randwick, Rockdale, Sutherland, Warringah, Waverley, Willoughby, and Woollahra. Each workshop was conducted within one day (Appendix II, Regional Workshops Synthesis Report: Part 2).

1.4 Report Structure

The report is broken into three main sections, including:

- i) an overview of the methods used for the regional workshops;
- ii) discussion of findings in relation to:
 - relative vulnerability assessment;
 - regional workshops systems conceptualisation;
 - regional workshops priority issues;
 - barriers and opportunities to managing climate change; and
- iii) recommendations for key knowledge requirements to build adaptive capacity for managing climate change within Local Governments.

METHODS

1.5 Research Design

In order to achieve the workshop objectives, a four-phase approach to the research was developed (figure 1). The sequential four stages allowed a participatory approach to data collection and analysis, whereby Local Councils were encouraged to respond to relative vulnerability mapping developed from secondary data sources, and to use both the mapping, combined with a participatory systems conceptualisation exercise, to identify priority climate change issues facing each Council – and the barriers and opportunities to managing those priority issues.

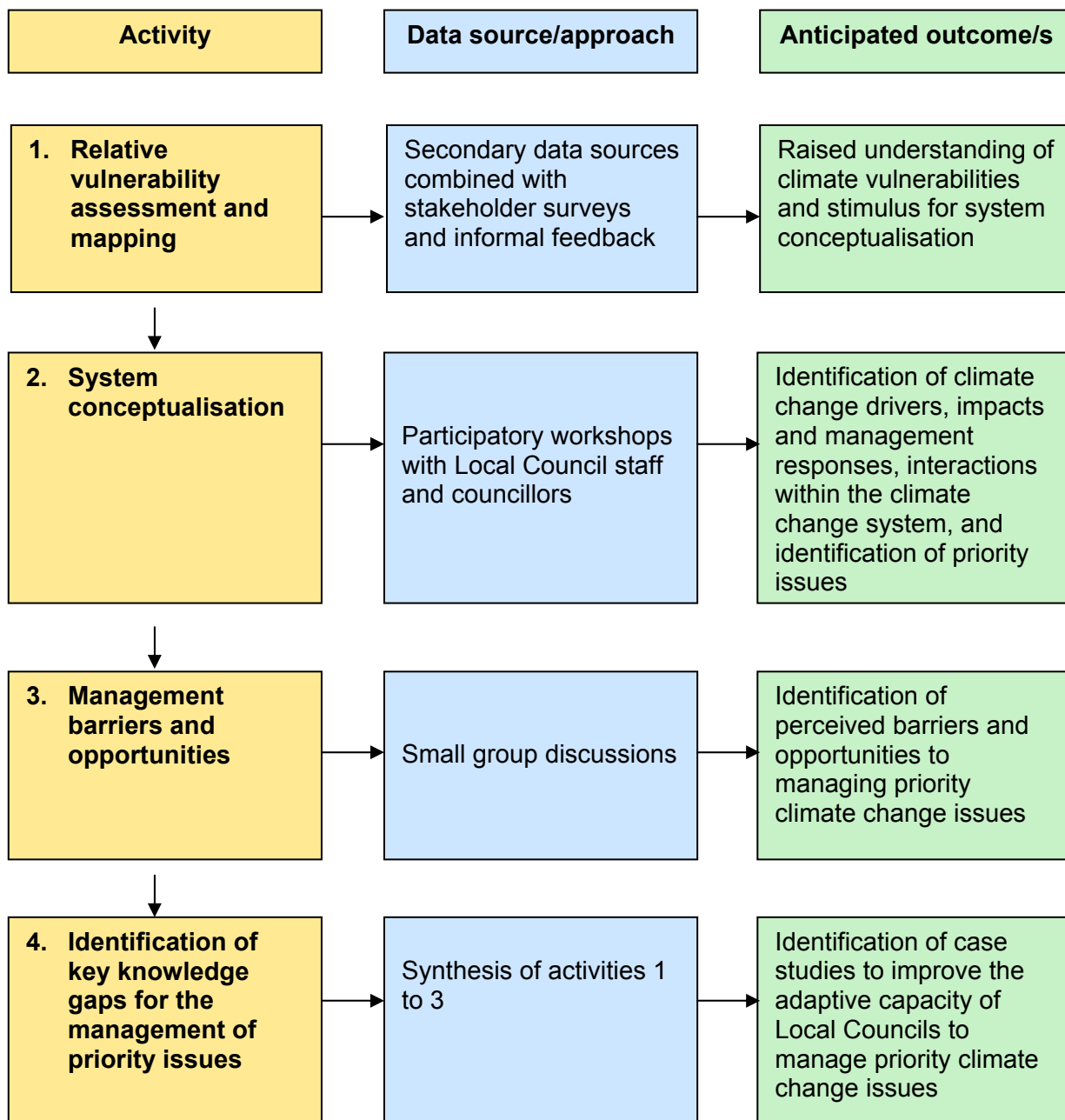


Figure 1: Flow chart of activities and anticipated outcomes.

1.6 Methods

1.6.1 Relative Vulnerability Assessment and Mapping

The first component of the stakeholder workshops conducted with each of the 15 SCCG member Councils was the presentation of results from the vulnerability assessment and mapping exercise (see Preston et al., 2008). The vulnerability mapping and its communication to stakeholders was designed to accomplish a variety of goals:

- Provide an introduction to the concept of vulnerability in the context of climate change;
- Identify some of the key climate change vulnerabilities of the SCCG region and some of the prior work that has been undertaken in their assessment;
- Identify some of the key determinants of vulnerability;
- Present spatial representations of relative vulnerability to some key impacts throughout the SCCG region;
- Provide some key conclusions and lessons gleaned from the assessment that may be useful in future research efforts;
- Provide stakeholders with an opportunity to review and comment on the assessment and suggest options for improvement and/or revision; and
- Stimulate thinking about climate change drivers, impacts and management responses.

In addition to providing information to the stakeholders, the project team was also interested in eliciting feedback from stakeholders regarding their perceptions of vulnerability and the utility of vulnerability assessment as a tool for building understanding about the implications of climate change.

1.6.1.a Defining vulnerability

In defining the concept of vulnerability, the assessment and mapping exercise utilised the definition developed by the Intergovernmental Panel on Climate Change (IPCC) as part of its Third Assessment Report (IPCC, 2001):

Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC, 2001).

As such, vulnerability reflects the degree of potential harm or susceptibility – not explicitly a prediction of future outcomes, such as is commonly generated through impact models and assessments. Rather, it is an analysis of risk factors that contribute to such susceptibility. While this may in fact be informed through the use of various modelling tools that indicate the relative susceptibility of different regions, communities or sectors to climate change, a broad array of other tools also may be employed. These may include stakeholder self-reported perceptions of vulnerability or the identification of relevant indicators that are commonly associated with susceptibility to harm or adverse outcomes.

Objective assessments commonly decompose climate change vulnerability into three constituent components: exposure, sensitivity and adaptive capacity (Figure 2, Allen Consulting, 2005; Metzger et al., 2005; Smit and Wandel, 2006):

Exposure refers to the exposure of a system of interest to stimuli that act on that system. This can be readily conceptualised as climate variability and/or the various changes in the climate system that are often of concern to stakeholders: temperature increases, rainfall variability and change (including extremes), or changes in the frequency or intensity of tropical cyclones.

Sensitivity refers to the responsiveness of a system to climate hazards. This is often represented conceptually as a dose-response model – the more sensitive a system, the larger the rate or magnitude of an adverse response to a given hazard. Sensitivity may vary considerably from one system, sector or population to another.

Adaptive capacity refers to the ability of a system to change in a way that makes it better equipped to manage its exposure and/or sensitivity to climatic influences.

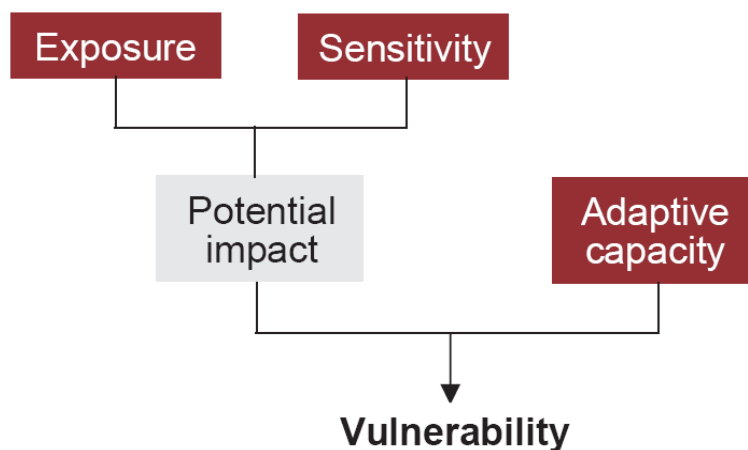


Figure 2: Components of Vulnerability (Allen Consulting, 2005).

The first two components, exposure and sensitivity, dictate the gross vulnerability of a system or process, and thereby provide an indication of potential susceptibility to adverse impacts. Meanwhile, the third, adaptive capacity, reflects the ability of the system to manage, and thereby reduce, gross vulnerability. For this project, adaptive capacity is conceptualised broadly, with emphasis placed on the fact that successful adaptation is a function not only of capacity in the form of the availability of resources to address vulnerability, but also the institutional barriers or constraints on the application of that capacity (Hulme et al., 2007). Similarly, Aall and Norland (2005) make the distinction between three categories of local vulnerability indicators, namely: (i) natural physical and biological vulnerability; (ii) socio-economic vulnerability with regard to climate policies and climate changes; and (iii) institutional vulnerability.

Given the inherent complexities and uncertainties associated with complex environmental and social systems, direct quantitative modelling approaches are often inadequate to capture the concept of vulnerability in a comprehensive manner. Therefore, attempts to assess vulnerability have often relied upon suites of relevant indicators that are assumed to be significantly correlated with different components of vulnerability (e.g., Adger et al., 2004; O'Brien et al., 2004; Brooks et al., 2005; Metzger et al., 2005; Lindley et al., 2006). For example, a suite of indicators may be developed that represent the exposure of a system to a given natural hazard, while another set of indicators may be developed that represents the capacity of the system to cope or adapt to such hazards. Although this approach prevents one from predicting outcomes (e.g., the number of lives lost or estimates of damages in dollars), it enables an assessment to draw on multiple sources of information to develop 'weight-of-evidence' estimates of vulnerability. Nevertheless, such estimates must still be cautiously interpreted and, where possible, they should be evaluated to ensure they are consistent with understanding of the system of interest.

1.6.1.b *Scope of assessment*

The landscape of the SCCG region varies significantly, from highly urbanised and densely populated communities, to more regional areas that are less intensively utilised, as well as areas primarily valued for their role in nature conservation. As a result, the vulnerability of people, assets, and ecosystems within the SCCG region is likely to vary significantly from point to point,

as well as among different types of climate changes and impacts. Furthermore, the management of the potential risks of climate change may vary significantly, with responsibility for risk being borne in some instances by an individual, and in others by local, State or Australian Government or other private institutions. To capture this diversity in potential climate change consequences and adaptation challenges, five areas of potential climate damage were selected for vulnerability assessment and mapping, all of which have relevance to the Sydney region (Preston, 2007):

- **Extreme heat and human health effects**
- **Sea-level rise and coastal hazards**
- **Extreme rainfall and stormwater management**
- **Bushfire**
- **Natural ecosystems and assets**

The assessment and mapping of vulnerability to these different impacts was designed to emphasise the diversity of factors that can conspire to create vulnerability and the complexity of their interactions, consistent with the ‘systems approach’ advocated by the project as a whole. In fact, Smit and Wandel (2006) state that the goal of vulnerability assessment “is not to produce a score or rating of a particular community’s current or future vulnerability. Rather, the aim is to attain information on the nature of vulnerability and its components and determinates”. In recognition of this, the SCCG project utilised the output of this vulnerability assessment as a starting point for a more intensive, bottom-up assessment of vulnerability and adaptive capacity of Local Government through participatory workshops (the focus of this report) and interviews with stakeholders as well as evaluation of existing management plans.

1.6.1.c Selecting and combining indicators

To identify relevant indicators of exposure, sensitivity and adaptive capacity to the five climate change impacts under consideration, a series of conceptual models was developed (Figure 3). These models were informed by published literature on climate change impacts and provided simple representations of the drivers of adverse consequences and the interactions among those drivers. A search of various data sources was then conducted to identify geographic data that were relevant indicators of the various drivers within the conceptual model. A large number of indicators were ultimately selected (Table 1). However, to ensure comparability in vulnerability estimates derived from indicators, indicators had to provide complete coverage over the entire SCCG region. This excluded a number of potential indicators including some data sets maintained by individual SCCG member Councils.

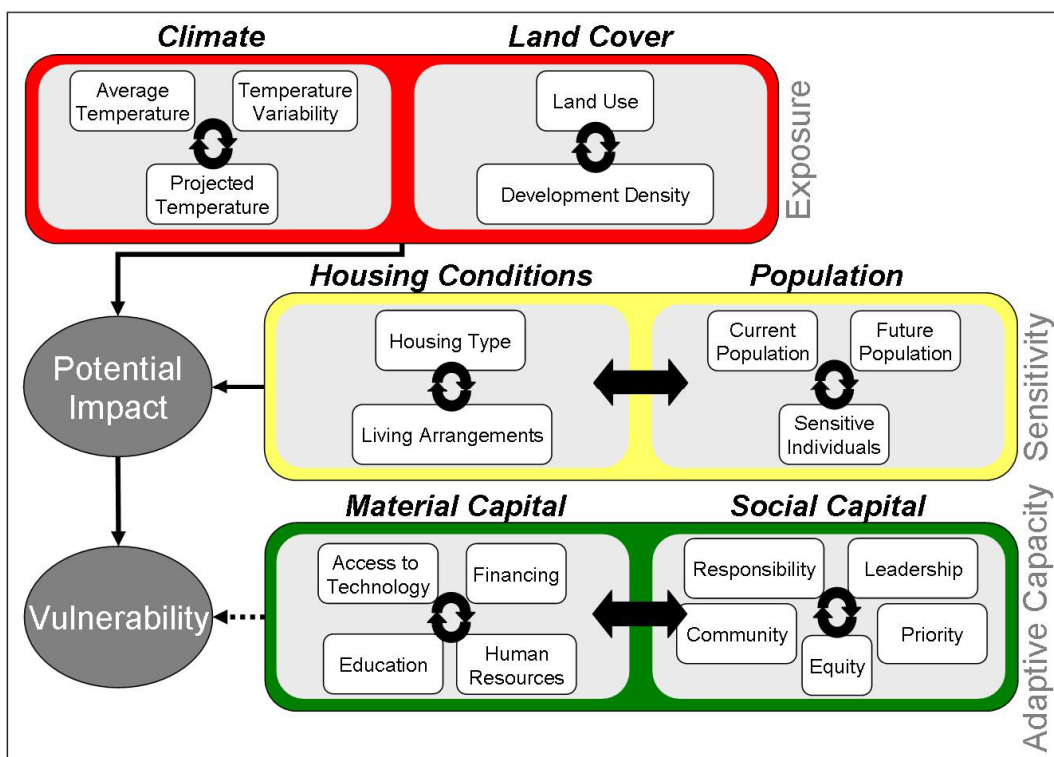


Figure 3: Example of a conceptual model for the vulnerability of human health to extreme heat events arising from climate change.

Note: Exposure (red) is driven by interactions between the climate system and the landscape. Sensitivity (yellow) is a function of the characteristics of the exposed population and the conditions in which they live. The combination of exposure and sensitivity creates the potential for an adverse impact. Adaptive capacity (green) is a function of the material and social capital that can address potential impacts and ameliorate vulnerability. Critical interactions and processes are represented by arrows.

Table 1: Example Indicators Used in Vulnerability Assessment.

Exposure	Sensitivity	Adaptive Capacity
<ul style="list-style-type: none"> • Present average January maximum temperature • Present average January minimum temperature • Present annual # Days > 30°C • Projected change in average DJF maximum temperature in 2030 • Distance to coastline • Present relative storm surge along SCCG coast • Elevation • Slope 	<ul style="list-style-type: none"> • % population ≥ 65 years of age • % population living alone • Land cover • % native vegetation • Population density • Road density • Projected population growth • Surface water condition 	<ul style="list-style-type: none"> • % population completing year 12 • Median home loan repayment • Median household income • % households requiring financial assistance • % population with internet access • Council per capita residential rates • Council per capita environment and health expenses

Once data layers were converted to a common spatial reference, data were assigned a qualitative ranking from 1 to 5, with 1 representing low exposure, low sensitivity or high adaptive capacity and 5 representing high exposure, high sensitivity or low adaptive capacity. The spatial extent of indicators was restricted for the assessment of sea-level rise and coastal hazards, due to the fact

that exposure to coastal processes is a precondition for vulnerability. As such, an arbitrary elevation limit was selected and the extent of all indicators was restricted to this area.

For each impact area, vulnerability was assessed through the aggregation of three maps representing the different components of vulnerability (Figure 4). Due to differences in the number of indicators available for each component of vulnerability for each impact area, data had to first be integrated for each component to prevent any one component from biasing the results. Integration of indicators for each component of vulnerability was achieved simply by calculating the sum of all indicators. Individual indicators were given equal weight due to a lack of knowledge about their relative importance or the quantitative relationships among variables. Sums were then rescored to a scale from 1 to 9, with 1 representing low exposure, low sensitivity or high adaptive capacity and 9 representing high exposure, high sensitivity or low adaptive capacity. Integration of the three component layers was then accomplished by summing the scores from the three vulnerability layers, with the result again being rescored to a scale from 1 to 9. Different components were weighted in the calculation of vulnerability due to expert judgment regarding their relative importance (see Preston et al., 2008). Where possible, vulnerability maps for individual impacts were compared to independent data sources as a validation test.

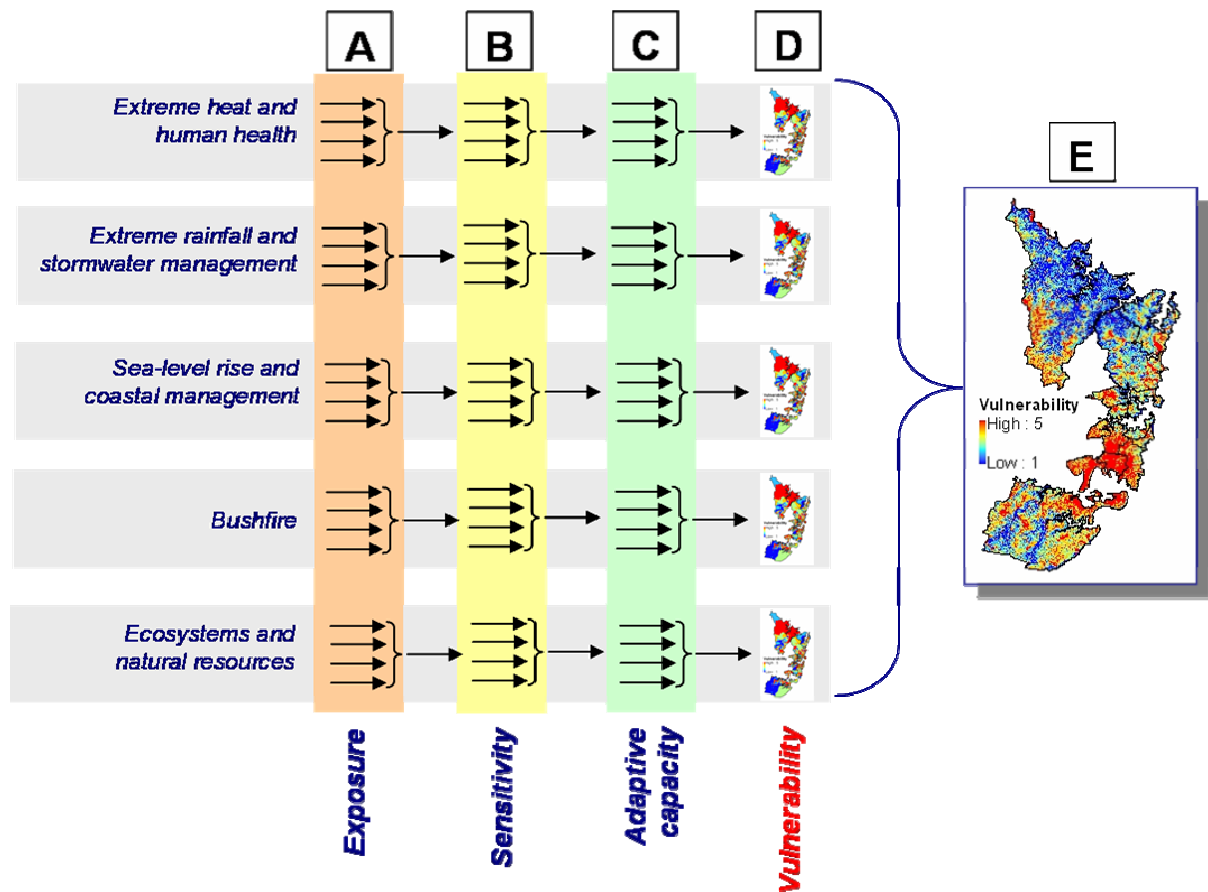


Figure 4: Conceptual model of the approach for assembling vulnerability maps for each of the five impact areas, and net climate change vulnerability for the region.

Note: Maps of the components of vulnerability (A, B, and C) were developed from multiple indicators, and summed to develop vulnerability maps (D). Each of the five vulnerability maps was subsequently summed to develop a map of net climate change vulnerability for the SCCG region (E).

The five vulnerability maps were subsequently integrated to generate a map of overall climate change relative vulnerability across the different impact areas using Councils' self-reported perceptions of vulnerability as importance weights in the integration (see Section 3.1.7). This sum was then rescored to a scale from 1 to 9, with 1 representing low vulnerability and 9 high vulnerability. This view certainly does not consider all aspects of climate change vulnerability, as it is limited to the vulnerability layers and associated impacts upon which it is based. Furthermore, it must be treated cautiously as it assumes that the different vulnerability scores are comparable and can be meaningfully combined, which is arguable. Nevertheless, it provides a quick snapshot of where the SCCG region's hotspots for vulnerability lie.

1.6.2 Systems Conceptualisation

The second stage of the workshops involved all workshop participants in developing a systems diagram of how climate change may influence the Local Government area and Local Government operations. A systems diagram is a way of visualising complex relationships. It provides a way to incorporate a range of views and insights and to share knowledge among diverse stakeholders. Systems diagrams can then be analysed to better understand parts of the system, and how they are interconnected.

1.6.2.a *Developing a systems diagram or "horrendogram"*

Developing the systems diagrams involved asking the workshop participants a series of questions to determine:

1. What activities and management actions are being undertaken by Council that maybe affected or are already affected by climate change;
2. What are seen as the drivers of change (these could include drivers other than primary climate drivers); and
3. What issues and/or activities will be affected by climate change.

The issues identified by participants were recorded on post-it notes and placed on a white board. Arrows between the issues were used to capture the relationships described by workshop participants (Figure 5). The systems diagram provides a "mental map" of the issues and relationships considered to be important in addressing climate change. The mental map allows participants to see the range of issues discussed and the connections between them. It also allows participants to identify indirect or flow-on consequences of actions, and reflect on how their concerns may be related to others. Typically a wide range of issues and links are identified during the workshop process, producing a complex systems diagram or "horrendogram".

The systems approach allowed the links between issues to be quickly explored. For each variable the approach enables the display the range of issues that were identified as direct and indirect drivers of change (Figure 7) and also the list of issues that were identified as being affected by that variable (Figure 8). This provides a method of identifying important issues, while keeping in mind the range of connections and issues that have been identified.

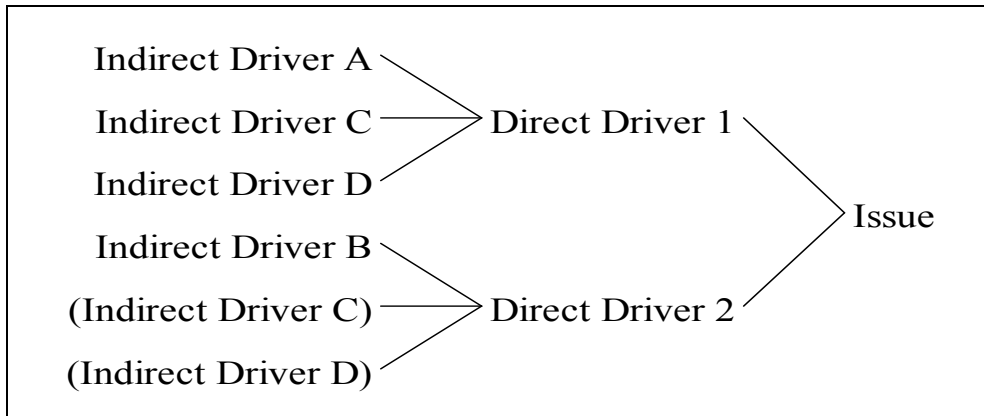


Figure 7: The multiple indirect and direct drivers of an issue.

Note: Where a driver or consequence appears twice in a figure a set of brackets is applied to its second appearance.

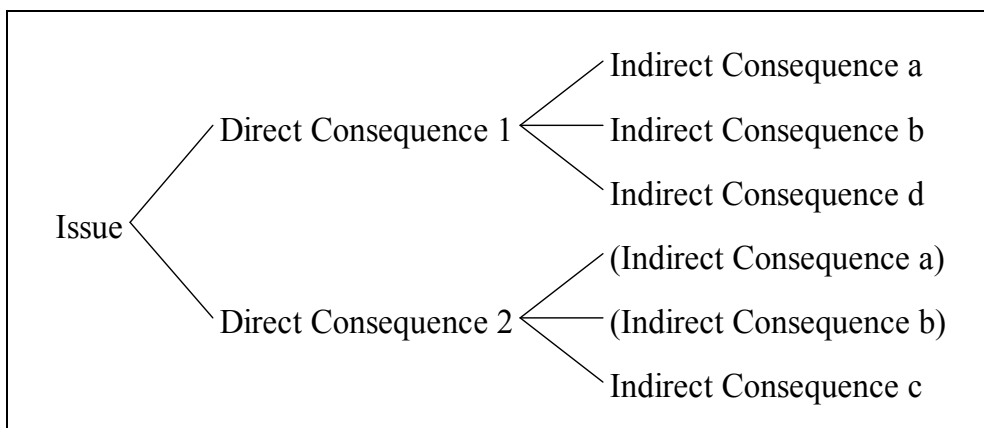


Figure 8: The multiple direct and indirect consequence of an issue.

These causal trees for variables of interest were displayed interactively at the workshop and discussed with workshop participants – with participants selecting the issues they wanted to explore in more detail. This analysis provided a basis for prioritisation of issues for further analysis in the workshop as discussed below.

1.6.2.b *Analysis of systems diagrams using Influence*

The systems diagrams contain a rich amount of information not only about the range of issues (or variables) related to climate change, but also about how these variables interact with each other. Systems thinking principles suggest that the interaction between variables can have an enormous impact on how a complex system operates and reacts to change. However it is not clear from inspecting the diagram which variables are most important to how the regional system will be affected by, and respond to, climate change. In order to identify issues that emerged as being

important and common across Councils, the systems diagrams were analysed using a software package called INFLUENCE (Walker, 1989). The INFLUENCE software considers the full range of direct and indirect links in systems diagram and scores both the influence and the dependence of each variable based on the number of direct and indirect connections. Highly influential variables may therefore not necessarily be highly connected, but may be connected to variables that are themselves highly influential. This scoring allows a method to explore concepts introduced by Godet (1994) (figure 9) to classify the variables in a system as either:

- **Drivers** or determinates;
- Relays;
- **Outcomes** or resultant; or
- Unconnected or excluded.

Drivers or determinants are factors that are highly influential in determining the future condition of the system, while not being affected by it. Drivers may be things outside of local control, such as sea level rise. However they may also indicate opportunities for influencing the system, say by Local Government social planning. The set of drivers is therefore of interest because it describes the range of possible opportunities that may be used to address climate change impacts.

Relay variables are both determined and influential. They may be of value in their own right but are also important because they affect other variables in the system. Relay variables tend to be physical things such as infrastructure, or human variables such as population and demographic distributions. Interestingly the relay variables can also be policy variables such as land use planning. This indicates that the ability to use a policy “lever” may be influenced by other variables in the system.

Outcome variables are factors that do not determine how the system behaves but are influenced by it. The list of outcome variables therefore indicates the range of potential direct and *indirect* impacts of climate change. They tend to be the things that we intrinsically value and are concerned about. However, given that the focus of the systems diagrams were climate change and Local Government, the outcome variables may also have other influences that were unspecified because they were considered to be outside of this system.

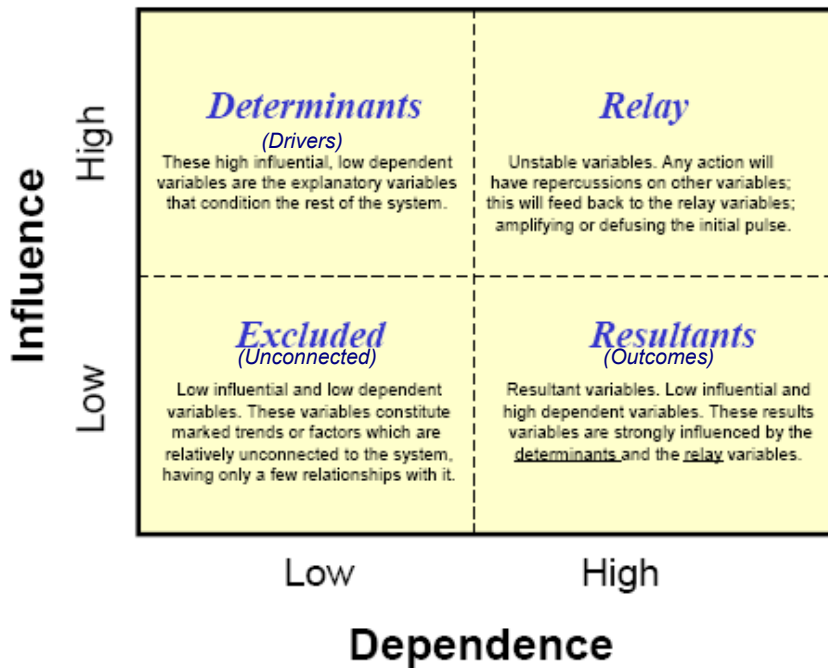


Figure 9: Classification matrix for system variables (Godet, 1994, adapted).

The INFLUENCE analysis provides a useful way to identify key variables in the system. To do this the influence and dependence scores were calculated for each variable in the 15 workshop diagrams. The scores are scaled so that the sum of the dependence and influence score over all variables are the same for each workshop. Similar variables from different workshops were then grouped and the total of the scores for each group used to classify the variables as either drivers, relay or outcome variables and to rank the variables within each category. For drivers, the variables are ranked by their influence score. For outcomes the variables are ranked in terms of their dependence. Relay variables were ranked according to the sum of their dependence and influence scores. Different methods of grouping variables from different workshops were tried. The results are presented for the minimal grouping used, where only very similar terms were grouped. This classification was preferred as the variables used in the workshop tended to be relatively high level variables already. In addition some variable names had specific meanings in the workshops. Further aggregation, while possible, tends to lead to a large loss of information.

To simplify presentation the variables are also classified as biophysical, social or government. Most variables discussed fitted well into this classification and it allows a comparison of similar variables. There is some ambiguity in these categories; the same variable may refer to the issue and its management, or in the case of a variable such as car use reflect both a social behaviour and a physical issue. However in general this is a natural categorization of the issues related to climate change that allows comparisons of like with like to identify important issues.

1.6.3 Identification of Priority Issues

Using the systems diagram software package (Vensim), workshop participants were able to interrogate perceived priority issues in terms of their flow-on effects (both direct and indirect), as well as identify key systems drivers (ie. those variables that linked to and affected numerous other variables). This participatory approach enabled agreement on the priority issues affecting each Local Government area.

1.6.3.a *Identification of Barriers and Opportunities to Manage Priority Issues*

Once priority issues were identified (usually 3 or 4) for each Local Government area, participants self selected the issue or issues that they wanted to explore in more detail. The workshop facilitators encouraged participants to work in small groups with participants from other Council sections / departments (eg. engineering, planning, and administration) in order to elicit a range of diverse perspectives on each of the priority issues. In some cases, issues were formed into interdependent clusters and explored in an integrated way. In order to start participants exploring barriers and opportunities to managing the priority issues, they were asked to rate both their perceived risk to the issue/s and their adaptive capacity to managing the issue/s. Participants were then asked to capture their perceived barriers and opportunities to managing the priority issues (using actual examples where possible), while a workshop facilitator worked with the groups to capture other key elements of the discussion. After the small group discussion a spokesperson from each group shared the top three barriers and opportunities with the other workshop participants.

Potential limitations with the approach included both the varied detail captured during discussion of key concepts and the potential bias of issues of current importance (eg. State Government asset management planning directives). The potential limitations were reduced through including one project researcher as an observer for each small group (recording key discussion points), and also sequencing the small group discussions after the systems conceptualisation exercise, which encouraged “bigger picture” thinking. While efforts were made by the researchers to encourage participation from a broad cross-section of Council staff (eg. inviting staff from various Council divisions such as engineering, planning, asset management, and community support) some key Council staff may not have participated in the workshops due to illness or other commitments. However, large numbers of participants from a range of Council divisions were present at most workshops (Part 2, Appendix 2). For more discussion on the principles underpinning the research project refer to Smith et al. (2007).

1.6.3.b *Analysis of Barriers and Opportunities to Manage Priority Issues*

Data from the small group discussions were analysed to identify the barriers and opportunities to managing the priority issues identified through the systems conceptualisation exercise. Data derived from the small group discussions were analysed through a multi-stage process. The first stage involved a concept mapping and frequency count analysis in order to determine the key discussion concepts (using the software package Leximancer). This analysis was used to rank the most commonly cited barriers and opportunities to managing the priority issues across all council workshops. The key discussion concepts (most commonly cited barriers and opportunities) were then used as the basis for in-depth transcript coding (ie. nodes in the qualitative analysis using the software package NVivo) to reveal emergent themes (Miles and Huberman, 1994). Using this approach the various dimensions of the dominant concepts were able to be explored for both the barriers and opportunities for managing climate change. The SCCG staff, other members of the project steering group, and the SCCG Technical Committee members from the 15 councils also had the opportunity to comment on the findings of the report.

Based on the findings, the three most common barriers from the 15 workshops have been selected as a focus of case studies of adaptive capacity in three representative Councils of the SCCG member councils – the rationale, methods, and findings of the case studies of adaptive capacity are documented in the third report *Case Studies of Adaptive Capacity* of the Systems Approach to Regional Climate Change Adaptation Strategies in Metropolises project.

2 FINDINGS

2.1 Relative Vulnerability Assessment and Mapping

Section 3.1 provides an overview of the findings of the relative vulnerability assessment and mapping undertaken for the SCCG region. A full account of the relative vulnerability assessment and mapping is contained within the report “Mapping Climate Change Vulnerability in the Sydney Coastal Councils Group” (Preston et al., 2008).

2.1.1 Extreme Heat and Human Health Effects

The net vulnerability of the SCCG region to extreme heat events was largely attributed to the interaction between exposure and adaptive capacity (i.e., vulnerable areas were often associated with both high exposure and low adaptive capacity) (Figure 11). As such, much of Hornsby Council and almost all of Rockdale Council were associated with high vulnerability, although the former’s vulnerability was also attributed to an area of significant sensitivity. A number of additional Councils had more spatially variable hotspots of vulnerability, including eastern Pittwater Council, the Councils of central Sydney north and south of the harbour, as well as northern Sutherland Council. Meanwhile, much of western Pittwater Council, northern Warringah Council as well as eastern and southern Sutherland Council were associated with relatively low vulnerability.

2.1.2 Sea-Level Rise and Coastal Hazards

The net vulnerability of the SCCG region’s coastal zone to climate change was concentrated around the east coast from Manly to Pittwater Councils’ coastline and, particularly, Botany Bay and Rockdale Councils (Figure 11). For these latter Councils, their high vulnerability is a function of multiple challenges including topography, high levels of development and low adaptive capacity. As a consequence assets, infrastructure, and coastal amenities (e.g., beaches) in vulnerable areas must be carefully managed in the future to protect both development and amenity. To this end, Local Governments’ adaptive capacities and their ability to partner with each other and State Government to achieve management goals may be particularly important.

2.1.3 Extreme Rainfall and Stormwater Management

The vulnerability of the SCCG region to extreme rainfall and the resulting runoff was closely correlated with development patterns that contribute to impervious surface and high runoff rates (Figure 11). For example, Councils associated with central Sydney generally had high levels of vulnerability. Nevertheless, a number of less urbanised areas were also judged to be vulnerable including areas of eastern Hornsby and northeast Sutherland Shire Council. These hotspots were largely the product of high levels of exposure and/or topographies and development patterns that enhance the sensitivity of the landscape. Low vulnerability was largely restricted to far northern Hornsby, northern Warringah, and western Pittwater Councils along with western Sutherland Shire Council, although some areas of vulnerability were identified along the northern edge of Hornsby Council along the Hawkesbury River.

2.1.4 Bushfire

Bushfire vulnerability for the SCCG region was closely correlated with available fuel loads as well as areas where climate conditions are projected to become more favourable for fire weather conditions (Figure 11). Hence, much of Hornsby Council was identified as being of considerably high vulnerability, with some moderate to high vulnerability in neighbouring Warringah and Pittwater Councils as well. The only other areas of significant vulnerability occurred in the south of the SCCG region in Sutherland Shire Council. Here, as with Hornsby, significant bushlands create a fire hazard, which is exacerbated by low adaptive capacity. However, changes in the climate are projected to be less severe, as is the case in the north. Comparison of the vulnerability map with independent data sources regarding the distribution of bushfire risk in the region revealed a relatively high level of agreement (Figure 10).

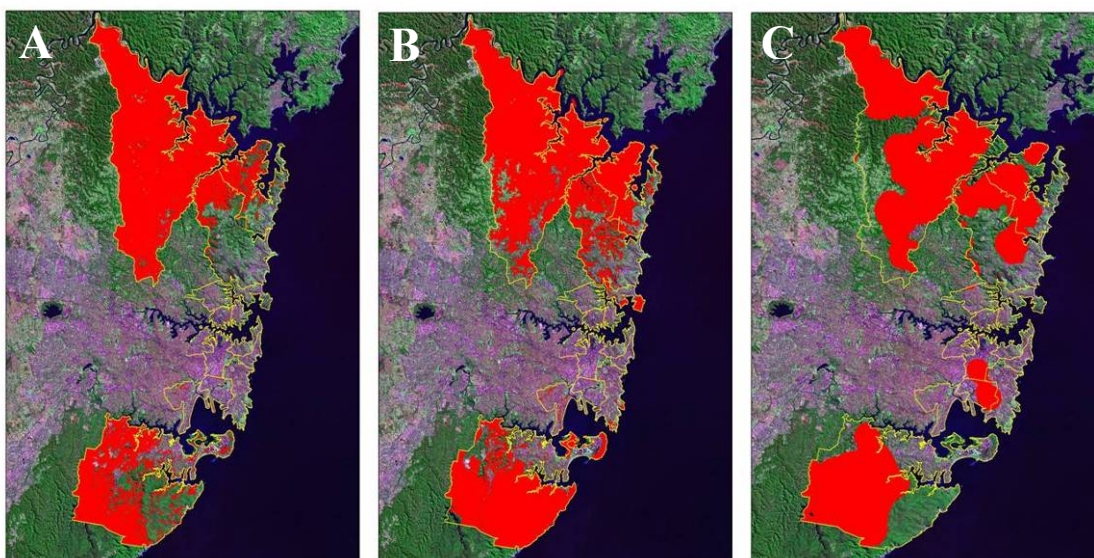


Figure 10: Comparison of assessment of bushfire vulnerability with other indicators of bushfire hazard.

Note: Map A) areas with moderate to high vulnerability as assessed in the current study. Map B) Bushfire hazard areas identified by Local Government planning overlays, vegetation mapping or land use. Map C) Pattern of bushfires (2000-2007) as detected by satellite.

2.1.5 Ecosystems and Natural Assets

The vulnerability for the SCCG region's ecosystems and natural resources was closely correlated with the sensitivity component of vulnerability (Figure 11). The most vulnerable areas were southern Hornsby and southeast Pittwater Councils, Councils associated with central Sydney north and south of the harbour, and northern Sutherland Shire Council. Vulnerability within the region's peri-urban areas may be more critical as these represent transitional areas, where some natural amenity persists, but is under significant pressure. The high conservation value areas found throughout most of northern Hornsby and southeast Sutherland appear to be potential ecological refugia that may be most resilient to the effects of climate change. This suggests a potential strong need to continue to maintain the environmental health of these regions in the future.

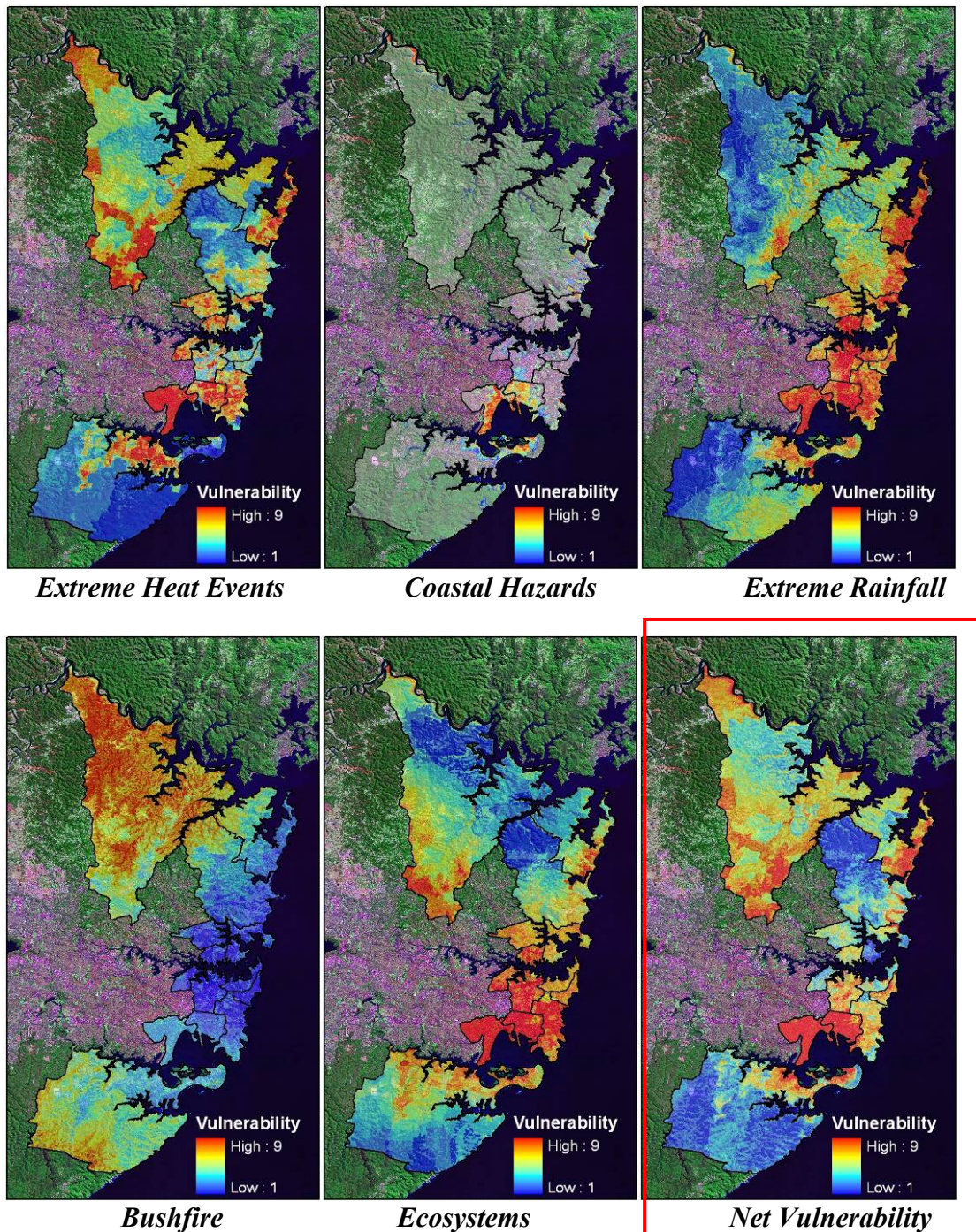


Figure 11: Results of vulnerability assessments for the five areas of potential impact and net regional vulnerability based upon weighted aggregation of the five areas of potential impact (see Preston et al., 2008).

2.1.6 Net Relative Climate Change Vulnerability Map

The combination of the five areas of potential impact vulnerability maps into a net climate change relative vulnerability map resulted in a pattern that largely reflects the development patterns of metropolitan Sydney. The greatest regions of vulnerability are associated with population centres and dense development: southern Hornsby Shire Council, eastern Pittwater Shire Council, Sydney Harbour to Botany Bay (particularly Rockdale and Botany Bay City Councils), and northern Sutherland Shire Council.

The region-wide maps of vulnerability for the SCCG were averaged over the 15 SCCG member Councils to generate internally consistent, but Council-specific aggregate estimates of vulnerability for each of the five impact areas. Figure 11 reveals the relative importance of different vulnerabilities among the 15 Councils. For example, whereas vulnerability for bushfire is relatively low for the majority of Councils, vulnerability to extreme rain events and ecosystems is relatively high for most of the SCCG Councils. It is also important to note that areas with low relative vulnerability may require protection (eg. as wildlife refuges from high vulnerability areas), as well as interventions in areas of relative high vulnerability.

Table 2: Mean Vulnerability Scores for the 15 SCCG Councils

Council	Impact Area					Net
	Extreme Heat	Sea-Level Rise	Extreme Rain	Bushfire	Ecosystems	
Botany Bay	7	9	8	2	9	9
Hornsby	6	1	4	7	4	5
Leichhardt	7	8	7	2	8	7
Manly	6	7	8	2	7	6
Mosman	4	3	7	1	7	4
North Sydney	7	2	9	1	8	7
Pittwater	6	5	7	4	5	6
Randwick	6	6	8	2	8	7
Rockdale	9	9	9	3	9	9
Sutherland	3	4	4	5	4	3
Sydney	5	8	8	1	8	7
Warringah	3	2	6	3	4	3
Waverley	4	4	7	1	7	5
Willoughby	7	1	7	2	7	6
Woollahra	4	6	8	1	7	5
Average	6	5	7	3	7	

Note: High values (red) indicate a relatively high degree of vulnerability to future climate change while low values (blue) indicate low relative vulnerability.

When the net vulnerability of Councils was considered, only Sutherland and Warringah Shire Councils stood out as having low vulnerability to the impacts of climate change. This is not to say that these Councils have no vulnerabilities, it is just that key vulnerabilities are few in number and/or are associated with a relatively small area relative to the size of the Council area when compared with other parts of the SCCG region. These Councils benefit from relatively limited exposure to significant climatic changes, limited development of the landscape, and limited exposure to the Tasman Sea. Nevertheless, low levels of adaptive capacity in northern Sutherland Shire Council contribute to this being one of the SCCG region's vulnerability hotspots.

Those Councils associated with particularly high net vulnerability included Botany Bay, Leichhardt, North Sydney, Pittwater, Randwick, Rockdale and Sydney (Table 2). Overall these are relatively urbanised Councils with significant exposure to the coast, and for Botany Bay and Rockdale City Councils, with generally low adaptive capacity (particularly when compared with other Councils). The relative vulnerability assessment and mapping exercise has demonstrated that urban landscapes are not necessarily immune to the effects of climate change. On the contrary,

unless carefully managed, other external drivers in urban landscapes such as population growth and associated infrastructure provision may increase vulnerability to climate change impacts.

Table 3: Summary of Benefits and Challenges Arising from Communicating Vulnerability Assessment Results to SCCG Member Council Stakeholders.

Strengths
<ul style="list-style-type: none"> • The concept of mapping vulnerability created significant interest among stakeholders, with some citing this as a principal motivation for attending workshops. • Mapping enabled stakeholders to readily compare analysis results with their own subjective perceptions of vulnerability given local knowledge of the landscape and how it responds to natural hazards. • Some stakeholders noted that the vulnerability-based approach offered the opportunity to think about vulnerability and risk in a novel manner. In particular, there was interest in the assessment of adaptive capacity and its incorporation as an integral part of vulnerability, as this was a novel framework for thinking about vulnerability and risk for stakeholders. • Stakeholders appreciated the complexity of the vulnerability assessment in its incorporation of a diverse array of indicators and drivers. Though challenging to comprehend and perhaps overwhelming without more detailed guidance, it proved effective in communicating the diversity of factors that could potentially influence vulnerability. • There was obvious interest in thinking more about how vulnerability assessments could be expanded. For example, it was proposed that the vulnerability maps could be used to expand existing geographic data sets and mapping tools within Councils, further examine assets and resources falling within different vulnerability categories, communicate with Council stakeholders, and undertaken additional analyses focused exclusively on individual Councils.
Challenges
<ul style="list-style-type: none"> • The spatially explicit nature of vulnerability maps invariably led to stakeholder focus on areas identified as high or low vulnerability and associated semi-quantitative scores. This created the potential for stakeholders to deviate into thinking about the assessment as a final product or output, as opposed to an introduction into thinking about complex systems. • Stakeholders sometimes struggled with the concept of relative vulnerability, assuming that significant differences in relative vulnerability necessarily translate into significant differences in absolute risk. This often contributed to disparities in stakeholder and investigator perceptions of risk (above). • As evidenced by the survey of stakeholder perceptions of vulnerabilities (Box 1), there often appeared to be differences in perceptions of vulnerability between stakeholders and the vulnerability assessment. This appeared to stem from differences in how vulnerability was framed. • Stakeholders were able to identify a number of variables or potential indicators that were not reflected in the analysis (e.g., non-resident populations or small-scale policy or management decisions) due to lack of readily available data or ignorance among investigators regarding its importance. • A number of stakeholders raised the issue of weights associated with individual indicators or components of vulnerability (exposure, sensitivity, and adaptive capacity). Although stakeholders did not object to the weights that were utilised, they were quick to recognise the potential importance of differential weighting of individual indicators. • The attempt to conduct a top-down objective assessment of vulnerability invariably overlooked institutional cultures and local contextual knowledge that can have a profound influence on perceptions of vulnerability and adaptive capacity as well as the effectiveness with which management decisions can be implemented. Therefore, objective measures of adaptive capacity may have little relationship with subjective perceptions. • Some stakeholders retreated to a position of expecting 'experts' to provide 'solutions'. With such an expectation, vulnerability assessment was judged inadequate as its emphasis on expansionist views of complexity and diversity of drivers was inconsistent with the desired outcome of reductionist identification of explicit impacts and management solutions delivered by external experts. This suggests the need for assessments that can feed directly into decision-making.

2.1.7 Stakeholder Responses to Vulnerability Mapping

Vulnerability maps were presented to stakeholders in all 15 of the SCCG Member Councils through a variety of methods. The primary vehicle was a 45-minute presentation to Council stakeholders which provided an overview of the concepts of vulnerability, methods utilised in the current vulnerability assessment, and regional as well as Council-specific results (in short, an overview of the material contained within Preston et al., 2008). These presentations focused on the diversity of drivers that may contribute to vulnerability rather than the resulting scores generated by the analysis.

Stakeholders were encouraged to provide feedback during and after the presentations, and were presented with the opportunity to provide follow-up comments at any point after the workshops. Such feedback was used to identify perceived inconsistencies in the estimates of vulnerability. This led to review of the various indicators utilised and in some instances revisions of the analysis. Through this process, a number of strengths and challenges of the assessment stood out as being particularly relevant to future assessment applications and their use in conjunction with stakeholders. These are discussed in more detail in Box 1, and provide useful information when thinking about future applications of vulnerability assessment.

2.1.8 Stakeholder Survey of Vulnerability

In addition to the vulnerability scores calculated for individual Councils based upon mapping of vulnerability across the five impact areas, Council staff were independently surveyed to obtain their initial subjective perceptions of vulnerability to the same five impacts addressed in the vulnerability mapping. Stakeholders were also asked to rate their capacities to manage those vulnerabilities. This provided an independent evaluation of vulnerability based upon a different approach and criteria, which provided an interesting comparison to the vulnerability mapping (Box 1).

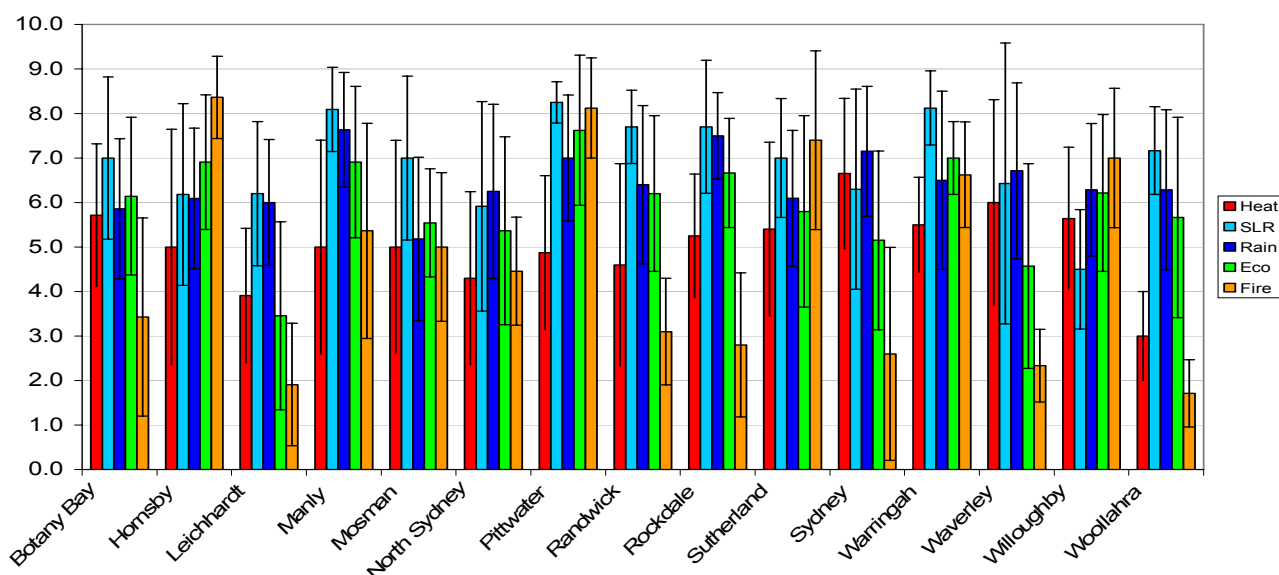


Figure 12: Stakeholder perceptions of vulnerability to different impacts.

Note: Vertical bars represent the mean and standard deviation of stakeholder vulnerability scores for each Council, with 1 representing low vulnerability and 9 representing high vulnerability.

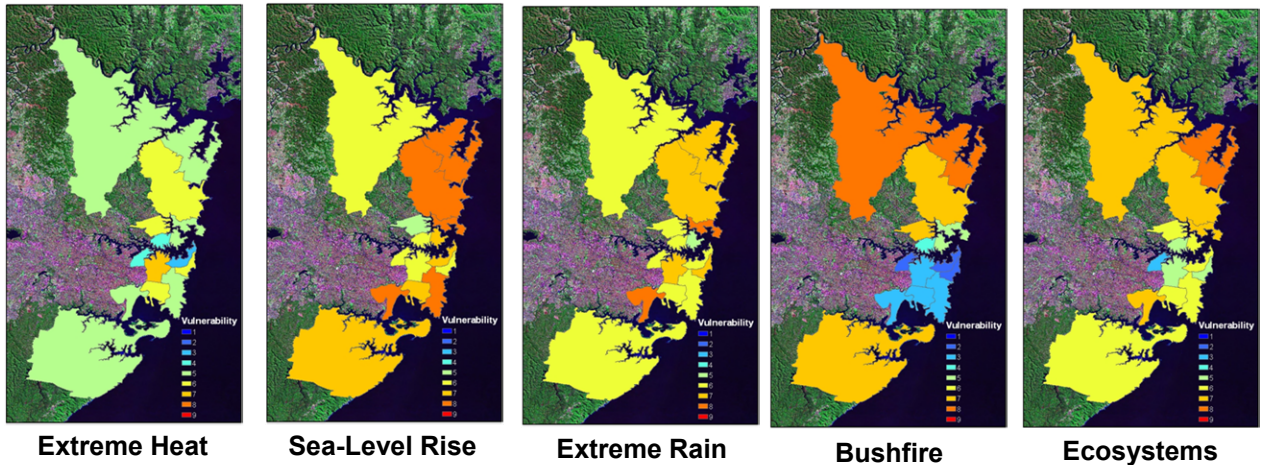


Figure 13: Stakeholder perceptions of vulnerability to different impacts.

Note: Colours associates with different Local Government areas represent the median vulnerability score for the impacts in question as reported by Local Government stakeholders during the stakeholder survey. 1 (blue) represents low vulnerability and 9 (red) represents high vulnerability. Correlations between stakeholder vulnerability scores and results from the vulnerability assessment appear in Table 4 (Box 1).

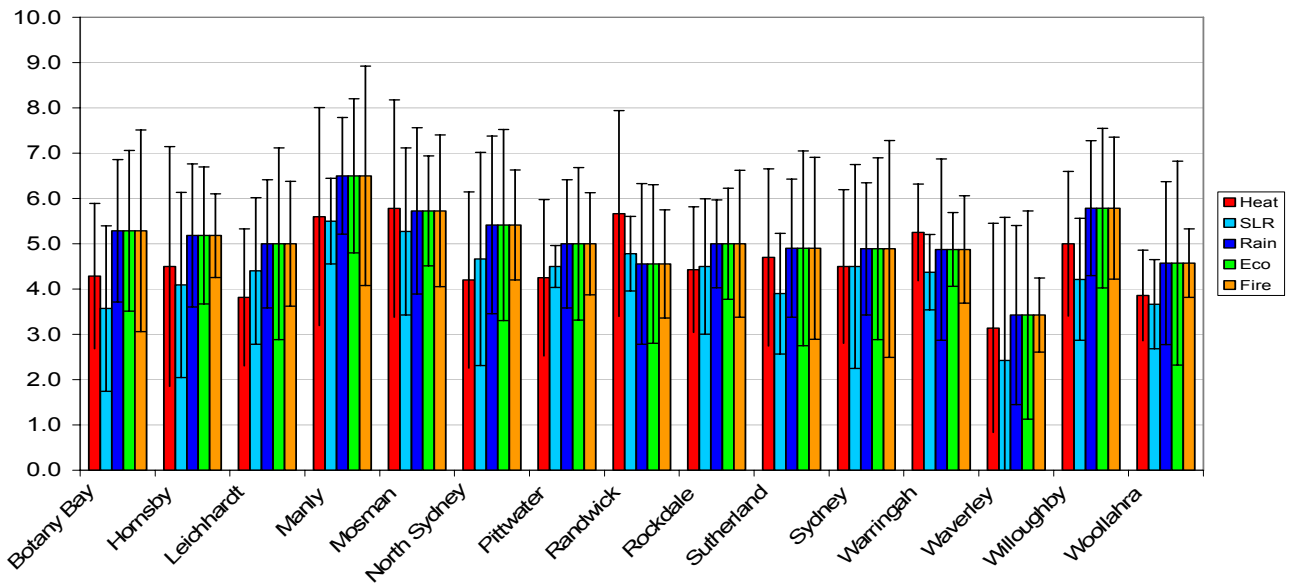


Figure 14: Stakeholder perceptions of management capacity of different impacts.

Note Vertical bars represent the mean and standard deviation of stakeholder management capacity scores for each Council, with 1 representing low capacity and 9 representing high capacity.

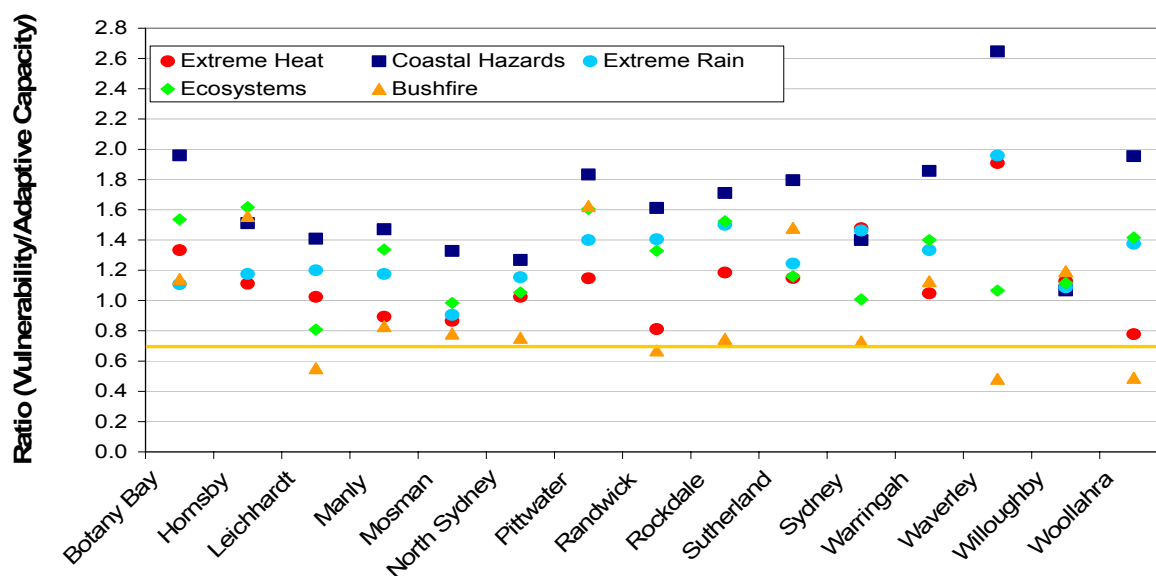


Figure 15: Stakeholder perceptions of vulnerability from the 15 SCCG Member Councils.

Note: Vulnerability is expressed as the ratio of mean vulnerability to mean management capacity. Values greater than 1 indicate vulnerability is greater than the capacity to adapt. Values less than 1 indicate adaptive capacity is sufficient to cope with vulnerability

Council-specific self-reported vulnerability scores generally indicated that concerns about sea-level rise and coastal hazards as well as extreme rainfall events were associated with the highest vulnerability (Figure 15). However, there were some Councils (e.g., Hornsby, Pittwater, Sutherland, and Willoughby) where bushfire exceeded both coastal hazards and extreme rainfall as the greatest vulnerability. When Councils’ self-reported capacities to address these impacts were examined, it was apparent that scores for adaptive capacity were generally lower than those for vulnerability (Table 4). This suggests a capacity gap where the impacts of climate change (or even current climate variability) may potentially exceed the ability of Local Governments to cope.

Box 1. Comparison of Objective and Subjective Council Vulnerability Scores

The correlation between the objective assessment of vulnerability from vulnerability mapping and these subjective perceptions of Councils (average value for vulnerability among survey participants) was moderately high for three areas: sea-level rise, extreme rainfall, and bushfire (Table 4). However, vulnerability mapping generated divergent estimates for extreme heat events and natural ecosystems in particular.

A number of explanations can be offered for the level of agreement/disagreement. First, some Councils noted that assessing vulnerability was a difficult task. Participants were not given a prior briefing on definitions of vulnerability, were not allowed to view vulnerability maps, and were not instructed on the manner in which to assess vulnerability (e.g., relative or absolute basis; with or without consideration for adaptive capacity). This largely explains the divergent estimates for vulnerability associated with extreme heat events and ecosystems. For the former, some respondents reported low vulnerability due to the proximity of the SCCG region to the coastline, overlooking the fact that heat-related mortality is nevertheless an annual occurrence in the region (Woodruff et al., 2005). For the latter, ecosystem vulnerability was likely associated with having significant ecosystem assets and natural landscapes. Hence, urbanised areas were assigned low vulnerability due to a paucity of natural assets, while more rural areas were perceived as having more assets that could be in harm's way.

In contrast, coastal vulnerability as well as vulnerability to bushfire and extreme rain events were more consistent with objective vulnerability measures from mapping, due to the more intuitive nature of vulnerability as well as the benefit of past experience. For example, those communities on the coast and/or with more coastal frontage are likely to perceive a higher vulnerability to sea-level rise and coastal hazards. Similarly those rural areas with more bushland and which have experienced significant bushfire events in recent years are more likely to perceive bushfire vulnerability to be high.

While this comparison provides some real-world validation of some of the vulnerability mapping, in that some results were consistent with the perceptions of Local Governments with local knowledge, it also highlights the high degree of disparity that can result from different ways of framing and/or assessing vulnerability. This represents a potential challenge in not only communicating climate change vulnerability and risk, but also adaptation, which will likely be driven by a combination of objective indicators but also subjective perceptions of risk.

Table 4: Comparison Between Council Vulnerability Scores and Council Self-Reported Perceptions of Vulnerability

Impact Area	Correlation ^a
Extreme heat	-0.09
Sea-level rise	0.42
Extreme rainfall	0.40
Bushfire	0.70
Natural ecosystems	-0.44

^a Correlation represents the level of agreement between the aggregate vulnerability scores calculated for each Council as part of this assessment and Council stakeholders' self-reported perceptions of vulnerability (ie. a number closer to 1 represents a higher level of agreement).

Sample size=159

The results of Box 1 can be explained more comprehensively by examining the ratio of vulnerability scores to management capacity scores (Figure 15). This analysis indicated that in all Councils except one, sea-level rise and coastal hazards represented the impact with the greatest disparity between vulnerability and management capacity. Secondary disparities varied among Councils. However, bushfire was the impact for which the majority of Councils appeared to

perceive their management capacity to be greater than their vulnerability. The exceptions to this pattern were those more rural Councils (e.g. Hornsby, Pittwater, Sutherland and Willoughby) with significant bushland and fire prone areas.

2.1.9 Conclusions

In light of the results of the vulnerability mapping and mindful of the notes above regarding the interpretation of vulnerability, the following conclusions emerge as robust outcomes of the mapping exercise that may prove to be useful messages for the SCCG Member Councils:

- There is significant spatial variability throughout the SCCG region with respect to climate change vulnerability. Not only does vulnerability vary from Council to Council, it also varies from city block to city block and, realistically, from household to household.
- Despite accounting for the significant changes in the climate system projected for the region in the decades ahead, urban drivers that may exacerbate climate impacts such as population growth and associated infrastructure, as well as adaptive capacity within the SCCG region emerge as key factors affecting future vulnerability.
- A number of qualities of the vulnerability assessment and mapping lend themselves well to communicating with stakeholders. However, care must be exercised in the presentation of vulnerability and stakeholders must be guided in the interpretation of results. Furthermore, challenges will invariably arise due to real or perceived inconsistencies between assessed vulnerability and stakeholder beliefs. Transparency in addressing such challenges and providing stakeholders with the opportunity to suggest potential revisions is essential to securing stakeholder buy-in of the assessment process.

Arguably, the true value of vulnerability mapping is the insight that is gained through the process of conducting the assessment and gathering feedback from affected parties. Hence, vulnerability assessment alone, without a ‘learning-by-doing’ ethos and/or a concerted effort to work with stakeholders in the communication and decomposition of vulnerability, is likely of limited utility in developing a rigorous understanding of adaptive capacity or the pursuance of adaptive decision-making.

2.2 System conceptualisation

The system diagrams or mental mapping exercises involved extensive consultation with the 15 Member Councils of SCCG through workshops held in each Council (for more detail refer to Regional Workshops Synthesis Report: Part 2). In total 257 staff and Councillors from the 15 Member Councils attended the workshops and the development of a system diagram attempted to capture the combined understanding of the significant direct and indirect implications of climate change. In total over 200 different issues related to climate change were identified during the 15 workshops. This work is therefore a comprehensive scoping of the issues related to climate change as seen by the Councils’ staff and some Councillors. This section provides an analysis of the 15 systems diagrams to identify issues or variables that are common across workshops and appear to be important in the sense that they are an integral part of how the regional system responds to climate change.

As discussed in the methods section (2.2.3) we used the INFLUNCE software to score the influence and dependence of all the variables in the system diagrams and then classify them as:

- *Drivers;*
- *Relays;* or
- *Outcomes.*

We present the highest ranking variables in each of these categories and discuss the results under three headings: biophysical, social and government. The number of councils that mentioned each variable are also indicated (note that similar variables appear in different places). While it is possible to aggregate variable names further, analysis at this low level of aggregation provides an indication of the context of the issues discussed. The discussion identifies to some natural groups and patterns that appear from these results.

2.2.1 Interpretation and Limitations of Analysis

The results provide an analysis of what people focused on in the workshops, and which variables were significant in these discussions. However, there are some important limitations. Firstly the diagrams were not complete. Time and space restrictions prevented exploration of many issues. In particular the impact of the management variables on the system could often not be explored adequately. Secondly there were a range of variables that were not conducive to analysis using mental mapping. Often this was because the concept was difficult to capture as simple variables and relationships, or because the influence was ubiquitous. The impact of State and Australian Government policy, planning frameworks, and financial constraints, are examples of factors that were mentioned frequently but did not always find their way on to the diagrams adequately. Another limitation is that not all variables are represented in the same level of detail. Some issues that were discussed in detail may not show up as important because their influence is spread across several variables. The lists should therefore be of interest for what they include, rather than what is missing. We hope they point to some key variables that may perhaps be missed otherwise, or are perhaps not thought of as related to climate change.

2.2.2 Biophysical Drivers, Relays and Outcomes Related to Climate Change

Biophysical variables related to climate change are presented in table 5. The top four biophysical drivers of climate change focus (in bold) were used as a starting point for the systems diagrams, this ranking therefore influenced the workshop process.

Table 5: Biophysical variables related to climate change*

Drivers		Relays		Outcomes	
Heat	15	Infrastructure	18	Land Use	4
Rainfall	15	Open Space	9	Land Degradation	4
Sea Level Rise	14	Transport	9	Pollution	4
Storm Surge	10	Water Supply	8	Stormwater	3
Wind	7	Bushfire	8	Transport Car Use	3
Storm Events	3	Flooding	8	Water Use	3
Acid Sulphate Soils	3	Development	7	Energy Use	3
Vegetation	2	Biodiversity	6	Green Space	2
Topography	2	Ecosystems	5	Environment (natural)	2
Beach Erosion	2	Transport Public	5	Building Design	2
Salinity	1	Energy	4	Heat Island	2
Sewage (Treatment plant)	1	Urban Form	4	Habitat	2
Foreshore Damage	1	Property Damage	3	Health impacts	2
UV	1	Ground Water	3	Disease	1
Viruses	1	Water Quality	3	Natural Assets	1
		Waste	3	Emissions	1
		Ecological Integrity	2	Coastline	1
		Erosion	2	Energy and Water	
				Supply	1
				Assets Private	1
				Property Risk	1
				Water (Runoff)	1

*The ranking reflects the INFLUENCE score. The number (1 to 15) is the number of Councils including the variable in the system diagram.

Other biophysical drivers such as acid sulphate soils, topography and beach erosion were either exacerbated by climate change, or influence the impact of climate change on other issues.

Many of the key biological and people-made assets appear in the system as relay variables, that is, having a range of drivers and outcomes.

The asset relay variables tend to be issues that have both biophysical and human drivers. This highlights that the design and location of man-made assets affects the impact of climate change. This interaction is important in issues such as:

- Infrastructure
- Development
- Transport
- Urban Form
- Property Damage

These variables also tend to be important in determining other impacts of climate change. For instance transport influences how urban form and development can adapt to climate change.

Many of the ecological variables are relay variables because they are affected by management and have important indirect impacts. These ecosystem relay variables include:

- Bushfire
- Biodiversity
- Open Space
- Ecological Integrity
- Ecosystems
- Erosion

Some water issues were also seen as relay variables, that is having a range of drivers and outcomes. As discussed more below, the analysis suggests that climate change means these water issues are increasingly connected and therefore need to be addressed as an integrated management problem. The water issues included:

- Water Supply
- Ground Water
- Flooding
- Waste

A feature of the biophysical outcomes variables is that they are diverse. In total 38 variables fit this category. One group is impacts on natural assets, and this includes:

- Coastline and Shoreline Regression
- Environmental degradation outside of region
- Environmental flows
- Saltmarshes
- Green space and sporting fields

Different aspects of the water cycle are also identified as outcome variables (impacts) including:

- Stormwater
- Water use and supply
- Runoff
- Impervious Surfaces
- Sewage

A third major group of impacts is built assets including:

- Private Property
- Transport Infrastructure and car use.
- Sea Walls
- Property Risk

2.2.3 Social Drivers, Relays and Outcomes Related to Climate Change.

The most influential social drivers of climate change impacts (Table 6) can be grouped to cover three main areas:

- Societal expectations, aspirations and consumption habits
- Community attributes and relationship with Councils
- Patterns of household distribution and development pressure

Table 6: Social variables related to climate change*.

Drivers		Relays		Outcomes	
Community Capacity	2	Population and demographics	22	Business	7
Community Liaison	2	Health	11	Insurance	6
Communications	2	Social Capital	9	Safety Public	2
Community Volunteers	1	Economic Activity	8	Housing	2
Aspiration	1	Tourism	6	Quality of Life	2
Expectations and Demands	1	Recreation	6	Human Services	2
Single households	1	Amenity	5	Community Behaviour	2
Community Participation	1	Community Expectations	5	Property Value	2
Density	1	Health public	4	Social Well Being	1
Social Status	1	Wealth	3	Lifestyle	1
Development Pressures	1	Consumption	3	Community Evacuation	1
Council Reputation	1	Community Value	1	Housing Affordability	1
Economic Rationalisation	1	Facilities and Services	1	Fear	1
Health Consumerism	1			Living costs	1
Disability	1			Employment	1
				Outdoor Recreation	1
				Construction Costs	1
				Community (Isolated Elderly Very Young)	1
				Social Services	1
				Settlement Patterns	1

*The ranking reflects the INFLUENCE score. The number (1 to 15) is the number of Councils including the variable in the system diagram.

The relay variables in Table 6 identify a number of areas where human responses to climate change may have flow-on impacts. Impacts on economic activity identified include tourism and consumption patterns. The age and social profile of local populations could also be influenced by climate change impacts, for instance via climate change induced changes in amenity values and recreation and tourism patterns, and indirectly by transport plans partly motivated by climate change mitigation. Another example of a relay variable is health. This may be affected by heat and an aging population and have consequences for the required health services and costs.

The social outcomes are also diverse. They included insurance implications, and economic implications such as housing and living costs. A range of quality of life impacts are also identified related to amenity values, recreation opportunities (for instance linked to pressures on sporting fields), social services, heat effects and changing settlement patterns.

2.2.4 Government Drivers, Relays and Outcomes Related to Climate Change

The variables related to government identified by the INFLUENCE analysis as the most significant drivers, relays and outcomes variables are listed in table 7. Note that a limitation of the analysis was that some of the key references to governmental policies, programs and impacts (all levels in Australia) were not necessarily recorded.

In total over sixty different variables related to government were identified as drivers of issues related to climate change. Some specific policies, for example Cities for Climate Protection, appeared in multiple Council workshops, as do land use and development planning, and a range of social policies.

Table 7: Government variables related to climate change*.

Drivers		Relays		Outcomes	
Open Space Management	6	Emergency Management	14	Asset Management	7
Funding	5	Water management	11	Financial Impact	2
Planning	5	Biodiversity Management	10	Infrastructure	
BASIX	5	Stormwater Management	10	Management	2
Social Planning	4	Transport Management	9	Cost	1
Environment Plan (LEP)	4	State Federal Policy	9	Strategic Planning	
Bushfire Management	4	Land use Planning	7	Sydney 2030	1
Regional Cooperation	3	Development Control	7	Internal Council	
Cities for Climate	3	Waste Management	6	Operations	1
Protection	3	Political Will	5	Councils (Neighbouring)	1
Coastline Management	3	Community Education	4	Operational Cost	1
Data Collection	3	Planning Controls	3	Local Employment	
Lobbying	2	Infrastructure Planning	3	Strategy	1
Tourism Management		Council Finances	2	Stormwater Reuse	1
Management	2	Councils Perception	1	Design Guidelines	1
Legislative and Planning				Green Star Scheme	1
Framework	2			Development Design	1
Litigation and Liability	2			Asset Redesign	1
State Regulation	2			Environmental Education	
Strategic Plan	1			Strategy	1
Education Awareness				Crisis Management	1
Raising	1			Staff Training	1
Greenhouse Gas					
Reduction	1				
Council Services	1				
Housing Strategy	1				

*The ranking reflects the INFLUENCE score. The number (1 to 15) is the number of Councils including the variable in the system diagram.

Broadly the government variables that are drivers of climate change can be grouped as:

- Social Planning including education and awareness, tourism, health and events.
- Climate change mitigation including specific energy and carbon programs.
- Development, planning and infrastructure: covering most aspects of planning and controls including land acquisition and foreshore building.
- Environment including open space, coastlines, bushfires, ecosystems, flooding, air quality, weeds, trees.
- General Government covering Council cooperation and amalgamation, regulation, compliance and planning frameworks, information and data collection.

Note that some influential policies were classified as relay variables because they were themselves influenced by other parts of the system. There are several notable groups:

- Development and land use planning are identified as being important but also heavily dependent on other factors such as development pressure.
- Management of water, including stormwater and stormwater reuse may require an integrated approach.
- Political perceptions, political will and State and Federal policy are both important and influenced by other aspects of climate change.

This is potentially important as it suggests that it may not be possible to operate these policies as required. Instead, coordinated policy action and new types of policy levers may be required.

Government variables classified as outcomes tend to have implications for Local Government outside of their responsibilities to manage climate change impacts and mitigation. The most significant of these are the impact on Council management of assets and finances.

2.2.5 Variation in Priority Issues across Councils

The systems diagram data were also reclassified into just two concepts, based upon whether issues reflected biophysical conditions (and their management) or socio-economic conditions (figure 16), indicating the biophysical or socio-economic bias of those Councils. Biophysical concepts included climate drivers (temperature, rainfall, sea-level rise), emergency management, and the management of natural resources and the environment (water, green/open space, vegetation or biodiversity). Socio-economic concepts included community expectations, consumption, funding, infrastructure and asset management, communication, education, transport and amenity. The bias of individual Councils was quantified simply by calculating the percentage of all concepts identified by stakeholders that corresponded with either biophysical or socio-economic issues. Councils with 50% to 75% identified concepts associated with socio-economic issues were classified as having a 'weak' socio-economic bias, while those with more than 75% of concepts associated with biophysical issues were classified as having a 'strong' socio-economic bias. Similarly, Councils with 50% to 75% or greater than 75% of identified issues associated with biophysical issues were classified as having a 'weak' or 'strong' biophysical bias, respectively.

Biophysical and socioeconomic issues tend to interact in determining how Local Governments view climate change. Variations among Councils in their social and biophysical assets therefore have complex implications for appropriate management. This variation was reflected in differences in the systems diagrams and in the wide range of government variables identified. The spatial variation in the required response highlights the importance of a local response (and Local Government) to climate adaptation.

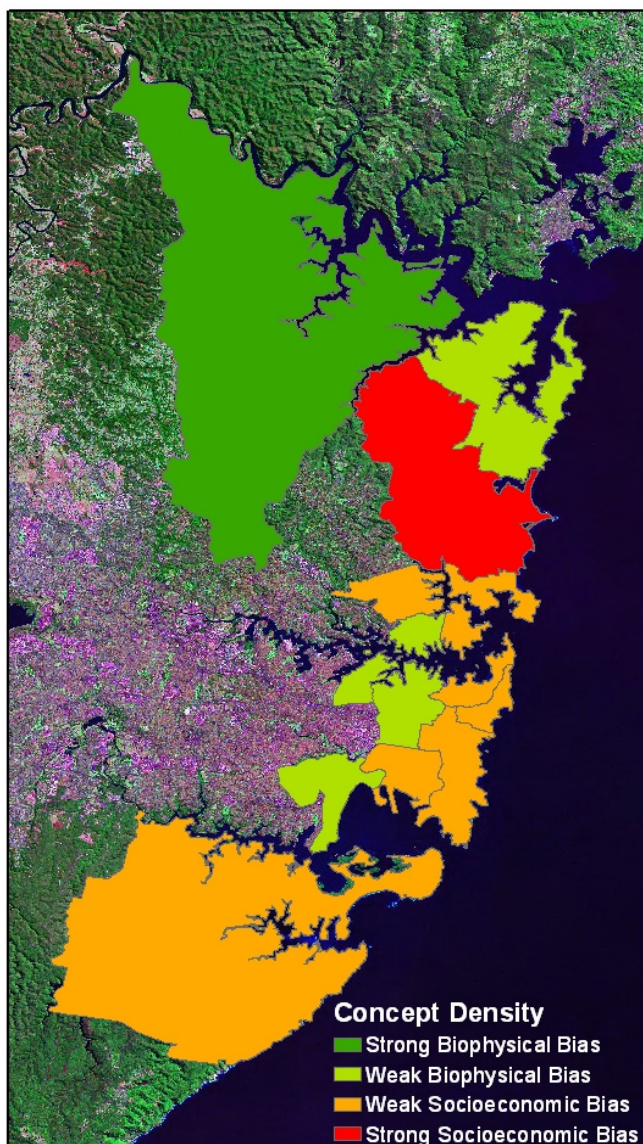


Figure 16: Local Government emphasis of system components.

The majority of Local Government areas possessed a weak socio-economic bias, indicating a slight preferential focus in their mental models for social and economic aspects of the climate change challenge. However, four Local Governments were identified as having a strong socio-economic bias – Pittwater, Leichhardt, Waverley, and Woollahra Councils. This suggests these Councils perceive the social, economic, and community characteristics of the community to be paramount to their vulnerability to climate change and the management of Local Government responses. In contrast, two Local Government areas, Willoughby and Manly Councils, have a weak biophysical bias, suggesting Local Government stakeholders are preferentially concerned about biophysical processes, such as changes in climate variables and natural hazards. Despite the two exceptions, Councils generally framed climate change as a complex mixture of biophysical and socio-economic processes. Those biases that were observed may reflect specific characteristics or management challenges commonly faced by Local Government.

Only one Local Government area exhibited a strong biophysical bias and similarly, only one Local Government area exhibited a strong socio-economic bias – indicating that the majority of Local Governments in the Sydney coastal region had similar appreciation of both biophysical and socio-economic climate change issues.

2.2.6 Discussion

The notable feature from this analysis of the workshop diagrams is the breadth of issues directly and indirectly involved in climate change in the Sydney coastal Councils region. The implications for government of climate change were correspondingly broad and covered:

- Social planning
- Climate change mitigation
- Development, planning and infrastructure
- Environment
- Emergency management
- General Local Government operations.

Many key government policy areas were also seen as both being influenced by, and affecting climate change. Specific issues that were highly prominent and where coordinated action could be useful include:

- Financial implications for Councils and government in general.
- Regional cooperation and relationships with the State and Australian Government.
- The relationship between Council and community, and its role in influencing community expectations, aspirations and capacity for coordinated action related to climate change mitigation and adaptation.
- The numerous factors affecting land use and development policy that may limit the scope for the use of these instruments to deal effectively with climate change.
- Uncertainty and risk management associated with climate change. This had several dimensions including litigation and liability issues, the associated uncertain financial impacts and implications for land use planning.
- An integrated set of issues related to the management of the water cycle including waste, stormwater and water supply, and use.
- Many aspects of information related to climate change including: monitoring, data collection, awareness and education.
- Asset and infrastructure management and planning. One participant's assessment was that assets need to be defined more broadly to include environmental assets. Environmental assets may be threatened by climate change and may also be of value in reducing climate change impacts.

2.3 Priority Issues

A total of 41 priority issues or groupings of issues were discussed in small groups (Table 8). The priority issues or groupings of issues that were chosen most frequently to be discussed in the small groups included, in no particular order:

- Infrastructure
- Assets
- Development
- Land use planning
- Coastal Management
- Water
- Ecological impacts
- Community value
- Human health and well being

The list of priority issues highlights the breadth of issues and impacts relevant to climate change affecting the SCCG region.

Table 8: Priority issue/s chosen by workshop participants.

Issue/s	No. of Councils	Councils
1.Cohesion, 2.Human health & social well being, 3.Human health, 4.Public health & social impacts	4	1.Pittwater, 2.Willoughby, 3.City Of Sydney, 4.Leichhardt
1.Community Value, 2.Community expectations, 3.Change Behavior, 4.Values, community expectations & consumption	4	1.Sutherland, 2.Hornsby, 3.Randwick, 4.Leichhardt
1.Biodiversity & green space, 2.Habitat loss, 3.Ecosystems, 4.Ecological impacts	4	1.Pittwater, 2.Warringah, 3.Willoughby, 4.Botany
1.Property damage & infrastructure, 2.Infrastructure, 3.Infrastructure, 4.Infrastructure	4	1.Pittwater, 2.Manly, 3.Rockdale, 4.Botany
1.Water & energy, 2.Water, 3.Integrated water management	3	1.Pittwater, 2.Hornsby, 3.Randwick
1.Development pressure, 2.Residential development,	3	1.Woollahra, 2.Manly,
Bushfire	1	Hornsby
Coastline impacts	1	Sutherland
1.Extreme rainfall & flooding, Flooding	2	1.Mosman, 2.Woollahra
1.Land use, population & development, 2.Land use planning for climate change,	2	1.Sutherland, 2.Warringah,
Sea level rise	1	Mosman
Beach amenity	1	Manly
Water use, stormwater – re-use, stormwater, erosion, bush regeneration, & vegetation	1	Waverly
Development, recreational demand & urban form	1	North Sydney
Development control	1	Rockdale
Development control & infrastructure	1	Willoughby
Public assets & aging infrastructure	1	Woollahra
Infrastructure & asset management	1	City Of Sydney
Infrastructure & funding	1	North Sydney
Assets	1	Hornsby
Urban development, urban redevelopment, emissions, vehicle usage & public transport	1	Waverly
Property development, asset management built & natural (green space)	1	Leichhardt
Transport	1	Willoughby

2.4 Barriers to managing climate change

Based on concept frequency modelling (using the software package Leximancer) the most common barriers to managing the issues identified by workshop participants ranged from community (noted as a barrier 33 times) to flooding (noted 5 times) (Table 9). The relationships between these concepts are graphically displayed in Figure 17.

Table 9: Regional barriers.

Barrier	Number of times cited
community	33
infrastructure	31
planning	29
water	23
funds / funding	21
development	17
state	15
Council	12
political	11
transport	10
government	9
knowledge	8
flooding	5

Iterations = 1000

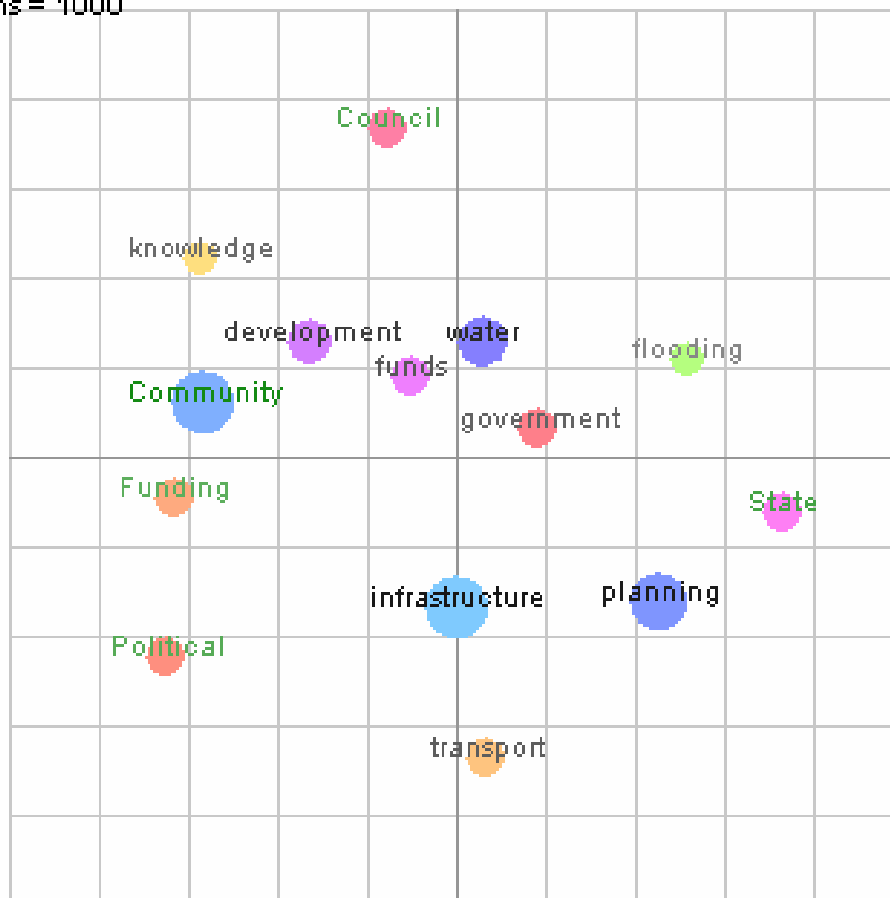


Figure 17: Synthesis of barriers to managing climate change impacts (all groups).

Note: The larger the circle the more dominant the concept, with the spacing of the variables relating to their relative connectedness. Concepts that are clustered were discussed more often together (eg. within each of the small group discussions).

The various dimensions of the key barriers to managing climate change issues and impacts are described below.

2.4.1 Community

The concept of “community” as a barrier to managing climate change was discussed by Local Councils specifically in relation to managing:

- property damage, assets, and infrastructure (eg. stormwater management);
- coastline impacts, (eg. beach amenity, erosion, and sea level rise);
- ecological impacts and ecosystems (eg. habitat loss and biodiversity);
- bushfire;
- behaviour change, community expectations / values, and consumption;
- development control, land use planning and urban form (eg. green space);
- development pressure and population;
- recreational and tourism demand;
- energy and water;
- extreme rainfall and flooding;
- human health and social wellbeing;
- economic development; and
- transport and vehicle usage.

Discussions of communities in managing these issues focused on human capital; diversity of perceptions; unsustainable mindsets; disconnections between attitudes and behaviours; magnification of climate risk; and community education and awareness.

2.4.1.a Human capital

Human capital constraints were identified as a barrier to managing climate change. For example, Pittwater Council participants identified a reduction in volunteer numbers, affecting climate change response capacity to issues such as biodiversity and green space. The human capital constraints were considered to be exacerbated by an aging population in many Local Government areas (eg. Pittwater and Hornsby) that relied on volunteers to respond to climate change impacts in the large areas of bushland included within those Local Government areas. An aging population was also considered to be a barrier in terms of the ability to undertake general property maintenance to reduce vulnerability to climate change (eg. ensuring home roofs were free from bushfire fuel such as leaves and sticks). The reduction in volunteers was also considered to be contributing to a general disconnect between people and the natural environment.

2.4.1.b Diversity of perceptions

Diversity of perceptions within communities was also cited as a barrier to managing climate change. For example, managing conflicting goals of asset protection and environmental conservation was considered difficult by Council participants. Furthermore, the prioritisation of assets was also considered to be difficult due to diverse perceptions within communities. Diverse perspectives were considered to stem from competing interests and expectations of various stakeholders. It was recognised by Local Council participants that finding common values and goals was critical to unified and mutually beneficial community responses, although it was also recognised that this was best achieved where the investment in time to build relationships and trust

had occurred.

2.4.1.c *Unsustainable mindsets*

Unsustainable mindsets such as disconnection with natural environments (eg. Gladwin et al., 1997) were identified as creating barriers within communities through unwillingness to respond. For example, participants perceived that some community members would not respond because they did not consider that climate change would affect them personally (eg. not affect them at home or work). Another example of barriers resulting from unsustainable mindsets related to the belief that short term effort for long term gain would be unattractive to some community members and that some community members would resist responding to climate change because those individuals believed that they would not gain benefits from their actions. Similarly, some participants believed that communities may not respond due to perceptions that climate change response is the responsibility of the various tiers of government rather than individuals.

The reasons for the lack of response were attributed to a number of factors, including: habits and laziness; fear of lowered standards of living; personal benefits prioritised over public benefits; and lack of trust in technological innovations. Other impediments to responses to climate change were perceived to relate to conflicting information and subsequent confusion over climate impacts and required mitigation measures within communities. Literacy and rental / public housing were also identified as response impediments. Cultural background was also cited by several groups in many Local Government areas as being a major impediment to climate change response. However, other constraints were also identified among communities who may want to respond, such as financial constraints and a lack of other resources (eg. services and facilities).

2.4.1.d *Disconnect between attitudes and behaviours*

Even though some communities were identified as having sustainable mindsets there was considered to be a disjunction between attitudes and behaviours of many community members (eg. reluctance to use public transport). Furthermore, some communities were considered to be unwilling to accept restrictions in relation to climate change (eg. water use). This disconnect was also considered to extend beyond communities to governments. For example, State Government reluctance to impose the true costs of water and energy resources typified this behavioural disconnect. Apathy between climate change events was also considered to contribute towards the attitude-behaviour disconnect.

2.4.1.e *Magnification of climate risk*

Some participants also considered that in a few cases communities magnified climate risks. For example, increased visitation in high amenity areas (eg. beaches at Manly) was considered to magnify risk to Councils – perhaps through increased loads on climate affected infrastructure. Communities were also identified as a barrier to the climate change response of other species. For example, wildlife movements were restricted due to conflicts with human habitation. Increased public access was considered to potentially exacerbate climate change impacts such as arson attacks in bushfire prone areas. Similarly to climate adaptation, some Local Councils also highlighted a number of community constraints to mitigative responses (eg. transport planning and vehicle usage), as well as adverse impacts on the capacity of Councils to develop and implement long term climate change planning.

2.4.1.f *Community education*

Lack of community education and awareness was cited by most Local Councils as a key barrier to community response. For example, apart from conflicting climate messages, some communities

are considered to be in denial over climate change. The denial was also recognised as being present in some Councillors and Council staff. Awareness of some specific issues was also identified as a barrier to response, such as a lack of understanding of ecological processes. Where communities were educated and aware, issues of consumption and personal wealth generation were considered to dominate behavioural response (or lack of response) to climate change.

2.4.2 Council and other Tiers of Government

The concepts of “Government” or “Council” as barriers to managing climate change were discussed by Local Councils specifically in relation to managing:

- property damage, assets, and infrastructure (eg. stormwater management and erosion);
- coastline impacts, (eg. sea level rise);
- ecological impacts and ecosystems (eg. habitat loss and biodiversity);
- community expectations / values, and consumption;
- land use planning and urban form (eg. green space);
- development pressure and population;
- energy and water;
- transport and vehicle usage;
- recreational demand;
- extreme rainfall and flooding;
- human health.

Discussions focused on multi-jurisdictional issues and divergent goals, as well as Council corporate culture; and intra-Council integration and communication.

2.4.2.a *Multi-jurisdictional issues*

Many workshop participants cited multi-jurisdictional issues as being a barrier to managing adaptation to climate change. In particular, it was noted that land, infrastructure, and assets were often controlled and managed by multiple government departments and quasi-government authorities, whose activities both directly and indirectly impacted on Councils’ ability to facilitate adaptation to climate change. Some of the areas cited by participants and considered to impact on Councils included national parks management, sewage treatment, port and airport management, energy supply, catchment management, public health, and development policies. For example, some participants stated that Local Councils had limited ability to control water pollution events resulting from flood waters entering sewerage systems. Limited communication between the various tiers of government (at an operational level) was considered to being a major barrier to a whole-of-government response to climate change (eg. in relation to the management of State Government assets within Local Government areas).

2.4.2.b *Divergent goals*

Climate change adaptation barriers also resulted from the different goals and worldviews of the various tiers of government. Many participants perceived that State and Australian Governments were focused on economic growth over sustainability concerns, limiting Local Government ability to manage for climate change proactively. For example, there was a perception among workshop participants of a reluctance of the State Government to impose the true cost of service provision, such as for water and energy supply. In addition, increased State Government sanctioned development was considered to be increasing flood risk in some areas due to an increase in impervious surfaces. Further compounding the perceived conflict between Local Government and the other tiers was the Federal and State Government power to veto some Council decisions. Some participants also believed that the various tiers of government were sending out mixed messages in

relation to climate change, which was considered to undermine universal acceptance to climate change and to threaten climate change response at community and business levels. Divergent goals and principles were also leading to inconsistent approaches and lack of uniform specifications (eg. on managing coastal impacts). Many workshop participants considered that climate change adaptation response required greater action at State and Federal levels of Government.

2.4.2.c *State Government*

State Government was seen to be a constraining factor for Councils in a number of areas, for instance:

- lack of State Government leadership in terms of articulating responsibilities for climate change impacts and adaptation;
- imposition of government policies influencing population density, but with no commitment to support infrastructure needs for an increased population;
- State reluctance to impose the true cost of resources such as water and energy supply;
- rate pegging and an inability to set income levels;
- lack of legislation on water saving;
- little control over where building codes / zones are applied;
- limitations to BASIX ;
- lack of long term infrastructure investment and conflicting policy directions, eg. new freeways versus bus routes.

There was a frustration that State and Federal levels of Government are not fast enough in responding to what are perceived as critical agendas at the local level. Another stated barrier was a lack of champions at all levels of Government.

2.4.2.d *Council corporate culture*

One of the major barriers identified by workshop participants as affecting Local Government's ability to respond to climate change was reluctance within Council to adopt innovative management approaches and technologies, and rather to adopt a business as usual approach, or minor incremental changes. The lack of champions within Councils was perceived to be exacerbating this conservatism. Often the conservative culture within Councils was driven by the values of senior management and Councillors. Furthermore, some participants perceived that some staff in Council considered that response to climate change should be tackled by other tiers of government, which represented a similar position with regards to environmental issues in some Councils, where several State Government agencies and regional bodies have legislated role in relation to environmental management. Some participants also cited a pro-development culture dominating some Councils. Similarly to communities, participants considered that there was a diversity of perceptions relating to climate change within Council, which resulted from staff engagement and affected organisational cohesion. Workshop participants cited that a reactive approach by Council and residents to climate change issues hampered response to climate change. Council response to climate change was also influenced by community members (eg. precinct representatives) who toned down the effects of climate change (eg. sea level rise). Another issue affecting Local Government culture was cited as the difficulty in quantifying climate change issues in triple bottom line reporting.

2.4.2.e *Intra-Council integration and communication*

Participants observed that climate change was generally seen as an isolated issue and not a something that affects a range of Council operations. Furthermore, poor integration and communication across different Council sections regarding management of Council assets was cited as an institutional barrier restricting a whole of Council response to climate change. Limited communication between Council sections was also cited as a barrier to managing ecological issues and catchments. Within Council, competing issues were identified as shifting the Councils focus towards other business areas and hampering cross-divisional interaction and sharing of information.

2.4.3 Planning and Development

The concept of “development” as a barrier to managing climate change was discussed by Local Councils specifically in relation to managing:

- assets and infrastructure (eg. aging infrastructure);
- coastline impacts;
- ecosystems (eg. habitat loss and biodiversity);
- bushfire;
- land use, new development and re-development (eg. green space);
- development pressure and population;
- water;
- extreme rainfall and flooding; and
- transport.

Many workshop participants indicated that current and future development proposals were likely to occur in areas more vulnerable to climate change (eg. areas at the urban-bushland interface more vulnerable to increased fire events). Some workshop participants noted that this was coupled with inappropriate development that had already taken place in ecologically sensitive areas. Development was also considered to exacerbate the impacts of climate change in other ways (eg. increased built environment creating reduced water absorption and thus magnifying flooding events). Some of the barriers to planning and managing development included: jurisdictional overlaps and inconsistencies; resources; lack of adequate Council standards; limited Local Government statutory control; and current incentives for development.

2.4.3.a *Jurisdictions and inconsistencies*

The most apparent set of barriers in the area of planning relates to jurisdictional overlaps and confusion. The multi-jurisdictional nature of responsibility means that Councils have no direct control over things such as water quality and environmental flows, or national parks. Multiple Government bodies are involved in decision making and land management. External management often has flow-on impacts on Council, yet Council cannot influence the land management actions of those entities. They are often surrounded by other governing authorities which can make planning and implementation difficult. Between Councils themselves there is a need to tailor Local Government policies so that there is commonality. Some participants noted that many of the decisions (particularly meta-decisions) relating to development were controlled by the State Government. Hence, Local Councils were left with trying to manage developments that had been approved by another regulatory agency, often resulting in compromised Local Government management ability in terms of enforcing development standards. Another issue raised by participants was the lack of legislation to facilitate adaptation to climate change, which was also considered by the participants to be a critical role of State Government in terms of responding to climate change. With so many players in the planning process it is difficult to reach consensus. It

takes time to agree, define solutions and decide action. There is no clear answer to the question - Who is responsible for the consequences of climate change?

Another perceived barrier was the absence of a consistent approach to planning. State Government policy and legislation was identified as being both complex and changeable. There was the perception of lack of political will at State Government level, coupled with a lack of sympathy for environmental sustainability, in favour of overriding economic concerns. Long term planning was thought to be hindered by political short term agendas and inconsistent policies and leadership from Council due to the limited 4 year term. Often issues require action at higher levels of Government, with Council then caught between political and community prioritising. Local Government perceives itself to be in a weak position with limited power to lobby for things such as funding, or land use appropriateness.

2.4.3.b *Council planning*

Even though many workshop participants were concerned about potential Council liabilities as a result of climate change, they commented that current Council plans did not take climate change into account. For example, land use planning, biodiversity planning, and stormwater management planning were cited as not incorporating climate change impacts. Furthermore, some participants noted that planning controls actually limited Councils' ability to respond to climate change (eg. BASIX was considered to reflect a minimalist set of responses to climate change). The formalised timeframes of policy and management processes (eg. Local Environmental Plan reviews) were also considered to be inadequate for the inclusion of climate change information. Workshop participants stated that approaches to managing infrastructure and conceptualising infrastructure risk did not currently include climate change considerations. Community expectations were also considered to influence the inclusion of issues such as climate change into Council planning.

Some participants also noted that increased development resulted in a range of other consequences that made responding to climate change more difficult for Local Councils (eg. increased pressure on existing infrastructure) and that even if development was managed well in one Local Government area, if adjoining Local Governments allowed development, service provision, infrastructure, and ability to respond to climate change would still be affected. Some participants did acknowledge that current planning processes within Councils may need to change in response to climate change (eg. due to changing water regimes and higher temperatures) and that the current uncertainty of the impacts of climate change was also leading to "less concrete actions" on the part of Local Governments.

2.4.3.c *Development incentives*

Current land use rights and the increased values of properties were cited as financial incentives for landholders to develop. These arrangements were also considered to result in public resistance to 149 certificate notations (for flood risk) due to potential devaluation of properties. While participants expressed concerns over potential Local Government exposure to liability as a result of climate impacts on Council approved developments, some participants noted that a combination of: (i) lack of clarity around responsibility for the various consequences of climate change; and (ii) lack of knowledge and acceptance of climate change by some Councillors, communities, developers, and Council staff, were restricting a change of Council practice in terms of development assessments. For example, participants from one Council stated that some precinct representatives (Local residents appointed to advise Council on decision-making) wanted to "tone down [the potential] effects of climate change and sea level rise" due to climate change information being perceived as unreliable, and potential devaluation of properties if re-zoned.

Another barrier raised by workshop participants related to lack of integrated design and planning for developments. For example, developers may be required to address some sustainability issues in the design of their developments, but then use unsustainable building products in the construction of the dwellings – reducing the capital expense for individual buildings and maximising the space for more buildings (eg. through minimal eaves to provide shade and natural cooling). Furthermore some participants noted that even if climate change or sustainability standards and / or requirements were present, they were easily challenged by developers. Another issue that was raised in relation to re-development included absentee landholders and rental investors, who are removed from some the nuances of climate change impacts and local discourses relating to adaptation.

2.4.3.d *Legacies and tradeoffs*

In dealing with climate change, Councils are hampered by previous poor planning, such as coastal developments, tip sites, and zoning; existing settlement patterns; and the type and condition of existing dwelling stock. Adapting to climate change will involve tradeoffs. For instance planning controls can limit Local Government responses to climate change; and adaptation actions and solutions can have environmental impacts. An example of this occurring would be where asset protection zones and hazard reduction works cause fragmentation of bushland. Funding of agriculture and human adaptation needs could drain resources from biodiversity issues. There was a perception that attention was already mainly focussed on the economic consequences of climate change.

2.4.4 Resources

The concept of “funding” as a barrier to managing climate change was discussed by Local Councils specifically in relation to managing:

- assets and infrastructure (eg. stormwater management and aging infrastructure);
- coastline impacts, (eg. beach amenity, erosion, and sea level rise);
- ecological impacts and ecosystems (eg. habitat loss and biodiversity);
- bushfire;
- behaviour change, community expectations / values, and consumption;
- development control (eg. green space);
- development pressure;
- recreational and tourism demand;
- energy and water (eg. integrated water management);
- extreme rainfall and flooding;
- human health and social wellbeing;
- economic development; and
- transport and vehicle usage.

The key issues raised by workshop participants related to the impacts of lack of Local Government funding to facilitate climate change adaptation, and the key factors affecting the financial capacity of Local Governments. Other resourcing concerns included human resource capacity in the community and Council.

2.4.4.a *Council capacity*

Most workshop participants discussed both resources and capacity issues as major barriers to effective Local Government response to climate change. Council capacity issues included the following:

- Availability of appropriate skills to maintain infrastructure;

- Competing priorities within Council for allocation of funds/resources;
- Lack of knowledge and acceptance of climate change by Councillors, the community, developers and staff;
- Lack of expertise in climate change within Councils;
- Lack of capacity to enforce compliance rules (eg. cutting down trees);
- Loss of continuity with initiatives due to staff turnover within Councils;
- Attracting and retaining staff.

The limited resources within Councils often resulted in environment sections being the only Council sections working (in a limited capacity) on climate change issues. Some participants also noted that even if Councils were to develop policies and management strategies in relation to climate change there would be insufficient resources to regulate and enforce those initiatives. One important resource in order to plan properly is time, and a number of participants remarked that there was insufficient time to consider climate issues within the LEP review. Many participants were also unclear as to the extent of Local Government statutory responsibilities in relation to climate change. With limited human and financial resources, and an inability to police and regulate, it was considered important to clarify what Councils' responsibilities are, and whether they are trying to do too much.

2.4.4.b *Impacts of lack of funding*

Lack of funding was considered by workshop participants to adversely affect the ability of Local Governments to:

- support bushfire evacuation requirements (eg. alternative roads and management plans);
- regulate (and police) biodiversity and green space climate change adaptation interventions – some participants also considered that funding to support agriculture and other human needs and wants would drain funding from biodiversity issues;
- educate communities on climate change adaptation strategies and options;
- provide adequate service provision and facilities for communities at risk;
- purchase land to implement adaptation solutions;
- manage built assets for climate change impacts;
- manage infrastructure for climate change impacts (eg. stormwater and drainage);
- undertake scientific studies to support the preparation of development control plans;
- understand the impacts of climate change – some participants noted that there were also financial impediments to gathering baseline ecological data or appointing ecologically trained staff;
- maintain infrastructure for existing conditions.

2.4.4.c *Factors affecting Local Government financial capacity*

The key factors affecting the financial capacity of Local Governments were considered by workshop participants to include:

- no commitment from State or Australian Government to support infrastructure upgrades for an increasing population in the region;
- rate pegging – restricting Local Government ability to raise additional resources from ratepayers to cover additional expenditure needed to adapt to climate change;
- limited leadership from State Government in relation to climate change leading to limited guidance to Local Governments and also limited flow-on of resources;
- Some Councils have a small rate base and pressure to keep rates low relative to other Councils, with no environmental levy or similar additional funding source available to address climate change;
- internal Council budgeting processes that create competition for resources between sections within Council;

- perceived large expense of managing built assets for climate change coupled with the financial constraints of Councils – some Councils stated that their financial position was worse due to small rate bases;
- current processes for obtaining grants is often time consuming (compounded by limited staff currently working on climate change issues within Councils with limited capacity – time and training – to complete grant applications);
- resistance within Council to approve investment in new technologies and general resistance to change;
- difficulties in quantifying financial returns on climate change adaptation expenditure (particularly in relation to environmental issues) within an economic rationalist culture;
- perceived equity issues among residents within Local Government areas (ie. climate change is not likely to affect areas in the same way – hence adaptation costs will vary);
- pressure to keep rates low relative to other Councils;
- no budget designated for climate change and competing against historical budget items;
- some Councils have not even implemented environmental levies;
- climate change often perceived as an environmental issue within Councils and thus actions are limited by the budgets of the environmental sections within Councils;
- State Government cost shifting to Local Governments for other management areas further constraining Local Government budgets;
- reduction in amount of Section 94 (developer contribution) funds;
- escalating infrastructure maintenance costs;
- international economic volatility – cited by some participants as affecting their funding base due to Council international investments;
- high cost of many current adaptation options;
- uncertainty of climate change impacts (what is vulnerable and to what extent?) affecting the ability of Local Governments to lobby for increased funding;
- lack of clarity over Local Government responsibilities in relation to climate change impacts.

Education of local communities was considered by some participants as necessary to justify an increase in rates to fund Local Government climate change adaptation interventions.

2.4.5 Knowledge

Although it is often perceived to be a predominant barrier in climate change adaptation, knowledge regarding the impacts of climate change was not paramount in the discussion of Councils' barriers to adaptation. However the issue was raised in regard to baseline data and best practice, human capital, uncertainty and scientific communication.

2.4.5.a *Data and information*

Lack of baseline data (e.g. existing ecological assets and resources, ground water), and knowledge of climatic impacts (e.g. changes to biodiversity, disease impacts and timing) were noted as barriers to adaptation. Lack of technology, knowledge of best practice and the quality of, and access to, information were also seen as barriers to making informed decisions.

2.4.5.b *Human capital*

In addition to problems obtaining or understanding external knowledge, lack of internal human capital was also mentioned. Councils lose continuity and knowledge with staff turnover and there is a lack of expertise on climate change impacts in general. There is poor integration and

communication across different departments within Council. Outside Council, in the general public, a transient population may mean loss of knowledge and historical memories of past climatic events, or ‘environmental amnesia’. In some cases there is a lack of hope, apathy, and despair at the enormity of the problem.

2.4.5.c *Dealing with uncertainty*

Scientific uncertainty was seen as a barrier, with some participants feeling that they need - but can’t get - answers. This uncertainty relates to impacts, to timescales and to local effects such as erosion. Uncertainty surrounding the impacts of climate change, together with information that is seen as both unreliable and too indirectly linked to important issues, results in less concrete actions by Councils. There remains a lack of acceptance of climate change as an issue by Councillors, the community, developers and staff. This scepticism relates to some of the aspects of climate science that are among the most certain, such as sea level rise and the increased potential for flooding.

2.4.5.d *Scientific communication*

Participants noted that there is a lack of consistency in climate change projection time frames and outcomes from State and Australian Governments. Some participants felt there was limited or no guidance given to Councils regarding approaches to addressing climate change, particularly adaptation. Choosing relevant information and avoiding confusion on the issue is therefore something that Councils find to be problematic.

2.4.6 Infrastructure

The concept of “infrastructure” as a barrier to managing climate change was discussed by Local Councils specifically in relation to managing:

- property damage and assets (eg. extreme rainfall and flooding);
- ecological impacts and ecosystems (eg. green space);
- amenity;
- development control;
- development pressure;
- recreation and tourism;
- human health and social impacts;
- economic development; and
- transport.

Discussions of infrastructure in managing these issues focused on the current under capacity of existing infrastructure; aging infrastructure; vulnerability of existing infrastructure; lack of infrastructure alternatives; lack of Council control over infrastructure; and community expectations.

2.4.6.a *Current under capacity*

Many Local Councils stated that current infrastructure was not coping with current loads (eg. leaking). For example, drainage networks were often cited by Local Councils as currently being under capacity for current peak flows (such as 1 in 50 year events). Furthermore, Local Councils also stated that there was no State or Australian Government commitment to support emerging infrastructure needs such as infrastructure to accommodate population increases. For example,

public transport was considered to be under capacity in many Local Government areas. Adaptation to climate change in the transport sector will have to contend with the historical form and layout of transport infrastructure (e.g. small roads) and the existing poor state of public transport across many Local Government areas in terms of coverage and quality. The legacy of past land use and transport infrastructure decisions is costly to correct. The topography of many areas in Sydney constrains transport infrastructure decisions. Many Local Councils therefore stated that they were having difficulty maintaining current infrastructure, even without accounting for climate change impacts.

2.4.6.b *Aging infrastructure*

Local Councils often cited aging infrastructure as a major barrier to responding to climate change and also cited a lack of financial resources to both maintain and replace infrastructure. Some Local Councils stated that rate pegging and increasing pressure to cap rate increases constrained Local Councils in their ability to manage their infrastructure. Cost shifting from State to Local Government was also identified as a barrier to managing infrastructure for climate change. Furthermore, upgrades to infrastructure were considered to be complicated due to diverse infrastructure owners (eg. infrastructure elements relating to the whole water cycle were owned by different councils and other agencies, across catchments).

2.4.6.c *Existing vulnerabilities*

Past planning decisions were considered to increase the vulnerability of existing infrastructure (eg. sewage pumping stations and development in low lying areas). The existing vulnerabilities were considered to be exacerbated by poor integration and communication within Councils (eg. between Council directorates), particularly as climate change is not seen as a common issue cross-cutting all Council business.

2.4.6.d *Lack of alternatives*

Lack of alternatives to hard infrastructure (eg. lack of green space for alternative water absorption) was also considered to be a barrier to responding to climate change. Heritage consideration was also cited as a barrier to change current infrastructure management approaches, as was the perceived dominance of a reactive, rather than proactive, management culture within Councils. Adequate examination of alternatives was also compromised by the lack of infrastructure risk assessments and management plans taking into account climate change impacts, as well as a lack of monitoring of infrastructure vulnerabilities. Uncertainty (both in terms of climate science and future needs such as population growth) was generally regarded across most Local Government areas as a major constraint to examining alternative infrastructure management approaches. Another factor inhibiting Councils' ability to respond relates to entrenched infrastructure, such as centralised infrastructure systems, that promote small incremental upgrades to existing infrastructure systems.

2.4.6.e *Lack of Council control*

Local Council participants cited limited policy and guidance from State and Australian Governments for addressing climate change impacts on infrastructure. Furthermore, Local Councils also expressed concerns that they had little control over much of the fundamental infrastructure that was vulnerable to climate change and of importance to their constituents (eg. sewerage and energy). Councils also stated that they had limited control over other major

government investments that may become vulnerable to climate change impacts (eg. the airport and port extensions). Some Local Councils also expressed concern over the pressure to develop, often overriding infrastructure planning. Lack of regulation over peak use was also cited as a major factor impacting on infrastructure management.

As with planning, transport authority rests with a number of agencies, such as the RTA and Sydney buses. Despite complex roles and responsibilities, adaptation in the transport sector will need to coordinate with CO₂ emission reduction efforts; consider changing structure of land use; potential service interruptions due to storm events or extreme heat; and understand how climate change will affect infrastructure.

2.4.6.f *Community expectations*

Expectations and perceptions of communities were considered to have major implications for Councils' ability for infrastructure response to climate change. Education of communities and justification of infrastructure management was considered critical for improving Local Council response to climate change impacts. For example, many Local Councils perceived a lack of interest among communities to fund the development and maintenance of infrastructure, even though communities expected infrastructure to cope at all times. However, due to transient populations and the sporadic nature of extreme events (eg. flooding), communities were considered to be apathetic to building resilience to those extreme events. Similarly, a few Local Councils cited some constituent perceptions that infrastructure issues should be funded and managed by other tiers of Government. They also perceived that because much infrastructure was out of sight, it was also out of mind. Council has very little control over car usage, car dependency and lifestyle choices. An increase in population, and increasing obesity in the community, is likely to lead to higher numbers of cars. Car ownership also increases with increasing wealth and a rise in the number of single person households.

2.4.7 Water

The prevalence of water as a concept in the barriers discussions relates to the way it links across many areas of Council activity. The areas of most concern to Councils were issues of public health and liability, and flood impacts and management.

2.4.7.a *Interlinkages*

Water resources provide a link to many other areas of activity, and are in fact needed for adaptation in other areas. For instance lack of water availability will make it difficult to fight fires, or to undertake bush regeneration. However as mentioned previously, ownership and control of water resources does not exclusively rest with Local Government, and this is a barrier to adaptation. For example Councils have no direct control over catchments, or over such things as water quality and environmental flows, or water pollution events such as flooding of sewer systems.

2.4.7.b *Liability and perceptions*

Public health and liability issues were seen as barriers with regard to the use of grey water, as were community perceptions surrounding the use of recycled water for drinking. These perceptions exist in the context of the low cost of potable water compared to the high cost of treatment and infrastructure.

2.4.7.c *Flood management*

One of the concerns raised by some Council staff included sensitivity issues in relation to flooding, in particular that their Local Government Area had a significant aging population, who were considered to be more at risk to flooding due to their reduced ability to evacuate during times of flooding. Other impacts considered important by Council staff related to health impacts, particularly in relation to stormwater and sewage mixing due to leaks and aging infrastructure, as well as overflows into Sydney Harbour. Participants noted that a combination of aging infrastructure and the under capacity of existing infrastructure exacerbated the impacts of flooding.

A range of flood management issues were raised by the workshop participants, including Council finances to maintain and replace infrastructure, as well as some assets not being owned by Councils, making upgrades problematic. Other physical geography issues were also raised in relation to managing flooding such as topography, lack of absorption due to lack of green space and geological impediments, and increased hard surfaces in the catchment (leading to more intense hydrograph spikes).

A number of other barriers to managing flooding included:

- Lack of political will
- Non-visibility of stormwater drainage – out of sight, out of mind
- Loss of flood management continuity and knowledge with staff turnover
- DISPLAN activated by State Government not Councils
- Apathy between events
- Private asset issues relating flood levels hence reluctance to map vulnerable areas
- Ownership of adjoining land
- Knowledge base (external and internal)
- Will in Councils – resistance to approve new technologies and resistance to change
- Uncertainty / scepticism (to sea level rise)
- Scepticism to climate change and greater potential for flooding

Table 10: Summary of the main barriers to adaptation.

Community	Government	Planning and development
<ul style="list-style-type: none"> • human capital constraints • reduction in volunteer numbers • ageing population • disconnect between people and environment • diverse perceptions within communities • competing stakeholder interests and expectations • unsustainable mindsets • cultural background • mismatch between attitudes and behaviours • lack of community education and awareness • climate change denial 	<ul style="list-style-type: none"> • lack of leadership and champions • poorly articulated responsibilities for adaptation • reluctance to impose the true cost of resources • conflicting policy directions and mixed messages • predominance of business as usual • poor integration and communication • speed of State and Federal response to critical local agendas • reactive approaches • difficulties quantifying climate change in triple bottom line reporting 	<ul style="list-style-type: none"> • jurisdictional overlap and confusion • difficulty reaching consensus • lack of consistency • lack of political will at State level • lack of sympathy for environmental sustainability • short term political agendas • lack of innovation in councils • legacy of past planning decisions • focus on economic consequences of climate change • limited enforcement • pro-development bias • divergent goals and worldviews of various tiers of government
Funding and Resources	Knowledge	Infrastructure, water
<ul style="list-style-type: none"> • rate pegging • lack of State and Federal support • competition for resources within council • small rate bases • difficulty applying for grants • resistance to change within council • justifying adaptation expenditure • cost shifting to local government • international economic volatility • lack of expertise • attracting and retaining staff 	<ul style="list-style-type: none"> • lack of baseline data • unknown climatic impacts • mismatch between information and priorities • apathy and despair in the community • staff turnover • transient population and environmental amnesia • scientific uncertainty • limited or no guidance • lack of consistency in projection time frames and outcomes • lack of acceptance of climate change by community, developers, councillors and staff 	<ul style="list-style-type: none"> • current under capacity • ageing infrastructure • State and Federal commitment to emerging needs • past planning decisions • existing vulnerabilities • lack of alternatives • entrenched systems • lack of council ownership and control • lack of community interest • community lifestyle choices • public health and liability issues • apathy between extreme climatic events • scepticism to climate change

2.5 Opportunities for Managing Climate Change

Based on concept frequency modelling (using the software package Leximancer), the most common opportunities for managing the issues identified by workshop participants ranged from community (noted as an opportunity 36 times) to policies (noted 6 times) (table 11). The relationships between these concepts are graphically displayed in Figure 18.

Table 11: Regional opportunities.

Opportunity	Number of times cited
community	36
development	20
water	19
Council	16
planning	15
management	14
policy/policies	13
education	12
capacity	11
transport	11
leadership	8
knowledge	7
action	6

Iterations = 1000

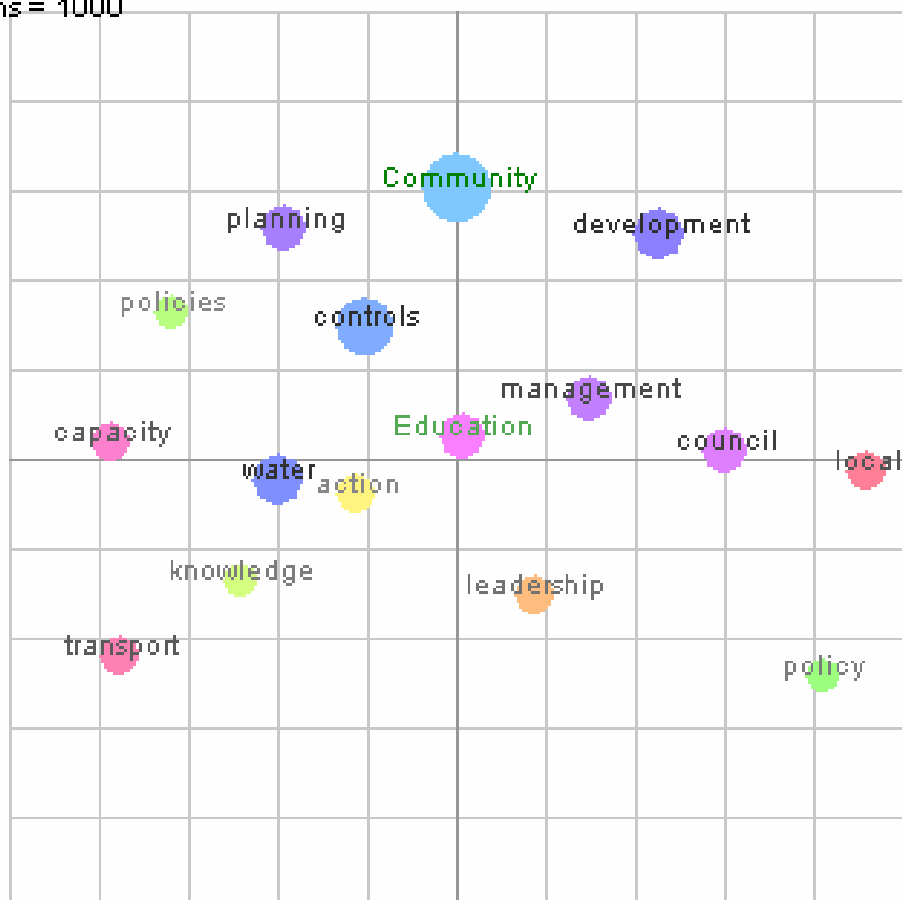


Figure 18: Synthesis of opportunities for managing climate change impacts (all groups).

Note: The larger the circle the more dominant the concept, with the spacing of the variables relating to their relative connectedness. Concepts that are clustered were discussed more often together (eg. within each of the small group discussions).

The various dimensions of the key barriers to managing climate change issues and impacts are described below.

2.5.1 Community

The issue of community was prevalent in many of the workshop sessions, across most Councils and topics. In addition to ideas for community education, the workshop participants discussed the existing character of the community and the advantages this had for adaptation, as well as identifying a number of areas for community engagement.

2.5.1.a *Nature of community*

Some participants noted that their community was motivated to act on climate change, and willing to fund change (for instance through an environmental levy), or that it gave Council strong support and feedback. Knowledge and appreciation of particular issues (e.g. beach issues, public health) was a feature of certain communities, and a strong sense of identity was discussed as a factor that could potentially aid adaptation.

2.5.1.b *Ideas for engagement*

Participants saw climate change as an opportunity to tie in social as well as environmental benefits, and have the community drive change. They considered a number of avenues for engaging the community on adaptation. These included:

- working on collaborative projects with the community to increase capacity and social cohesion;
- collaborating with communities beyond the Council's own;
- using Aboriginal cultural heritage to illustrate care for country;
- communicating the impacts of climate change in terms of community values;
- recognizing that clubs and associations are an important element in socially supporting networks;
- mobilising well educated, connected members of the community to work with Council to develop plans;
- promoting volunteerism;
- planning for village hubs;
- establishing a climate change watch group; and promoting social connectedness, for instance through such things as improvements in pedestrian access.

2.5.2 Education

A large number of the workshops identified Councils' role in education as an opportunity to adapt to climate change. The fact that climate is the 'topic of the day' was thought to provide an opportunity to change community awareness, expectations and attitudes as information becomes available, and to lead by example.

2.5.2.a *Education needs*

Key topics that were identified as necessary for educating for adaptation were:

- biodiversity conservation, the need for trees and healthy bushland, and linkages between human behaviour, native habitat and water;
- better dwelling construction and retrofitting techniques;
- compliance issues for development applications (DAs), educating applicants and architects about BASIX, and allowing a better understanding of the implications of climate change on land and property value;
- drainage and runoff information to prepare for heavy rainfall, advertising flood levels, and developing a process to assist people to flood proof property;
- reduction of waste, including greenhouse gases; and
- awareness that ‘things might get worse’ as climate change increases, and that everyone is responsible for climate change and its solutions and may need to make personal sacrifices for the community good.

2.5.2.b *Tools and methods*

A number of tools and methods were identified to undertake these education activities, for instance:

- school programs;
- use of technology, including TV advertising, to spread messages, and using Council websites to communicate existing projects and emissions reduction commitments;
- incentive programs;
- showcasing and demonstrating new technology such as high visibility solar energy and sustainable homes;
- ecotourism and interpretation;
- lobbying and changing behaviour of the private sector by working with business;
- creating a centre of climate change to showcase best practice and support community unity; and
- Council staff training in environmental management and educating Councillors to take leadership in lower car usage and alternative transport.

2.5.3 **Capacity and Leadership**

The workshop groups specifically identified areas of existing Council capacity, such as:

- Councillors that are fairly ‘Green’;
- existing networks with external agencies in areas such as emergency management;
- good infrastructure and facilities such as public broadcast and communications systems, or nursing, aged care and hospital facilities;
- Council human resources, such as outdoor staff (e.g. rangers) who could have a communications role, or staff with expertise in sewer mining, recycling, or stormwater collection;
- good internal operations and communications, for instance the relationship between waste, parks and assets, or good cross-unit linkages generally; and
- wealth and assets – a well educated community, a good and varied assets base with the potential for increased rates, and, in some cases, high incomes in the community.

Some of the ideas that were raised for increasing capacity include forming partnerships with other Councils and organisations, and working as an integrated team between all Council departments.

Many participants identified that Councils could be advocates for positive behaviours, and lead by example in areas such as consumption and green energy. Suggestions included encouraging local businesses to adopt alternative energy sources, by giving climate change awards, or establishing a climate change watch group. One group noted the possibility of the trigger effect driving behavioural change. Leadership also involved partnership between other Councils and government bodies, and applying a consistent approach to climate change practices at the Local, State and Federal level. Increased collaboration among Local Governments could help build this consistency, with the SCCG and Catchment Management Authorities playing a role in providing commonality of policy across NSW. Better synergy with State Government and its agencies would lead to coordinated action and savings.

2.5.4 Knowledge

Climate change was identified as an opportunity for innovative thinking and the promotion of knowledge, allowing Councils to be proactive rather than reactive in predicting the potential impacts of climate change and preparing for them. Many respondents identified the possibility of more State and Australian Government grants for research. It was suggested that regional coordination of grants, plans and knowledge sharing could result in more political weight for Councils.

Suggestions ranged from existing knowledge needs to ideas for future research and communication. Existing needs include skilled employees; data and mapping; greater certainty and transparency in research; and detailed location-specific data.

2.5.4.a *New knowledge*

It was thought that new technological developments in many areas could bring changes in cost effectiveness. Examples of areas where new knowledge could facilitate adaptation include:

- dwelling construction and retrofitting techniques;
- fire fighting technology and equipment improvements;
- habitat restoration;
- stormwater reuse and management;
- alternative energy sources and technologies for infrastructure assets;
- sand replenishment and management of coastal erosion;
- alternative fuels and vehicles; and
- environmental economics and valuation.

2.5.4.b *Communication*

The process of communication was discussed, although not to the same extent as knowledge needs. Climate change was seen as an opportunity to open communication lines between Councils to share information. One idea was to combine resources through a regional mechanism to bring about standard operating procedures, ways of assessing climate change impacts and development

solutions. Councils identified the need for mechanisms to communicate with vulnerable groups such as the elderly and non-English speakers.

2.5.5 Policy

The policy opportunities that were identified related to economic incentives, legislation and controls; lobbying; and Council strategies and funding.

2.5.5.a Economic incentives

Proposed economic incentives included a user pays biodiversity audit; incentive programmes for better dwelling construction techniques; and better State pricing of exhaustible/ non-renewable natural resources (e.g. solar panels or wind turbines). Ideas in the area of legislation and controls include environmental audits of industry; various types of levy; and making legislation more ecologically focussed.

2.5.5.b Lobbying

There were a number of opportunities for lobbying, such as raising the profile of things such as tourism, biodiversity conservation, and green initiatives, and working towards behavioural change in the private sector. Not unexpectedly, many of the ideas involved lobbying State Government: for putting electricity supplies underground, light rail, mass transit and sustainable transport options, greenlinks, and more land for open space. Another suggestion was to use the Local Government network to work on partnerships with utilities and services.

2.5.5.c Funding

Climate change was seen as an opportunity to obtain more funding for grants and research as well as for Council operations (for instance to prepare for, and clean up after, fires). Regional coordination of grants was seen to be politically advantageous.

2.5.5.d Council strategies

Ideas for Council strategies included innovative stormwater policies and decreasing the amount of hard surfaces in catchments; local energy production and distribution to meet a carbon neutral goal; a homeless people program to target the vulnerable sector; promotion of affordable housing; and various transport initiatives. Climate change was seen as an opportunity to obtain more funding for some of these areas of Council operations (for instance to prepare for, and clean up after, fires) as well as for grants and research. Regional coordination of grants was seen to be politically advantageous.

2.5.6 Planning

Planning was noted as offering opportunities for adaptation in almost every area of Council activities, for instance emergency response evacuation and alternative road access; design and construction improvements for resilience; zoning; transport; energy; biodiversity; and coastal and estuarine management. A great number of responses, however, mentioned planning without being particularly specific. More detailed suggestions can be classified into vulnerability reduction,

capacity building, and risk management. Other ideas for planning opportunities are addressed in other sections, in particular development (4.5.9), water (4.5.10) and transport (4.5.11).

2.5.6.a *Vulnerability reduction*

Participants identified a number of ideas that could be introduced into planning for the purposes of reducing vulnerability. These included locating seniors' living locations outside bushfire prone land; land use planning for biodiversity and strengthening environmental criteria in the LEP; more indoor and multi-purpose facilities; increased open space and turning existing lawn areas into wildlife corridors; planting climate tolerant trees, more native trees and less grass; blurring the line between public and private open space; and developing Council policy to identify and control development in vulnerable areas.

2.5.6.b *Capacity building*

A number of suggestions related to planning activities that would build Council's capacity to respond to change, such as more funding for Council operations; mapping and data for planning improvements; working with existing partnerships to develop regional strategies; long term planning and steps to minimise short term agendas by politicians; and planning for village hubs.

2.5.6.c *Risk management*

The need for risk management was identified by a few groups, and one referred to the need to understand community perceptions of risk. Specific ideas that can broadly be classed as 'risk management' were to model climate change in long-term financial plans for assets; less reliance on centralised sources of water and energy; and consideration of strategic loss of properties in high risk locations.

There were a number of ideas for opportunities for improved management, for instance in the areas of coasts, biodiversity and assets. Coastline management opportunities included natural foreshore protection of dunes as a means of mitigating storm damage; using offshore sand sources to nourish beaches; and developing alternative solutions to coastline management. Thoughts for improved biodiversity management opportunities included selection of more tolerant species; focusing on landscape connectivity and bush corridors; species translocation; and bushfire management programmes focused on ecosystems. Opportunities for asset management included generating an income stream from recreational facilities; redefining what is available to the public; improved technology, design and higher standards; shades above sporting facilities and streetscapes; a water re-use strategy for sporting fields; and seeking improvements in litter and waste management in public places in conjunction with locals and businesses.

2.5.7 Development

Participants saw an opportunity for Council to take an innovation and leadership role and showcase best practice local development. For instance Councils could take the lead and convert their administration buildings to green power with the hope that others in the community would follow. The potential exists to harness growing community awareness to develop progressive policies and to introduce better incentive-based controls to encourage sustainable development.

The current review of LEPs and DCPs was noted as an opening for changes in planning and the introduction of tighter controls. Continuous review of planning controls was thought to be necessary in order to incorporate the current and projected impacts of climate change. Areas where development controls could be useful for adaptation include ESD development controls; BASIX; design specification and building codes; building standards (i.e. water conservation, stormwater retention, energy efficiency); and the ability to denote flood potential on 149 certificates. One suggestion was to lobby higher levels of Government for increased capacity and guidance regarding planning and design. Another was to release rate pegging and then raise rates to pay for infrastructure. One group suggested that, in the future, there could be increased revenue from climate change recreational refugees in some areas. New development could bring funding opportunities and therefore resources to ensure climate change needs are met. Council funds (e.g. infrastructure levies) could be used to pay for the establishment of a climate change reserve, or remediation of land could result in the development of more open space.

2.5.8 Water

Water management opportunities were divided between technical and policy solutions. Technical suggestions included:

- sustainability retrofitting;
- recycled water for drinking and irrigation;
- rainwater harvesting;
- treatment of stormwater and pipe stormwater inspections;
- approved flood barrier techniques;
- water capture for reuse, such as grey water on sporting fields, with existing water reuse and treatment systems and future systems developed to treat water to safe standards; and
- ensuring new technology such as stormwater reuse improves environmental outcomes.

Policy suggestions included innovative stormwater policies; better habitat value for watercourse and creek lines; less reliance on centralized sources of water and energy; energy and water action plans; better relations with Sydney Water; and collaboration and knowledge sharing with other Councils regarding source catchments. Several groups mentioned the possibility of a special levy to make sure climate change needs are met.

2.5.9 Transport

Since Councils have control over a number of transport issues, this featured as an opportunity. Some thought that future changes to land use might provide an opening to change travel behaviour. Promoting alternative forms of transport could lead to flow-on effects on human health, social networking and connectedness. Options that were discussed include:

- bike facilities;
- transport choice;
- cycle ways to improve connectivity;
- internal Council initiatives to encourage use of public transport, for instance offering train and bus tickets rather than allocating vehicles to staff;
- promotion of walking and cycling, making bike lanes and pedestrian ways safer;
- review of Council parking schemes to encourage lower car use for residents;
- moving priorities and funding away from maintaining and creating car corridors to funding and prioritizing alternative transport;
- increased use of waterways;
- facilitating provision of additional public transport in poorly serviced locations; and
- lobbying for light rail, mass transit and sustainable transport alternatives.

Table 12: Summary table of the suggested opportunities

Community	Education and Knowledge	Capacity and Leadership
<ul style="list-style-type: none"> • motivated community • good community feedback • strong sense of community identity • public knowledge and appreciation of issues • opportunity for collaborative projects with the community • supporting caring for country • promoting volunteerism • planning for village hubs • promoting social connectedness 	<ul style="list-style-type: none"> • utilising schools and IT to communicate • showcasing new technology • working with business • staff and councillor training in environment • assisting people to flood proof property • promoting biodiversity conservation • fostering community responsibility • new knowledge in building techniques; fire fighting; habitat restoration; stormwater management; alternative energy; coastal management; environmental economics and valuation • new communication lines between councils • understanding community risk perception 	<ul style="list-style-type: none"> • green councillors • existing networks with external agencies • good infrastructure and facilities • high community incomes • good and varied asset base • good internal operations and communications • encouraging alternative energy • establishing a climate watch group • enhanced partnerships and collaboration • coordinated action and commonality of policy
Policy	Planning	Water and Transport
<ul style="list-style-type: none"> • incentive programs • better pricing of resources • more ecologically focussed legislation • using local government network to partner with utilities • lobbying state government • more funding for research and operations • regional coordination of grants • local energy production and distribution • affordable housing 	<ul style="list-style-type: none"> • emergency response and evacuation plans • land use planning for biodiversity • strengthening environmental criteria in the LEP • more open space and multi-purpose facilities • ability to control development in vulnerable areas • planning for village hubs • habitat rehabilitation, landscape connectivity • generating an income stream from recreational facilities • continuous review of planning controls • increased revenue from climate change immigrants 	<ul style="list-style-type: none"> • sustainability retrofitting • rainwater harvesting • improved flood barrier techniques • less reliance on centralised sources of water and energy • energy and water action plans • collaboration regarding source catchments • climate change levy • promotion of alternative transport • cycle ways and connectivity • encouraging lower car usage • shifting transport priorities • increased use of waterways • connecting poorly serviced locations

3 DISCUSSION

The research highlights a paucity of information and understanding upon which Local Governments are able to base management responses in relation to climate change adaptation. An important finding is that Local Governments recognise a vast range of biophysical and socio-economic climate change issues likely to impact on their operations and constituents, although they also highlight deficiencies in terms of understanding the extent of each of the potential impacts and limited capacity to manage those issues.

Although uncertainly regarding the impacts of climate change and lack of data were cited as barriers to a climate change response, these issues were not paramount in the discussion of Councils' barriers to adaptation. A number of barriers to climate change relate to legacy effects, or the implications of an area's history, demographics, and individual circumstances. Examples include reliance on decreasing numbers of volunteers; an ageing population; past development in low lying areas; or ageing infrastructure. It is important to realise therefore, that some of these barriers impose certain limits on adaptation by Councils. However, frequently cited barriers were related to resources and funding. For instance, funding restrictions limit the ability of Councils to purchase land to implement adaptation solutions; maintain infrastructure and assets; gather data and understand impacts; and educate their staff and communities. Council control, responsibility and intergovernmental relations were also key to a whole suite of barriers that include lack of a whole-of-government response to climate change; lack of control over vulnerable investments; complex legislation that is constantly changing; and short term political agendas. Underlying these structural concerns were a group of barriers related to attitudes and behaviours. These included a lack of sympathy for environmental sustainability at State Government level; a pro-development bias in some Councils; evidence of a disconnect between attitudes and behaviour in the community; and conservatism within Council cultures and an associated lack of champions.

Although participants identified a far greater number of barriers, some opportunities were identified to enable Councils to adapt to climate change. Some of these were locally specific, and while these are important for the individual Council in question, they are not necessarily transferable between different Councils in the SCCG. Examples of such locally specific opportunities include a motivated and wealthy community; specific local knowledge; or "green" Councillors. A further large subset of opportunities consisted of activities that would involve doing what Councils already do, only better. Examples here include collaborating with the community, business, and other Councils; supporting social networks; education in areas such as biodiversity and dwelling construction and retrofitting techniques; bushfire management; and promoting volunteerism. While these activities do support adaptive management, they are not necessarily novel suggestions. A number of suggested opportunities could best be classified as 'windfall opportunities' - in other words, things that might happen in the future, but were definitely outside Councils' direct control, such as improvements in technology (e.g. alternative fuels, fire fighting techniques); or more State and Australian Government grants for climate impact research. For the most part, far reaching or novel opportunities for adaptation to climate change assumed two things: additional funding or multi-jurisdictional collaboration, particularly in the area of planning. Suggested opportunities include planning for village hubs; Council showcasing and demonstrating new technology such as solar energy and sustainable homes; strengthening environmental criteria in the LEP; and the introduction of incentives and levies for adaptation.

In a post-workshop evaluation (Appendix 1), participants stated that they had gained increased awareness and understanding of a range of climate change adaptation issues. For example, 40% of participants stated that they gained a better appreciation of the complexity and interrelationships of climate change impacts. Furthermore, 11% of participants noted that they valued the opportunity to interact with other Council staff and to hear their perspectives.

4 RECOMMENDATIONS

Based on the regional workshops a number of recommendations are proposed by the researchers to build the capacity of Local Governments to adapt to climate change. The recommendations address specific issues resulting from the findings of the 15 workshops with Local Councils in the SCCG region.

Issue 1:

- The regional workshops identified that collective systems models of climate change drivers, impacts and management were complex and that many of those variables had intricate relationships between one another. Furthermore, many of the system complexities were identified through council staff participating actively in the workshop process.

Recommendation 1:

- Local Governments must recognise that climate change is complex and simple solutions are not easily identifiable. Furthermore, the most productive approach to dealing with complex and uncertain issues such as climate change, where the decision stakes are high, is for Local Governments to play an active role in directing, participating in, and validating the research – thereby ensuring that climate change assessments have maximum benefit for decision-making.

Issue 2:

- Although there was appreciation of some of the major issues facing other councils, the regional workshops highlighted the absence of information sharing and awareness of many issues and management responses between councils, especially where councils were facing similar issues – particularly in relation to socio-economic impacts.

Recommendation 2:

- Increased cross-Council dialogue regarding climate change adaptation strategies and interventions – with the purposes of: (i) raising understanding of potential and actual climate impacts; (ii) sharing lessons on adaptation successes and failures; and (iii) maximising leverage from individual Local Government interventions through targeted and synergised interventions for impact at the regional scale.

Issue 3:

- The regional workshops exposed that climate change responsibilities were largely isolated to the environmental divisions within the SCCG Councils, and that there was limited integration of climate change issues within other Local Government divisions.

Recommendation 3:

- Providing Councils with information on their current options for the integration of climate change in their management planning and decision making processes; and including climate change considerations within all Local Government sections – rather than isolating climate change response to environmental sections within Councils.

Issue 4:

- Many workshop participants stated that climate change had not been factored into Local Government policies, planning controls, planning standards, and development regulations. Participants also acknowledged that climate change had also not been mainstreamed into State and Federal policies and legislation.

Recommendation 4:

- Review and amendment of policies, planning controls, planning standards, development regulations, and legislation to facilitate climate change adaptation.

Issue 5:

- The regional workshops showed that Local Governments were uncertain over their actual roles and responsibilities in relation to climate change impacts. Furthermore, many participants stated that they required more leadership from both State and Australian Governments in terms of providing statutory guidance and resourcing for climate change adaptation.

Recommendation 5:

- Committing the drivers of statutory responsibility (ie. State and Australian Governments) to greater leadership in terms of articulating responsibilities and liabilities for climate change adaptation and adequate resourcing of adaptation responses.

Issue 6:

- Local Councils in the SCCG region were more able to articulate climate change drivers and some direct impacts, rather than management responses and adaptive capacity. Many workshop participants also struggled to identify their sensitivity to climate change impacts or articulate their adaptive capacity to off-set potential climate impacts.

Recommendation 6:

- Expand government investments into research on climate change ‘exposure’ to also include ‘sensitivity’ and ‘adaptive capacity’ in order to comprehensively understand climate change vulnerability.

Issue 7:

- Lack of resources to adequately respond to climate change was cited as a key issue for all councils in the SCCG region, particularly in relation to infrastructure upgrades and future enforcement of climate change regulations.

Recommendation 7:

- Resourcing for Local Council climate change interventions – for example, infrastructure upgrades and climate change adaptation regulation enforcement.

Issue 8:

- The high levels of participation (ie. the numbers of participants and senior positions of participants) indicated a desire to interact with the researchers on this project. Similarly to issue 7, workshop participants also identified a lack of resources for Local Councils to work with researchers on climate change issues. Furthermore, many workshop participants acknowledged the uncertainties associated with climate change impacts and the need to take an adaptive management approach.

Recommendation 8:

- Resourcing for Local Councils to work with researchers to develop and test monitoring and evaluation frameworks to determine the reasons for success or failure of climate change adaptation interventions and their potential transferability to other regions.

Issue 9:

- The regional workshops highlighted the current inability of SCCG Local Councils to “scale-up” to address climate change issues collectively at the regional scale.

Recommendation 9:

- Greater understanding of the key cross-cutting regional barriers to managing climate change – this is the focus of the third phase of the ‘Systems Approach to Regional Climate Change Adaptation Strategies in Metropolises’ project.

5 CONCLUSIONS

Local Governments in the Sydney coastal region clearly recognise climate change as an issue that will affect their strategic and day-to-day operations. An assessment of relative climate change vulnerability found that there is significant spatial variability throughout the Sydney coastal region. The vulnerability assessments were used to stimulate discussion of climate change drivers, impacts and management responses through 15 SCCG member Local Government workshops – it was not intended to quantify specific climate change impacts for local government areas. The discussion was captured through a systems conceptualisation approach, which identified key concepts and relationships between those concepts. Interactive discussions of the systems diagrams were used to assist Councils to identify their priority climate issues, which were then discussed in more detail in small groups in terms of barriers and opportunities to managing them.

The recognition of the importance of climate change among Sydney Local Governments was demonstrated by the cross-section and number of Local Government participants in the workshops, combined with their respective system conceptualisations and articulation of key barriers and opportunities to adapt to climate change. Furthermore, workshop participants were aware that climate change is likely to impact on a range of biophysical, social and economic issues. However, there was great uncertainty over the extent of each of the potential impacts and who was actually responsible for managing those impacts. Even though many workshop participants were concerned about potential liabilities as a result of climate change, they commented that current council plans did not take climate change into account. Additionally, many participants were unclear as to the extent of the Local Government statutory responsibilities in relation to climate change.

Significant issues were also raised in terms of the capacities of Local Governments to adequately respond to climate change. In particular, barriers to managing climate change related to water management, funding, development, State Government, Councils' own management approaches, politics, transport management, Australian Government, knowledge, and flooding management. However, the three key regional cross-cutting barriers identified related to communities, infrastructure, and planning and decision-making. Through understanding the key cross-cutting regional barriers to adapting to climate change in Sydney, Local Governments will be better placed to scale-up their individual efforts in order to more effectively respond to climate change at the regional scale.

Other recommendations relate to: (i) recognition of complexity and flow-on effects of council interventions; (ii) greater interaction between councils on climate change issues; (iii) mainstreaming climate change issues across all business divisions within councils; (iv) reviewing and amending policies, management actions, and legislation at all tiers of government to include consideration of climate change issues; (v) improved government leadership for climate change issues; (vi) including assessments of sensitivity and adaptive capacity, as well as exposure; (vii) adequate resourcing for councils to implement climate change adaptation interventions; and (viii) adequate resourcing for councils to monitor and evaluate climate change adaptation interventions.

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APPENDICES

Regional Workshops Synthesis Report: Sydney Coastal Councils' Vulnerability to Climate Change PART 2

APPENDIX I: SUMMARY OF WORKSHOPS FEEDBACK

Attachment 1: Average Rating for all Workshops

Attachment 2: Summary Feedback for all Workshops

APPENDIX II: INDIVIDUAL SCCG MEMBER COUNCIL WORKSHOP REPORTS

Report 1: Mosman Workshop Report

Report 2: Pittwater Workshop Report

Report 3: Manly Workshop Report

Report 4: Sutherland Shire Workshop Report

Report 5: Rockdale Workshop Report

Report 6: Randwick Workshop Report

Report 7: Hornsby Shire Workshop Report

Report 8: Warringah Workshop Report

Report 9: Willoughby Workshop Report

Report 10: Waverly Workshop Report

Report 11: Woollahra Workshop Report

Report 12: Botany Workshop Report

Report 13: Leichhardt Workshop Report

Report 14: City of Sydney Workshop Report

Report 15: North Sydney Workshop Report

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